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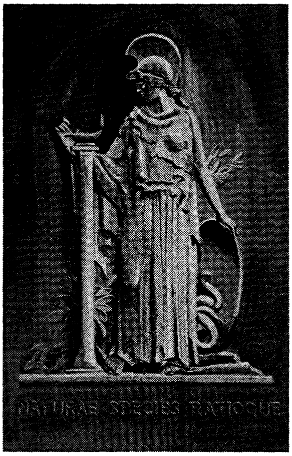

LIV — 1965

Editor

GOODWIN F. BERQUIST, JR.

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TRANSACTIONS OF THE WISCONSIN ACADEMY

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Volume LIV

WISCONSIN TORNADOES

*M. W. Burley and P. J. Waite**

INTRODUCTION

Tornadoes are one of nature's more spectacular storms. The American Meteorological Society's 1959 Glossary of Meteorology defines tornadoes as "A violent rotating column of air, pendent from a cumulo-nimbus cloud, and nearly always observable as a "funnel cloud" or tuba. On a local scale, it is the most destructive of all atmospheric phenomena. Its vortex, commonly several hundreds of yards in diameter, whirls usually cyclonically with wind speed estimated at 100 to more than 300 miles per hour." Later information indicates that wind speeds within the tornado vortex may possibly exceed 500 miles per hour. Most people will live their lives without seeing a tornado, but that does not mean that tornadoes are not a real threat in Wisconsin. With increasing population in the state, the number of people and amount of property within the paths of tornadoes will also increase. Timely forecasts and public cautionary measures are becoming more important.

Tornadoes have captured public attention at irregular intervals. Since the Civil War, outstanding damage or loss of life in Wisconsin from these storms has occurred over four dozen times and have been at times as devastating as anywhere in the world. The "Circus Day" tornado in New Richmond on June 12, 1899 killed 117 persons and destroyed much of the town as it swept down the main street that evening. Damages estimated at seven million dollars were reported in a single tornado of a complex of five on the evening of June 4, 1958 at Colfax in Dunn County. This exceeded, only in inflated dollar value, the four million dollar loss sustained on September 9, 1884 in a tornado that moved east-northeastward out of Minnesota, across St. Croix County to finally end in Price County in the north central portion of the state.

Known tornadoes and some of the more severe windstorms from 1843 through 1964 are tabulated for the first time in a chronological sequence to meet public requests, particularly those originating from news media. The statistics of Wisconsin tornadoes are derived

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from the 1916–64 period, except the tabulation and map of outstanding Wisconsin tornadoes, which spans the century from 1865 to the present. The data in this paper provide seasonal, diurnal and areal probabilities for a variety of applications and research. Following the seven million dollar loss suffered on June 4, 1958, insurance companies exhibited considerable interest in Wisconsin tornado statistics. The State Department of Public Instruction investigated the feasibility of including tornado safety features in planning school construction. South Carolina also investigated this possibility in 1959.[1] The need for adequate preparation in the event of a tornado strike has been demonstrated. The climatological information on tornadoes now available permits intelligent planning for such contingencies.

Obviously some bias exists in tornado records because of the methods of gathering information, the variable density of population, the location of the collection centers, and variable public and professional interests. Classifying these data by categories has not wholly eliminated bias, but it is believed that the longest and most damaging tornadoes are most likely to have been reported. There is evidence that a storm reported as one tornado may have been a complex of two or more tornadoes or have been subject to other human error, thereby producing some variation in tornado statistics.

Sources and Reliability of Data

Wisconsin windfall and tornado tabulations from the beginning of record-keeping in the early 1800's through 1964 were obtained from a number of sources.[2] Windfall record was derived from original public land survey maps and from the notes of the surveyors by Increase A. Lapham.[3] U. S. Signal Corps records were used for the portion of the record from 1840 to 1891.[4] Since 1891 official publications of the Weather Bureau have provided most of the data.[5] Newspaper accounts on file at the Wisconsin Historical Society Library provided supplemental information, particularly about earlier tornadoes.

The tornadoes reported during the early history of the state were mostly the spectacular ones—those with great loss of life and property. Examination of the written record of what has been called the earliest recorded tornado in Wisconsin, August 20, 1843, clearly describes a water spout. This phenomenon occurred 12 miles south of Kenosha over Lake Michigan; its formation and dissipation were witnessed by scores of people and vividly described by Lapham.

The range of detail used to describe earlier tornadoes appears in the following two examples:

> May 31, 1851. "Near the second of the Four Lakes in Dane County, six miles from Madison, the Capitol of the State of Wisconsin, was seen a dark column of leaves and branches whirling around with great rapidity, extending far above the forest trees, which bent and swayed before it like reeds. The noise and confusion defied all description; a tract of more than 100 acres was stripped bare of trees, all blown down, torn up by their roots, or twisted into fragments; the ground looking as if it had been harrowed. It took a direction nearly from the west, destroying everything in its way.
>
> Another tornado passed on the same day, from near the farm of Abel Nutting in Farmington, Jefferson County, where two clouds came in contact, through portions of the towns of Concord, Ixonia and Oconomowoc, where it swept over LaBelle Lake assuming many of the characteristics of a water spout. Houses were unroofed and trees blown down for many miles in extent, and over a breadth of from 80 to 100 rods. Among the incidents that happened, was that a girl 13 years of age was lifted up, clinging to a feather bed, over the top of the trees and landed without injury—thus, literally riding upon the whirlwind."[6]

The opposite to this is contained in a comment. "October 15, 1870. A tornado occurring in the city of Milwaukee was not considered enough of a news event to make the local paper."[7]

The increase in the number of reported tornadoes in the 1870's was due to the efforts of the Signal Corps; increases are also noted in 1916 when the Weather Bureau strengthened their tornado observing network and in the early 1950's when the public became concerned with tornado forecasting. We can assume we have record for only a small percentage of the state's tornadoes prior to 1870, all notable tornadoes from 1870 to 1916, probably most of the tornadoes from 1916 to 1953, and nearly all tornadoes from 1952 to date.

There is no question that some tornadoes have been omitted or improperly classified. Tornadoes with long paths or with skipping paths suggest a complex of tornadoes generated at intervals by a parent storm. However, original records were not revised unless evidence strongly indicated that a change was in order.

The large increase in the number of tornadoes reported in recent years can be attributed primarily to the expansion of the Weather Bureau's storm reporting networks, the increase in the number of storm detection and radar tracking stations, and the new public awareness of possible danger through the issuance of tornado forecasts for specific areas and particular time periods. Wider distribution of public information materials on tornado warning procedures have also contributed to the recent increase in the detection and reporting of tornadoes. One of the recent problems is the tendency to call all severe storms tornadoes. Investigations of damage sometimes show that reported tornadoes were locally severe thunderstorms with straight line winds.

The dollar value of storm damage can be useful in computing insurance rates, but was not used in this paper to obtain totals over a period of time as it is considered to be a misleading statistic. Estimates on actual loss have often been found erroneous, and changing property values and inflation casts doubt on computed dollar values.

Although there are shortcomings and omissions in the data presented, these records are the best presently available and have been carefully evaluated by meteorologists throughout the years.

WINDFALLS

The earliest comprehensive study on Wisconsin tornadoes was made by Increase A. Lapham in the 1850's and 1860's. He summarized his findings in a letter written to General A. J. Myer, Chief Signal Officer in May 1872. In addition to data on observed tornadoes, Lapham went to public surveys for information. The maps he examined were original surveys made between 1834 and 1865.

Early public land surveyors were required to record all windfalls crossing township and section lines. Windfalls were defined as "the tracks of tornadoes through forests as shown by the prostrated and confused masses of timber." Undoubtedly some of the entries were the result of straight line winds and not tornadoes, although examination of the maps indicate that many of the windfalls could only have been caused by tornadoes. In either case, winds were strong enough to blow down strips of virgin timber. These old surveys give us a record of severe wind storms that passed over the forested areas of the state within the time it took blown down trees to decay; few traces were left on open or prairie country in their natural condition.

Lapham prepared eighty pages of diagrams giving the exact location, length and width of each of the 360 windfalls recorded. Many of the storm tracks were so short that their direction cannot be accurately determined, although fifty-three paths were long enough to indicate the movement of the storm. The average direction from which these destructive winds blew was 254°, or about west–southwest. Lapham found that two tracks traveled directly from the south, seven from between south and southwest, twenty-nine from between southwest and west, thirteen between west and northwest, one from north–northwest and one from north. Approximately two-thirds of the windfalls were less than one mile long with only a few exceeding two to three miles. The width of the tracks ranged from a few rods to a mile or more, and averaged less than a quarter mile. Several severe storms, apparently not tornadoes, covered many square miles.

A windfall in the northeastern part of the state was over twenty-two miles long, occurring between the time the township lines were surveyed in 1857 and the section lines in 1865. Another windfall extended from township 32N, range 6W to 38N, range 2W, touching down six times and devastating thirty-three miles of timber over a distance of fifty-five miles; parallel to this track and at a distance of eight miles away a second tornado of apparently even greater force touched down four or possibly five times.

Several of Lapham's interesting interpretations of the data are:

> "That two or more tornadoes may be united with one,[8] and pursue a course in a direction intermediate between that of each, is well established by these surveys . . . . . a case in township 35N, range 14E, where four tornadoes are united, each apparently modifying the general direction of the track and increasing in breadth. There are perhaps 20 other cases where tracks are thus united."
>
> "There are also a few cases where tracks became divided, and two tornadoes continue their separate mark of destruction; and some, after thus separating, became united leaving a kind of island of standing timber amidst an expanse of prostrate trunks."
>
> "We may suppose that the tornadoes causing the windfalls represented on the map occurred within a period of about ten years; and that therefore, there are about thirty-six cases annually when the wind blows in some part of the state with sufficient force to prostrate trees. Of these, perhaps not more than twenty are of sufficient magnitude and extent to cause considerable damage. Now, if these are compared with the 200,000 quarter sections in the state, it will be seen that there is about one chance in probability in 10,000 that any particular farm of 160 acres (in any year) will be visited by such a calamity."

Tornado Characteristics and Statistics in Wisconsin

The causes for the formation of tornadoes is only generally understood. They often develop southeast of a deep low centered in the central or north central states; they may appear in any section of the low and be associated with fronts, instability lines, troughs and have even formed within high pressure ridges. Their highly localized nature and random distribution make it impossible to forecast the spot they will strike with our present knowledge. The best meteorologists are able to do is to forecast an area in which they are likely to develop.

Wisconsin lies to the northeast of the principal tornado belt in this country. In comparison with other states it ranks seventeenth in number of days with tornadoes and eighteenth in number of tornadoes. Table 1 lists 102 tornadoes from the beginning of record

TABLE 1. LIST OF REPORTED TORNADOES FROM BEGINNING OF RECORD THROUGH 1964

Place: County	Place: Town	Date	Time	Direction of Advance	Length of Path, Miles	Width of Path, Yards	Number of Persons: Killed	Number of Persons: Injured	Estimated Damage: Property (exclusive of Crops)*	Estimated Damage: Crops*
Fond du Lac		1844 28 Aug.	3 PM	NNE		330				
Milwaukee		1848 4 June	4 PM							
Ozaukee	Saukville	1850 30 July								
Waukesha, Jefferson	Through portions of Concord, Ixonia, Oconomowoc	1851 31 May		NE		500				
Dane	South of Madison	1851 31 May		E						
Monroe		1852 16 Aug.								
Waukesha		1853 3 July	3 PM	NE		550				
Monroe		1853 23 July								
Columbia, Sauk		1857 21 Aug.	6 PM	ESE						
Dodge		1860 22 Aug.		E						
Winnebago	Oshkosh	1861 8 July	2 AM							
Juneau	New Lisbon	1863 11 Aug.	Early morning	NE						
Portage		1863 21 Aug.	9 PM	SE						
Vernon		1864 17 June	Afternoon	NE						
Vernon	West of Viroqua to Hillsboro	1865 28 June	4 PM	NE	40	160	24	100	200, 000	
, Milwaukee	Milwaukee	1870 15 Oct.	3:30 PM							
Crawford		1872 Oct.				220				
Vernon		1875								
La Crosse		1875	7:40 PM	SE		200				
Grant	Hazel Green	1876 10 Mar.	4:30 PM	E	5	170–220	9	15	46, 000	
Waushara	Wautoma	1877 5 July								

TABLE 1. LIST OF REPORTED TORNADOES FROM BEGINNING OF RECORD THROUGH 1964—Continued

Place		Date	Time	Direction of Advance	Length of Path, Miles	Width of Path, Yards	Number of Persons		Estimated Damage	
County	Town						Killed	Injured	Property (exclusive of Crops)*	Crops*
Oconto	Pensaukee	1877 7 July	6–7 PM	SE	6	330	8	30	300, 000	
Iowa, Dane, Waukesha, Jefferson, Milwaukee	10 miles west of Mineral Point to Milwaukee	1878 23 May	3:00 PM	NE	150	220–330	At least 19	45 or more	130, 980	
Rock	Beloit	1880 18 April	5 PM	NE		160–2300	several		75, 000	
Monroe		1880 11 June	Afternoon	NE						
Wood		1880 20 Sep.	9:30 PM	NE						
Waushara	Wautoma	1881 29 Sep.	5 PM	NE		400–660				
Buffalo	Mondovi	1881 29 Sep.	Afternoon	NE			12			
Waupaca		1881 29 Sep.	2 PM	NE						
Sauk		1882 June	Afternoon	NE						
Rock		1883 9 May	4 PM	NE		220				
Rock		1883 18 May	4:15 PM	E		110				
Racine		1883 18 May	7 PM	NE	3	220	25	100	200, 000	
Waukesha		1883 25 May	Afternoon							
Rock		1883 11 June	5:50 PM	SE						
Green Lake		1883 11 June	4:45 PM	NE						
Sauk, Columbia		1883 10 July	Noon	S						
Jefferson, Waukesha		1883 16 July	1:20 PM	N		220				
Clark, Wood		1883 21 Aug.	Noon	E						
Wood		1883 21 Aug.	1:30 PM	NE		10–120				
Trempealeau		1883 8 Oct.	Noon	NE		660				
Crawford		1883 25 Nov.	9 PM	NE						

TABLE 1. LIST OF REPORTED TORNADOES FROM BEGINNING OF RECORD THROUGH 1964—Continued

Place		Date	Time	Direction of Advance	Length of Path, Miles	Width of Path, Yards	Number of Persons		Estimated Damage	
County	Town						Killed	Injured	Property (exclusive of Crops)*	Crops*
Trempealeau		1884 22 July	12:30 PM	ENE						
Ashland		1884 22 July	1 PM	NE						
Dunn		1884 25 July	2:40 PM	ESE						
Shawano		1884 29 July	4 PM	ENE						
Richland, Sauk, Columbia		1884 2 Aug.	5 PM	N		110–440		2	150, 000	
Buffalo		1884 22 Aug.	4:30 PM	N		75				
Crawford, Grant		1884 22 Aug.	6:20 PM	SE		55–440		Several		
St. Croix, Barron, Chippewa, Price, Polk		1884 9 Sep.	5 PM	NNE	120	880	6	75	4, 000, 000	
Vernon		1885 7 June	1 PM	NNE						
Waupaca		1885 8 July	8 PM	NE						
Winnebago		1885 8 July	8 PM	NE						
Dane	Madison	1885 8 July	9 PM	SE		880				
Fond du Lac		1885 3 Aug.	3:35 PM	ENE		70				
Marathon		1886 21 June	Afternoon	NE		Narrow				
Rock		1886 6 Aug.	Afternoon							
Polk		1887 1 May	6 PM	NE		Narrow				
Clark		1887 1 May	9 PM	NE		Narrow				
Dunn		1887 6 July	5 PM	NE		330–1300				
Clark		1887 16 July	2 PM	NE		1000				
Waupaca		1887 16 July	5 PM	NE		Narrow				
Walworth		1887 10 Aug.	Afternoon	E		Narrow				

Table 1. List of Reported Tornadoes From Beginning of Record Through 1964—Continued

Place		Date	Time	Direction of Advance	Length of Path, Miles	Width of Path, Yards	Number of Persons		Estimated Damage	
County	Town						Killed	Injured	Property (exclusive of Crops)*	Crops*
Richland		1887 11 Aug.	4 PM	NE						
Green		1888 4 May	4 PM	NE						
Crawford		1888 12 May	5 PM	SE						
Eau Claire		1888 11 June	3:30 PM	NE		440				
Winnebago		1888 18 June	11 PM	E						
Walworth		1888 19 June	3:30 PM	NE		Narrow				
Green		1888 3 July	7 PM	NE		220				
Washington		1888 4 July	4 PM	NE		270				
Kewaunee		1888 1 July	4 PM	NE		880				
Trempealeau		1888 28 July	6 PM	E		Narrow				
Dunn		1888 30 July	10:20 AM	NE		100				
Trempealeau		1888 1 Aug.	11 PM	E						
Trempealeau		1888 4 Aug.	9:40 PM	E						
Dunn		1888 16 Sep.	6 PM	E		Narrow				
Waukesha	Ottawa	1890 30 May	3 PM							
Milwaukee	Milwaukee	1891 14 June	2:51 PM						4, 000	
Grant	Near Livingston	1892 4 April	2:50 PM						Light	
Lafayette	Darlington	1893 22 May	5 PM	NE			2			
Iowa	Moscow	1893 22 May	5:03 PM				3		3, 500	
Clark	Humbird	1895 2 May						3	300	
Winnebago	Near Oshkosh	1896 8 June							One barn	

TABLE 1. LIST OF REPORTED TORNADOES FROM BEGINNING OF RECORD THROUGH 1964—Continued

Place		Date	Time	Direction of Advance	Length of Path, Miles	Width of Path, Yards	Number of Persons		Estimated Damage	
County	Town						Killed	Injured	Property (exclusive of Crops)*	Crops*
Polk	Clayton	1896 24 June	6:30 PM					2	6 houses, a few barns	
Eau Claire, Clark, Marathon, Lincoln, Langlade	Abbotsford, Antigo	1898 18 May	4 PM-6:40 PM	NE	110		17	100	710, 000	
Dane	Began SW of Madison	1898 18 May	6 PM	NE					10, 000	
Price, Oneida		1898 18 May	6:30 PM	NE	50	100	7	15	200, 000	
St. Croix, Polk, Barron	"New Richmond Tornado"	1899 12 June	6:30 PM	NE	45	100	117	125	600, 000	
Sheboygan		1900 20 Aug.	12:45 PM						25, 000	
Portage	Almond	1903 3 Oct.		NE		80	Several			
Vernon, La Crosse		1906 6 June		NE	20	400	4	18	70, 000	
Clark, Jackson, Juneau		1907 3 July	4:45-6:30 PM	SE	95	80	26		100, 000	
Green Lake, Winnebago		1907 3 July	6:30 PM	E	8		2			
Vernon to Juneau		1908 7 June	3:30 PM	NE	17	35	2			
Portage	"Stevens Point Tornado"	1908 25 Nov.	7 PM	NE	12	10–100	1	2	100, 000	
Wood	Rudolph	1908 25 Nov.	6:30 PM	NNE	7		1	6		
Rock		1911 11 Nov.	2 PM	NE	30		9	10	500, 000	
Vernon, Crawford, Juneau	"Soldiers Grove Tornado"	1913 10 Oct.	1:30 PM				4	27	250, 000	
Rock		1913 10 Oct.	4:20 PM					6		
Crawford	"Lansing–Ferryville Tornado"	1915 12 June	5:30 PM	NE	20	120–400	7	25	100, 000	
Sauk		1915 12 June	6:30 PM	NE	10	60	1	15	50, 000	
Dane	Near Mazomanie	1916 1 June	9 PM	NE	5–6	440			20, 000	
(None Reported)		1917								
Rusk, Price	Ladysmith to near Phillips	1918 19 May	1–4 AM	NE	40	67–100	1	2	50, 000	

TABLE 1. LIST OF REPORTED TORNADOES FROM BEGINNING OF RECORD THROUGH 1964—Continued

Place		Date	Time	Direction of Advance	Length of Path, Miles	Width of Path, Yards	Number of Persons		Estimated Damage	
County	Town						Killed	Injured	Property (exclusive of Crops)*	Crops*
Grant, Iowa, Richland, Sauk	1 mi. S of Glenhaven to 6 mi. N of Lancaster to Lone Rock to Baraboo	21 May	6:30 PM to later than 8 PM	NE	85	67–433	8	100	650, 000	
Wood, Portage	NE Wood County, NW Portage County	26 June	8–8:30 PM	E	few miles	50–67	0	1	15, 000	
Sauk	2 mi. NE of Ableman	1919 20 Aug.		NE	Short	200			500	
Walworth	Eastern Walworth County	1920 28 Mar.	12:30	N			1		25, 000	
		1921		NNE					60, 000 (incl. crops)	
Outagamie, Shawano	SE Shawano	20 June								
Dane	Near Madison	19 Aug. 1922	4:15 PM				2		620, 000	
Pierce	Trim Belle	3 May	Night	NE					10, 000	
St. Croix	From Roberts to intersection of Polk, Dunn, Barron, St. Croix cos. to near Chetek	15 June	7–9 PM	ENE	50	Few rods to 2 mi.	8	More than 100	500, 000	
Langlade (None reported)	W of Antigo	16 June 1923 1924	2:30 PM	NE	2	50–100	0		50, 000	
Racine	Center of Racine Co.	20 June	7:30 AM	ENE	30	300–3520	0	12	500, 000	
Trempealeau, Jackson	Osseo to Black River Falls	7 Aug.	6:30 PM	SE	27	334–1760	4	} 100	200, 000	
Barron, Chippewa	Dovre Township thru Chippewa Co.	7 Aug.	7 PM	SE	15	330	3		100, 000	
Barron, Rusk, Sawyer, Bayfield, Ashland	Chetek, Barron Co. to Marengo, Ashland Co.	21 Sept.	2–5:30 PM	NNE	90	67–880	10	50	250, 000	
Oneida	Minocqua	21 Sept.	4 PM						None reported	
Eau Claire, Clark, Marathon, Taylor, Lincoln, Oneida	Augusta, Eau Claire to near Three Lakes, Oneida Co.	21 Sept.	2:20-4:30 PM	ENE	120	67–880	26	114	564, 000	
Langlade	Antigo	21 Sept. 1925	Afternoon		Short				4, 000	
Calumet	Near center of county	11 April	12:30 AM	SW	Short	Up to 880	0	0	4, 000	
Clark	SW corner of Clark Co.	2 June	10:30 PM	NE	20	100	0	0	30, 000	
Florence	Brule	3 June	1 AM				2		2, 500	
Juneau	SW Juneau County	13 June 1926	5:45 PM		Short	20–25			30, 000	
Bayfield, Ashland, Iron, Vilas	20 mi. NW of Ashland Jct. to 4 mi. S of Winchester	16 July	6:15-7:45 PM	ESE	85	100–440	3	16	90, 000	
Sauk	3 mi. S of Wonewoc	20 Aug. 1927	12 PM	NE	½	167	0	1	1, 000	

TABLE 1. LIST OF REPORTED TORNADOES FROM BEGINNING OF RECORD THROUGH 1964—Continued

Place: County	Place: Town	Date	Time	Direction of Advance	Length of Path, Miles	Width of Path, Yards	Number of Persons: Killed	Number of Persons: Injured	Estimated Damage: Property (exclusive of Crops)*	Estimated Damage: Crops*
St. Croix, Pierce, Dunn	N Pierce to W Dunn	12 July	Evening						20, 000	
Ashland	N of Morse	30 Oct.	4:30 PM		Short	880	0	0	1, 200	
		1928								
Pierce	W and N central Pierce Co.	20 June	1:30-2:00 PM	NE	4	110	0	0	35, 000	
Polk	Dresser Jct.	2 July	12:30 AM	ENE	6		0	0	60, 000	
Barron	Prairie Farm	2 July	1:30 AM				0	0	50, 000	
Trempealeau	Blair	2 July	2:00 AM				0	0	25, 000	
La Crosse	New Amsterdam to near West Salem	20 Aug.	6:00 PM	SE	20	100–1760	0	Few	60, 000	
Rock	Magnolia	14 Sept.	3 PM		1	440	0		30, 000	
Dane	Riley, Verona	14 Sept.	3 PM		15	Few rods–880	0	13+	100, 000	
Waupaca	Scandinavia to Marion	14 Sept.	3:30 PM	NE	20	55–110	0		27, 500	
		1929								
Polk	10 mi. SW of Balsam Lake to 5 mi. N of Balsam Lake	5 April	6-6:30 PM	NE	15	440	0	0	10, 000	
Pierce to Iron	SW River Falls to Van Buskirk	5 Apr.	5:45-8:30 PM	NE	170	30–400	12	100	725, 000	
Grant to Green	Cuba City to N of Monticello	6 April	4:30-6:30	ENE	45	30–330	0	25	250, 000	
Rusk	Ladysmith	10 June	7:15 PM	SE	11	150	0	5	150, 000	
Oneida	Minocqua	10 June	7:30 PM	SE		35–200			100, 000	
Sawyer	8 mi. NW Stone Lake, Washburn Co.	29 June	8 PM	SSE	14	Few rods	0	1	12, 000	
		1930								
Vernon	N Vernon Co.	1 May	7:30 PM	E	5	70	1		100,000	
Trempealeau, Monroe, La Crosse	S. Trempealeau, across N La Crosse Co.	1 May	7:30-8 PM	E	33	500	1		202, 000	
Kewaunee		1 May	10:30 PM	NE	5	440	0		60, 000	
Walworth, Racine, Milwaukee	Angled across Racine, Milwaukee Co. line	1 May	11:00 PM	NE	40	500	0		30, 000	
Lincoln	N Lincoln Co.	3 June	2:15 PM	NE	3	Narrow	0	0	900	
Price	N Central Price Co.	12 June	6:45 PM	NE	2	20	0	0	5, 000	
Trempealeau, Jackson, Clark, Marathon, Lincoln	W Trempealeau, N Jackson, E Clark, NW Marathon	13 June	5:30-7:30 PM	NE	80	1, 300	0	0	600, 000	
Pierce, Dunn, Eau Claire, Chippewa, Clark	Cent. Pierce, S Dunn, NW Eau Claire, S Chippewa	13 June	5:30-8:00 PM	E	125	1, 000	6	80	1, 000, 000	
Dunn	Parallel to above tornado on left	13 June	6:30 PM	E		90	0	0	125, 000	
Eau Claire	Parallel to above tornado on right	13 June	7 PM	E	16		0	0	25, 000	
Portage	Near Darcy	20 July	4:30 PM	E	10	880	0	0	15, 500	

TABLE 1. LIST OF REPORTED TORNADOES FROM BEGINNING OF RECORD THROUGH 1964—Continued

Place: County	Place: Town	Date	Time	Direction of Advance	Length of Path, Miles	Width of Path, Yards	Number of Persons: Killed	Number of Persons: Injured	Estimated Damage: Property (exclusive of Crops)*	Estimated Damage: Crops*
Portage	Coddington	27 July	1:30 AM	SE	3	880	0	0	10,000	
		1931								
Dane	Madison NE	6 May	5 PM		<1	50	0	0	100	
Rusk	Near Tony	1 July	Afternoon		<1	Narrow	0	0	8,000	
Lafayette	Darling and vicinity	1 July	5:30 PM	NE	7	880	0	0	25,000	
Rock, Jefferson, Waukesha	Near Oxfordville to Oconomowoc	21 Sept.	7:30-9:00 PM	NE	50	200	1	9	300,000	
		1932								
Manitowoc	Kiel	19 Sept.	7 PM	NE		440	0	0	2,000	
		1933								
Pepin	Durand	30 April	3 PM	S	2	100	0	0	5,000	
Wood	10 mi. SW Wis. Rapids to Rudolph	23 May	3:30 PM	NNE	15	100	0	1	75,000	
Green Lake	N of Marquette to Kingston then SE of Manchester	5 June	5:15 PM	SSE	10	150	1	4	100,000	5,000
Sauk	Reedsburg	1 July	7:30 PM	SE		250	0	0	5,000	
Polk	Clear Lake	10 Aug.	4:45 PM	ENE	12	50	0	0		
Polk	Clear Lake	10 Aug.	4:45 PM	ENE	20		1	4	25,000	
Dane	3½ mi. W of Cambridge	26 Sept.	Midnight		1	Narrow	0	0	5,000	
		1934								
Dane	Cottage Grove	17 Mar.	2:45 AM	S	Short	60	0	0	1,300	
Walworth	East Troy	21 May	3 PM		1½		0	0	10,000	
Dodge	Reeseville	8 June	2:30		2	220	0	0	4,000	
Green	Brodhead	20 June	5:45 PM		3	330	0	0	10,000	
Adams	Briggsville	25 June	11:30 PM		1½	880	0	0	3,000	
Waupaca	Manawa	30 June	3 PM				0	0	7,000	
Calumet, Manitowoc	NE Potter to SE Reedsville	12 July	8:00 PM	E			0	0	None	
Polk	E of Milltown	5 Oct.			5	35	0	3	10,000	
		1935								
Vernon	3 mi. W of Viroqua	26 April	Afternoon		Short	Narrow	0	0	300	
Eau Claire, Clark	Fairchild	5 July	5:45 PM	E	3	33–167	0	0	12,000	
Marathon	Wausau	5 July	7:15 PM	ENE	25	100–167	0	0	125,000	
Langlade	Phlox	11 July	5:30 PM	E		880	0	1	10,000	
Langlade	Near Neva	17 Sept.				33	0	0	1,000	
Polk	6 mi. NE of Amery	16 Oct.	5:30 PM		1/5	67	0	0	4,000	
Polk	3 mi. SE or Amery	16 Oct.			Short	Narrow	0	0	500	
		1936								
Trempealeau	N Trempealeau Co.	16 May	Mid-night	NE	6	275	0	0	30,000	
Lincoln	Tomahawk	11 July	4:30 PM	E	1	1,320	0	0	5,000	
Washington	West Bend	22 Aug.	12:20 AM	NE	3	140	0	0	300	
		1937								
Lafayette	S Cent. Lafayette Co.	25 June	3:30 PM	SSE	8	100	0	0	10,000	

TABLE 1. LIST OF REPORTED TORNADOES FROM BEGINNING OF RECORD THROUGH 1964—Continued

Place: County	Place: Town	Date	Time	Direction of Advance	Length of Path, Miles	Width of Path, Yards	Number of Persons: Killed	Number of Persons: Injured	Estimated Damage: Property (exclusive of Crops)*	Estimated Damage: Crops*
		1938								
Langlade	W of Antigo	3 May	3:30 PM	E	2	35	0	2	10, 000	
Juneau	6 mi. NW of Wis. Dells	23 Aug.	1:00 PM	NE	3	100	0	0	5, 000	
(None reported)		1939								
		1940								
Vilas	Land O'Lakes	17 June	4:15 PM	E	5½	100	1	4	2, 500	
Oneida	Lake Tomahawk	17 June	4:30 PM	E	2	125	1	3	5, 000	
		1941								
Langlade	Deerbrook	13 April	4:00 PM	E	6	160	0	0	12, 000	
Portage	Plover	14 April	2:00 PM	NE	2		0	0	4, 000	
Rock	S Footville to Leyden	19 April	8:30 PM	NE	6	100	0	0	10, 000	
Grant	Cassville	3 Sept.	6:00 PM	NE		100	0	2	1, 000	
		1942								
Chippewa	Edson to SE of Thorp	4 April	5:00 PM	E	18	70	0	0	60, 000	
Polk	10–12 mi. SWbf Deronda to Deronda	13 May	3:00 PM	NE	12	30	0	2	50, 000	
Jackson, Clark	Black River Falls to Loyal, Clark Co.	13 May	3:00 PM	NW	35	100	1	1	100, 000	
Langlade	Antigo	13 May	3:45 PM	NE	10		0	0	15, 000	
Douglas	Hawthorne	11 June	Afternoon				0	0	500	
Winnebago	Waukau	28 July	4:00 PM	E	1½		0	1	10, 000	
Waushara	Hancock	28 July	4:00 PM	NE		30	0	0	3, 000	200
Chippewa	Stanley	16 Sept.	6:00 PM	NE	1½	50	0	0	Minor	
Chippewa	SE Chippewa Co.	17 Sept.	11:30 PM	E	1½	100	0	0	20, 000	
(None reported)		1943								
		1944								
Manitowoc	Two Rivers	4 June	4 PM	NE		67	0	0	600	
Portage		18 June	3:50 PM	ESE	12	55–1, 320	0	3	100, 000	5, 000
Lafayette	Belmont—crossed to Illinois	22 June	6:30-8:00 PM	SE	36	200–1, 760	7	65	1, 000, 000	25, 000
Wood	SE Wood Co.	22 June	9:30 PM	E	20	880	0	0	15, 000	25, 000
Dane	7 mi. NNE of Madison	23 July	5-5:15 PM	E	1½	67	0	1	15, 000	5, 000
		1945								
Taylor	S Taylor Co.	27 Mar.	7:30 PM	E	1		0	1	6, 000	
Langlade		11 April	3:20 PM	ENE	10	1, 760	1	0	100, 000	1, 000
Waushara	NW Waushara Co.	21 May	7:00 PM	NE	6	220	0	0	7, 000	
Wood, Portage	Sigel to southern Stevens Point	19 Sept.	3-3:45 PM	E	25	200	0	2	25, 000	
		1946								
Sauk	Lake Delton and vicinity	22 Sept.	5:55-6:10 PM	NE	Short	27	0	0	10, 000	
(None reported)		1947								

TABLE 1. LIST OF REPORTED TORNADOES FROM BEGINNING OF RECORD THROUGH 1964—Continued

Place: County	Place: Town	Date	Time	Direction of Advance	Length of Path, Miles	Width of Path, Yards	Number of Persons: Killed	Number of Persons: Injured	Estimated Damage: Property (exclusive of Crops)*	Estimated Damage: Crops*
		1948								
Grant	Near Lancaster	29 July	5:15 PM	NE		Narrow	1	1	25, 400	
Iowa	Near Linden	29 July	5:25 PM	NE	1	333	0	0	10, 000	1, 100
Dane	Near Springfield Corner	29 July	6:00 PM	NE	2	133	1	11	20, 850	650
La Crosse		29 July	6:30 PM	NE		5	0	0	500	
		1949								
Polk	Near Amery	17 May	2:30 PM	NE	8	50	0	0	Minor	
Winnebago	Near Omro	19 May	4:03 PM	NE	Short	70	0	0	5, 000	
Lincoln	N of Tomahawk	18 July	Afternoon	ENE	15	300	0	0	No estimate	
Oneida	Clearwater	27 July	Afternoon	NE	Short	Narrow	0	0	Minor	
		1950								
Rusk	Ladysmith	25 June	7:20 PM	ENE	Short	Narrow	0	0	50, 000	
Price	Near Prentice	25 June	8:20 PM	ENE	1	Narrow	0	0	54, 000	
Oneida	SW Rhinelander	25 June	9:00 PM	NE	12	500	2	50	500, 000	
Clark	Near Unity	25 June	Night	NE	Short	Narrow	1	0	25, 000	
Green Lake	Berlin	25 June	11:30 PM	E	1	300	0	0	100, 000	
		1951								
Dodge	Near Brownsville	19 June	8:30 PM	NE	1	500	0	0	25, 000	Minor
Richland	Near Cazenovia	3 July	8:00 PM	NE	½	50	0	0	10, 000	
Pepin, Dunn	Greatest destruction 6 mi. E of Menomonie	12 Sept.	11:30 AM	NE	30	200	0	2	127, 000	Minor
Waupaca	Most destruction 3 mi. N of Waupaca	26 Sept.	3:50 AM	NE	20	100	6	3	250, 000	Minor
Columbia	Near Cambria	26 Sept.	4:30 PM	NE	10	100	1	10	225, 000	Minor
		1952								
Polk	Centuria	23 June	9:15 PM	NE	15	100	2	6	250, 000	
		1953								
Pierce, St. Croix, Polk, Burnett, Washburn, Douglas	First observed at River Falls, Pierce Co.	10 May	6:30-8 PM	NNE	100	100	4	27	1, 000, 000	Minor
Buffalo, Trempealeau, Eau Claire, Chippewa, Taylor, Price	Crossed River from Minn. into Buffalo Co.	10 May	6:30-8 PM	NE	100	100	0	10	1, 000, 000	
Oneida	Near Three Lakes	20 June	PM		Short		0	0	30, 000	
		1954								
Iowa	6 mi. N of Highland to 3 mi. SE of Avoca	7 April	5:45 PM	NE	6–8	400	0	4	60, 000	300
Waukesha	Oconomowoc	7 April	1:15 PM	NE			0	0	50, 000	
Fond du Lac	Mt. Calvary	7 April	Late AM-PM	E			0	0	30, 000	
Waushara	Neshkoro, Lohrville, Redgranite	15 April	3 PM	NE			0	0	10, 000	

TABLE 1. LIST OF REPORTED TORNADOES FROM BEGINNING OF RECORD THROUGH 1964—Continued

Place: County	Place: Town	Date	Time	Direction of Advance	Length of Path, Miles	Width of Path, Yards	Number of Persons: Killed	Number of Persons: Injured	Estimated Damage: Property (exclusive of Crops)*	Estimated Damage: Crops*
La Crosse, Trempealeau	At Camp Dekorah between Holman and Galesville	26 April	3:35 PM	N			0	0	600	
Grant	N of Andover	26 April	4 PM				0	0	Losses not reported	
Jackson	Hixton	18 June	6:30 PM	ESE	10	900	0	0	100,000 Includes Crops	
Marathon	Near Mosinee	20 June	2:40 AM	E			0	0	Losses not reported	
Calumet	Near Brothertown	20 June	AM				0	0	Losses not reported	
Pierce	Herbert (8 mi. SE Ellsworth)	29 June	3:30 PM	NE	6	....	0	0	5,000 Includes Crops	
Columbia	Lodi and Vicinity	30 July	7 PM	ESE	8	200	0	0	80,000 Includes Crops	
St. Croix	New Richmond and Vicinity	15 Aug.	6 PM	E	6		0	0	70,000 Includes Crops	
		1955								
Crawford	Near Prairie du Chien to near Lynxville	18 April	1 AM	NNE			0	0	25,000	
Iowa	Dodgeville, Ridgeway, Barneveld	18 April	4 PM	E	13		0	0	Losses not reported	
Dane	Belleville and Vicinity	18 April	5 PM	ESE			0	0	250,000	
Walworth	Heart Prairie and Vicinity	18 April	7 PM	E	4		0	1	Losses not reported	
Lincoln	Irma	3 May	6 PM	ENE	8		0	2	20,000	
Rock	7 mi. NW of Janesville	28 May	1:15 PM	E	4	100	0	0	20,000	Losses not reported
Waupaca	3 mi. W of Clintonville	28 May	3 PM	N	3	75	0	4	20,000	Losses not reported
Pierce	Elmwood	22 July	2 PM	NE	2	220	0	0	1,000	Minor
Manitowoc	Newton	31 July	5:10 PM	SSE			0	0	50,000	25,000
		1956								
Iowa	5 mi. NE of Highland	3 April	11:00 AM	NE	4	200	0	0	100,000	
Portage	From Bancroft to near Amherst	3 April	12:50 PM	NE	18	100	2	7	180,000	
Green Lake, Winnebago	Berlin and Northeastward	3 April	2:05 PM	NE	12	400	7	50	1,000,000	
Door	Brussels	1 July	12:00 PM	NE			0	0	100,000	10,000

TABLE 1. LIST OF REPORTED TORNADOES FROM BEGINNING OF RECORD THROUGH 1964—Continued

Place: County	Place: Town	Date	Time	Direction of Advance	Length of Path, Miles	Width of Path, Yards	Number of Persons: Killed	Number of Persons: Injured	Estimated Damage: Property (exclusive of Crops)*	Estimated Damage: Crops*
Waukesha	Big Bend and Muskego areas	16 July	12:30 PM	E	3	30	0	0		1,000
Dodge	W of Beaver Dam	21 July	4 PM	E			0	0		
		1957								
La Crosse	Holmen	19 April	2:30 PM	NNW	2–3	150	0	0	18,000	
Juneau	Near New Lisbon through Necedah to Refuge N of Necedah	19 April	4 PM	NNE	20	300	1	0	7,500	
Walworth, Racine	Burlington area	19 April	4 PM	NE	6	200	0	2	75,000	
Portage	Coddington and Bancroft	19 April	4:05 PM	NE	5	30	0	0	15,000	
Waushara	Wautoma, Saxeville	19 April	4:15 PM	NE	12	150	0	1	50,000	
Monroe	Kendall	19 April	8:30 PM	NE	8	400	0	0	60,000	
Grant	Bloomington to Fennimore	25 May	4:30 PM	NW to NE	20	40	0	0	20,000	
Florence	Florence	14 June	5:30 PM	NE	7	100	0	0	50,000	
Barron	Brill	4 July	6:30 AM	NE	4	150	0	4	75,000	
Brown	Denmark	11 July	1:30 PM	ENE			0	0	1,000	
Manitowoc	Whitelaw	11 July	2 PM	NE			0	0	2,000	
Vernon	Hillsboro	19 Sept.	12:30 AM	NE	10	165	0	0	50,000	10,000
		1958								
Marinette		17 May	2:20	NE	5	80	0	1	175,000	
St. Croix, Pierce		24 May	2:45 PM	SE	50	50	0	5	385,000	
Lafayette		31 May	2:30 PM	NE	3		0	0	75,000	
St. Croix, Dunn		4 June	5:30 PM	ENE	32	880	19	110	7,000,000	10,000
Chippewa		4 June	6:45 PM	ENE	12	600	4	56	1,000,000	
Rusk		4 June	7:00 PM	ENE	15	200	0	0	7,500	
Chippewa		4 June	7:00 PM	ENE	5	300	0	3	75,000	2,000
Eau Claire, Clark, Marathon		4 June	7:30 PM	ENE	60	880	4	3	750,000	50,000
Chippewa		22 June	1:30 PM	E	440 yd.	25	0	0		1,000
St. Croix		22 June	3:25 PM	E	440 yd.	50	0	0	500	
Lincoln		30 June	5:30 PM	E	2	50	0	0	1,000	
Barron		14 July	1:00 PM	E	1	75	0	0	10,000	
Iron		14 July	2:45 PM	SE	25	250	0	0	75,000	
Milwaukee		7 Aug.	2:47 PM	SE	1	100	0	4	45,000	
Marinette		30 Aug.	5:30 PM	E	1	100	0	0	6,000	
St. Croix		9 Oct.	12:00 PM	NE	8	50	0	0	30,000	1,000
Dane		9 Oct.	4:45 PM	NE			0	0		

TABLE 1. LIST OF REPORTED TORNADOES FROM BEGINNING OF RECORD THROUGH 1964—Continued

Place		Date	Time	Direction of Advance	Length of Path, Miles	Width of Path, Yards	Number of Persons		Estimated Damage	
County	Town						Killed	Injured	Property (exclusive of Crops)*	Crops*
		1959								
Chippewa	10 NE Eau Claire	4 May	9:12 AM		¼		0	0		
Marathon	SW of Wausau	4 May	10:30 AM		1	200	0	0	2	1
Langlade	Deerbrook	4 May	11:05 AM		1	100	0	0	1	
Jackson	1 N Black River Falls	4 May	1:00 PM		1	150	0	0	4	1
Buffalo	Mondovi	5 May	7:00 PM		¼	150	0	0		
Waupaca	Symco to near Clintonville	6 May	3:20 AM		10	1, 000	0	0	5	
Outagamie	3 NE Shiocton	6 May	1:30 PM		3	200	0	0	4	
Columbia	Portage	10 May	7:20 PM	NE	2	200	0	0	3	
Brown	Green Bay	10 May	8:50 PM		6	600	0	3	6	
Grant	SW Lancaster	19 May	5:20 PM	NE	5	200	0	0	4	
						Funnel later sighted near Mt. Horeb, Dane County.				
Trempealeau, Jackson	Trempealeau, Fairchild	26 May	3:45 PM				0	3	5	
Eau Claire										
Rusk	Ladysmith	26 May	3:45 PM				0	0	4	
Sauk	Prairie du Sac	28 May	2:02 PM				0	0	3	
Fond du Lac	5 N Ripon	28 May	3:05				0	0		
		A few small tornadoes touched the ground. Also funnels reported.								
Winnebago	N Oshkosh	28 May	3:15 PM				0	0	3	
Brown	7 S Green Bay	28 May	3:30 PM				0	0	3	
Brown	15 S Green Bay	28 May	3:38 PM				0	0		
Walworth	Whitewater	6 June	3:37 PM				0	0	0	
		Touched down once—no damage.								
Brown	4 E Green Bay	10 June	1:20 PM				0	0	0	
Waukesha	25 WSW Milwaukee	12 June	Mid-night to 1:45 AM		2	1, 000	0	0	3	
Chippewa	12 N Chippewa Falls	26 June	1:20 PM							
Marquette	Harrisville	8 July	Mid-afternoon				0	0	4	
Marinette	Niagara	8 July	4:54 PM		Short		0	3	4	
Outagamie	26 SW Green Bay	28 Aug.	2:04 PM				0	0	2	
Burnett	Grantsburg	6 Sept.	6:24 PM		Short		0	0	0	
Clark	10 SE Stanley	22 Sept.	6:30 PM		½	30	0	0	2	
Milwaukee	Milwaukee	26 Sept.	6:28 PM		4	Narrow	0	3	5	
Racine, Kenosha	Kansasville to Racine	26 Sept.	6:30 PM		15	50	0	0	5	
Waukesha	2 NW Mapleton	8 Oct.	4:00 PM		1	Narrow	0	0	4	
Racine	Near Franksville	8 Oct.	4:48				0	2	4	
		1960								
Sawyer	27 SE Winter	23 April	7:00 PM				0	0	2	
Manitowoc	7 E Chilton	24 April	Late Afternoon		Short		0	0	2	
Sauk	40 NW Madison	21 May	5:10 PM				0	0		
Fond du Lac	20 W Fond du Lac	21 May	5:14 PM	NE			0	0		

TABLE 1. LIST OF REPORTED TORNADOES FROM BEGINNING OF RECORD THROUGH 1964—Continued

Place: County	Place: Town	Date	Time	Direction of Advance	Length of Path, Miles	Width of Path, Yards	Number of Persons: Killed	Number of Persons: Injured	Estimated Damage: Property (exclusive of Crops)*	Estimated Damage: Crops*
Winnebago	5 W Oshkosh	21 May	5:30				0	0		
Trempealeau	Eleva	28 June	3:45		10	60	0	0	3	
Buffalo	Mondovi	28 June	Afternoon	SE	10					
Dodge	3 S Reeseville	8 Aug.	4:00 PM	S	Short	Narrow	0	0	2	
Iowa	15 SE Lone Rock	20 Aug.	4:05 PM				0	0		
		Two tornadoes, briefly touched ground.								
Taylor	3 N Medford	27 Aug.					0	0	Slight	
Monroe	8 N Sparta	28 Aug.	3:30 PM				0	0	4	
Rock	1½ N Union	15 Nov.	Late afternoon		2	Narrow	0	0	2	
Clark	2 NW Chili	15 Nov.	2:25		35	100	0	1	4	
		1961								
La Crosse	La Crosse	14 May	1:50 PM		1	35	0	0	4	
Burnett	Grantsburg	2 Aug.	7:00 PM	Touched momentarily						
Price	Park Falls	14 Aug.	7:50 PM	NE	5	400	0	0	5	4
St. Croix	Glenwood City	2 Sept.	9:30 PM				0	0		
Marathon	Fenwood	3 Sept.	12:10 AM				0	0		
Clark	5 W Thorp	3 Sept.	12:15 AM		3½	5	0	0	4	
Marathon	Athens	3 Sept.	1:00 AM				0	0		
Walworth	1 S Whitewater	22 Sept.	12:00 PM		5	Narrow	0	1	5	4
Fond du Lac	Campbellsport	22 Sept.	1:30 PM		4–5	300	0	0	3	4
		1962								
Fond du Lac	5 NE Ripon	17 June	6:00 PM	NE	1	75	0	0		
Clark	Thorp	23 June	4:40 PM				0	0	2	
Brown	Point Sauble, Green Bay	23 June	4:30 PM				0	0		
Portage	15 E Stevens Point	23 June		Briefly touched ground			0	0		
Milwaukee	West Allis	22 July	12:48 PM			25	0	0	3	
Lincoln	Merrill	24 July	5:00 PM				0	0	3	
Barron, Chippewa	Barron, Rice Lake, Bloomer, Cadott	15 Aug.	3:15 PM	SE		400	0	0	3	3
		Touched at Barron 8 NW at 3:15; at Rice Lake 12 SW at 3:30; Bloomer 14 NE at 5:00 PM; and Cadott shortly after 5:00 PM.								
Milwaukee	Greendale	4 Oct.	3:20 PM	NE			0	0	Minor	
Jackson	18 SE Neillsville	10 Oct.	8:30 AM		3	400	0	0	3	
		1963								
Dodge	Hustisford	8 June	7:15 PM	SE thne E	Short	30	0	0	5	
Dodge	Lomira	13 June	4:55	SE	Touched briefly.		0	0	2	
Kenosha	Near State Hwy 50 and County "B"	19 July	4-5 PM	S	8	30	0	0	4	4
Columbia	Prairie du Sac, Lodi	16 Aug.	7:15 PM	E	6	Narrow	0	13	5	4

TABLE 1. LIST OF REPORTED TORNADOES FROM BEGINNING OF RECORD THROUGH 1964—Continued

Place: County	Place: Town	Date	Time	Direction of Advance	Length of Path, Miles	Width of Path, Yards	Number of Persons: Killed	Number of Persons: Injured	Estimated Damage: Property (exclusive of Crops)*	Estimated Damage: Crops*
Lafayette and Green	Lamont to 3 E Argyle	2 Sept.	5-6 PM		10	Narrow	0	0	5	
Dane		2 Sept.	6:30 PM			Narrow	0	0		
		Touched down in rural Mazomanie; rural Waunakee and rural Sun Prairie.								
Marquette	Buffalo	2 Sept.	6:30 PM				0	0	3	
Forest	Laona	19 Sept.	6:00 PM		½	Narrow	0	0	4	
		1964								
Jackson	2 SE Melrose	4 May	5:00 PM	NE	9	200	0	1	5	
Crawford	Lynxville to Rising Sun	4 May	8:00-8:45 PM	NE	25	200	0	2	5	
Juneau	Fountain and Orange	4 May	8:00-8:20 PM	NE	6	100	0	0	4	
Oneida and Vilas	St. Germain	4 May	6:00 PM			125	0	0	4	
Juneau	3 W Necedah	4 May	8:30 PM			25	0	0	3	
Barron	7 W Cumberland	5 May	2:15 PM		¼	100	0	0	4	
Juneau	1 N Meadow Valley	7 May	2:30 PM	ENE	4	30	0	1	3	
Wood	Wisconsin Rapids	7 May	6:00 PM	E		100	0	14	5	
Vernon and Richland	Readstown to 3 SW Hillsboro	8 May	5:30 PM	NE	23	300	0	1	5	
Marathon	Bevent to Elderon	8 May	4:50 PM	NE	12		0	0	5	
Waupaca	1 W Clintonville	8 May	5:00 PM	NE	3	200	0	1	5	
Juneau–Adams		8 May	5:15 PM	NE	25	150	0	0	5	
Winnebago–Outagamie	Fox Cities area	8 May	6:30 PM	NE	35	25–100	0	5	6	
Buffalo	5 SW Gilmantown	23 May	7:30 PM	NE	2	100	0	0	4	
Trempealeau–Jackson	Pleasantville	23 May	7:30 PM	NE	10	100	0	0	5	
Brown	Bellevue	30 May	1:28 PM				0	0	0	
Shawano	Belle Plaine	9 June	2:30 PM				0	0	4	
Marinette	Pound	9 June	3:00 PM				0	0	4	
Barron	Cameron	18 June	6:00 PM	NE	7½	12	0	2	4	
Buffalo	Mondovi	20 June	8:10 PM				0	0		
		Touched ground briefly.								
Taylor	2½ W Medford	6 July	6:15 PM				0	2	3	
Washington	Jackson	6 July	9:30 PM				0	0		
St. Croix	Hamilton	28 July	7:15 PM				0	1	3	
Fond du Lac	8 E Fond du Lac	22 Aug.	1:55 PM	NE	Short	Narrow	0	0	3	
Fond du Lac	Fond du Lac	22 Aug.	3:15 PM	NE	1	500	0	2	5	
Portage	Grant	22 Aug.	Mid-afternoon	NE	7	Narrow	0	0	4	4
Dodge	Lowell	22 Aug.	Mid-afternoon		Short	Narrow	0	0	3	3
Ozaukee	Port Washington	22 Aug.	3:55 PM	NE	1	50	0	30	6	
Milwaukee	Oak Creek	22 Aug.	4:00 PM	NE	2	400	0	0	5	
Barron–Burnett		28 Aug.	1:45-2 PM	NNW	4½	50	0	0	4	
Richland	Near Hwy. 60 and Co. "F"	3 Sept.	3:15-3:45 PM		15	850	0	4	5	4
Dodge	7 NW Hartford	3 Sept.	5:00 PM		Short	Narrow	0	0	3	3
Milwaukee	Milwaukee	3 Sept.	5:20 PM		1/8	100	0	0	5	

*After 1958, tornado damage is placed in the following categories:
1—Less than $50; 2—$50 to $500; 3—$500 to $5,000; 4—$5,000 to $50,000; 5—$50,000 to $500,000; 6—$500,000 to $5,000,000.

through 1915 and 293 tornadoes from 1916 through 1964. Unless otherwise specified, the data used in this paper are for the period 1916–1964.

Distribution of the number of tornadoes and number of tornado days by month is given in Figure 1. The number of tornadoes and tornado days reach the maximum in June, followed by May and July with a secondary peak in September. The two peaks occur at the approximate times of the beginning and ending of meteorological summer in Wisconsin, as well as the rainfall peaks of the year.

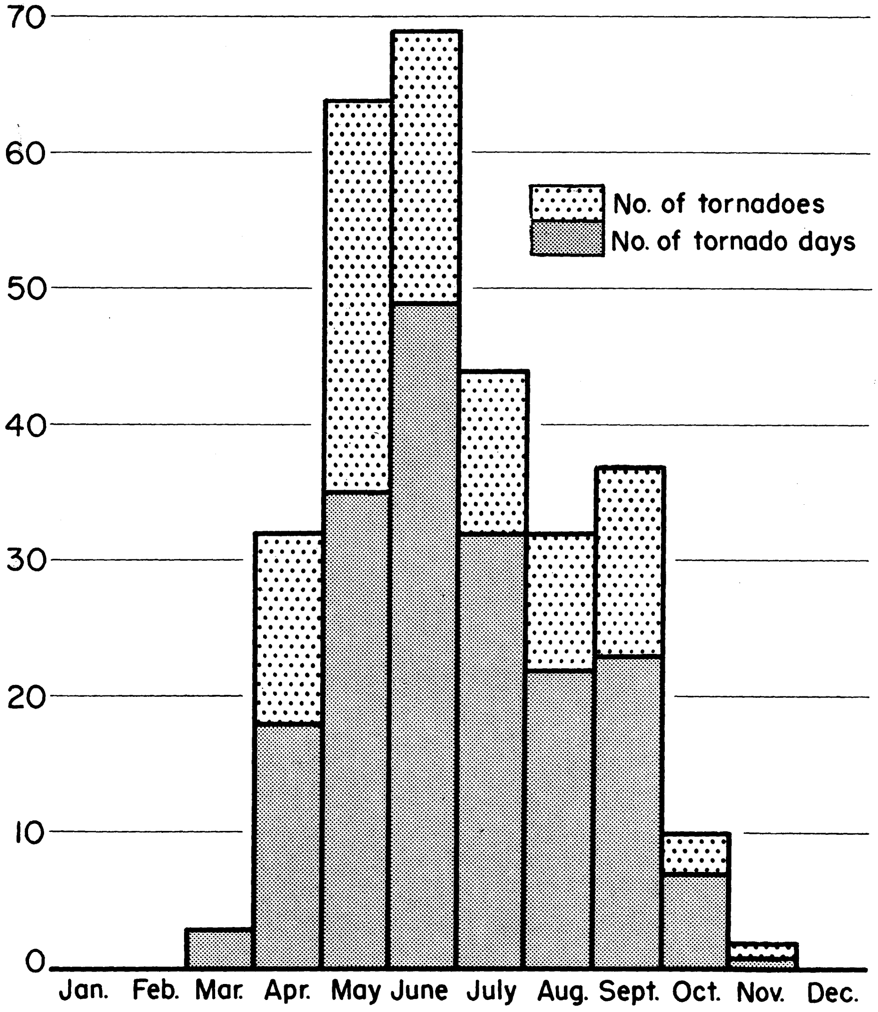

FIGURE 1. Number of tornadoes and tornado days, 1916–1964.

This timing is different from the national average, where the maximum number of tornadoes is reached in May with a secondary peak in November, and the number of days with tornadoes having one peak in June. Approximately 95% of the tornadoes and tornado days occur in the five-month period, April through September. No tornadoes have been reported in this state in December, January or February. The season's earliest recorded tornado occurred March 17, 1934, while the season's latest recorded tornado was November 15, 1960. Although tornado occurrences are generally distributed through the season, the highest probability is from June 20 to 25.

During the period 1916–1964, about 13% of the tornadoes were responsible for loss of human life, 28% were responsible for injury, and 32% were responsible for either death or injury. The fewer deaths and injuries in recent years are believed to reflect better forecasting, timely warning, and a better informed public knowing what safety precautions to take.

The number of tornadoes has averaged 6.0 per season, while the number of days with tornadoes has averaged 3.9 per season. (Table 2) No tornadoes were reported in 1917, 1923, 1939, 1943, and 1947. The thirty-three tornadoes reported and confirmed in 1964 makes it the highest season on record, followed closely by 1959 with thirty. There have been deaths in twenty-two of the forty-nine years in this study for an average of 3.2 deaths per year. Tornado related injuries occurred in thirty-three of these years for an average of 19.6 per year.

The most frequent time of day for tornadoes to occur is between 3 P.M. and 7 P.M., (Table 3) with 5 P.M. being the most probable hour. Three out of every four tornadoes have touched down between 1 P.M. and 8 P.M. The hours of least probability are between 2 A.M. and 11 A.M.

TABLE 2. NUMBER OF REPORTED TORNADOES, TORNADO DAYS, DEATHS, INJURED, PROPERTY LOSS BY YEAR, 1916–1964.

YEAR	NUMBER	DAYS	DEATHS	INJURED	PROPERTY LOSS
1916	1	1	0	0	$ 20,000
1917	0	0	0	0	0
1918	3	3	9	103	715,000
1919	1	1	——	——	500
1920	1	1	1	——	25,000
1921	2	2	——	2	620,000
1922	3	3	8	100+	560,000
1923	0	0	0	0	0
1924	7	3	43	276	1,618,000
1925	4	4	2	0	66,500
1926	2	2	3	17	91,000
1927	2	2	0	——	21,200
1928	8	4	0	13+	387,500
1929	6	4	12	131	1,247,000
1930	12	6	8	80	2,173,400
1931	4	3	1	9	333,100
1932	1	1	0	0	2,000
1933	7	6	2	9	220,000
1934	8	8	0	3	45,300
1935	7	5	0	1	152,800
1936	3	3	0	0	35,300
1937	1	1	0	0	10,000
1938	2	2	0	2	15,000
1939	0	0	0	0	0
1940	2	1	2	7	7,500
1941	4	4	0	2	27,000
1942	9	6	1	4	258,500
1943	0	0	0	0	0
1944	5	4	7	69	1,130,600
1945	4	4	1	3	138,000
1946	1	1	0	0	10,000
1947	0	0	0	0	0
1948	4	1	2	12	56,750
1949	4	4	0	0	5,000
1950	5	1	3	50	729,000
1951	5	4	7	15	637,000
1952	1	1	2	6	250,000
1953	3	2	4	37	2,030,000
1954	12	8	0	4	405,600
1955	9	5	0	7	386,000
1956	6	4	9	57	1,380,000
1957	12	6	1	7	423,500
1958	17	10	27	182	9,635,000
1959	30	17	0	14	*
1960	14	9	0	1	*
1961	9	6	0	1	*
1962	9	7	0	0	*
1963	10	6	0	13	*
1964	33	14	0	66	*
Total	293	190	155	1303	
Average	6.0	3.9	3.2	26.6	

*Losses categorized by classes after 1958.

TABLE 3. NUMBER OF TORNADOES BY HOUR AND MONTH, 1916–1964

HOUR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL
00				1	1	1	1	1	3				8
01				1	1	1	2		1				6
02							1						1
03			1		1	1							3
04						1			1				2
05													0
06							2						2
07						1							1
08										1			1
09					1		1						2
10					1								1
11				1					1				2
12			1		1		2		2	1			7
13				2	4	4	3	1	1				15
14				3	6	4	2	3	2		1		21
15				4	11	6	1	4	5	1			32
16				8	7	4	6	6	2	2			35
17				2	9	9	7	4	3	3			37
18				3	7	7	5	3	10				35
19			1	2	7	11	4	5	2				32
20				2	3	5	2	1					13
21					1	4			1				6
22					1	1							2
23					1	2			1				4
Unknown				3	1	7	5	4	2	2	1		25
TOTAL			3	32	64	69	44	32	37	10	2		293

Surface winds in weather systems with devoloping tornadoes are usually from the southwest, and most tornadoes move from this direction. (Figure 2) However, tornadoes can come from any

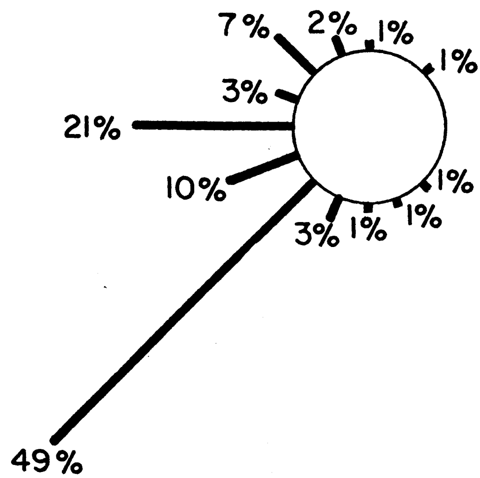

FIGURE 2. Tornado rose for Wisconsin showing percent of reported tornadoes moving from indicated directions, 1916–1964.

direction. Ninety fiive per cent of the tornadoes in Wisconsin have moved from a westerly direction with nearly fifty percent moving directly out of the southwest. National averages and Lapham's windfalls closely approximate these figures. The length of individual paths vary from brief touch downs to 170 miles. Although the average tornado path is 11.7 miles, the median of four miles is considered more representative since the average includes several extremely long paths. Tornado paths have been less than one mile in length 26% of the time, for one to five miles 32%, six to ten miles 15%, eleven to twenty miles 14%, twenty-one to fifty miles 9%, and over fifty miles 4% of the time. The average width of the path is 285 yards, while the median is 100 yards. Widths have been under 100 yards 35% of the time, from 100 to 200 yards 32%, from 300 to 500 yards 15%, from 600 to 1,000 yards 9%, and greater than 1,000 yards 5% of the time.

Tornadoes have been observed in nearly ever county in the state. (Figure 3) The area of greatest frequency is the west central section, while the area of least frequency is a band of counties along the northern border of the state and a band along Lake Michigan north of Milwaukee. A map of Lapham's windfalls, also by county,

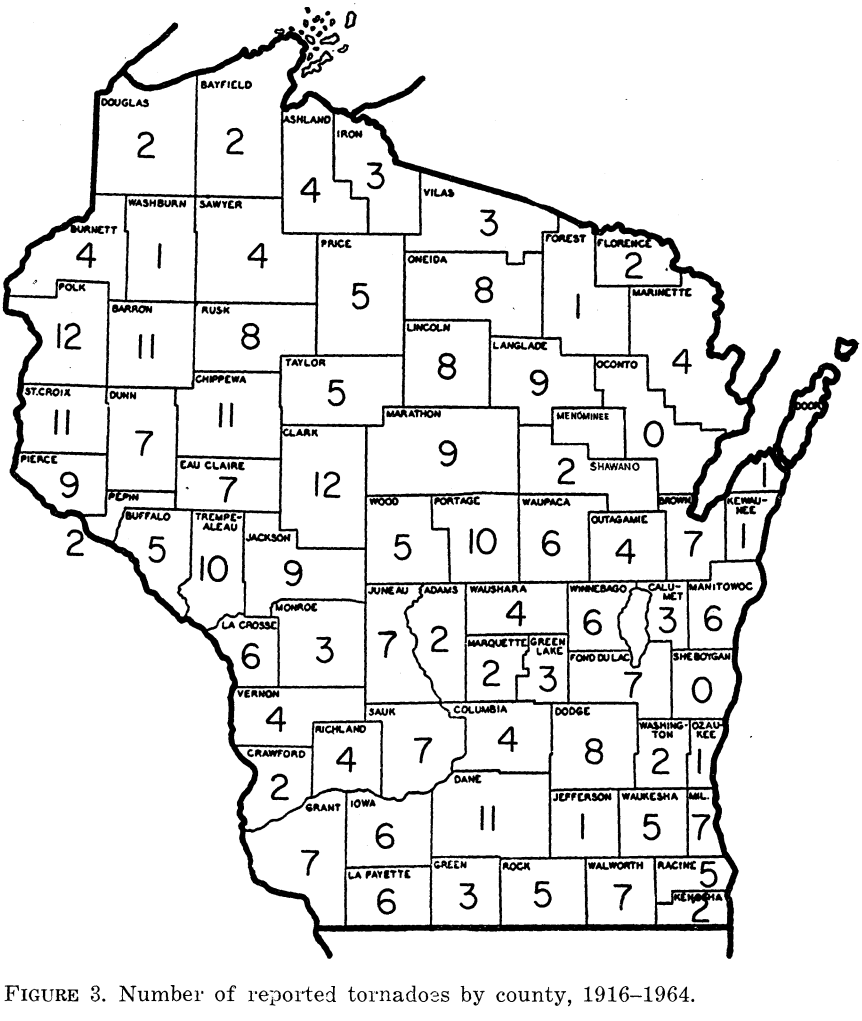

FIGURE 3. Number of reported tornadoes by county, 1916–1964.

makes an interesting comparison. (Figure 4) The highest frequency of windfalls is to the east and north of the highest frequency of tornadoes, suggesting that there were different wind flow patterns in the two periods. In the forty-nine year span, 1916–1964, no tornadoes were reported in Oconto County although early surveyors listed twenty-three windfalls in the county. Bryson's work with Wisconsin's earliest weather data indicates that wind

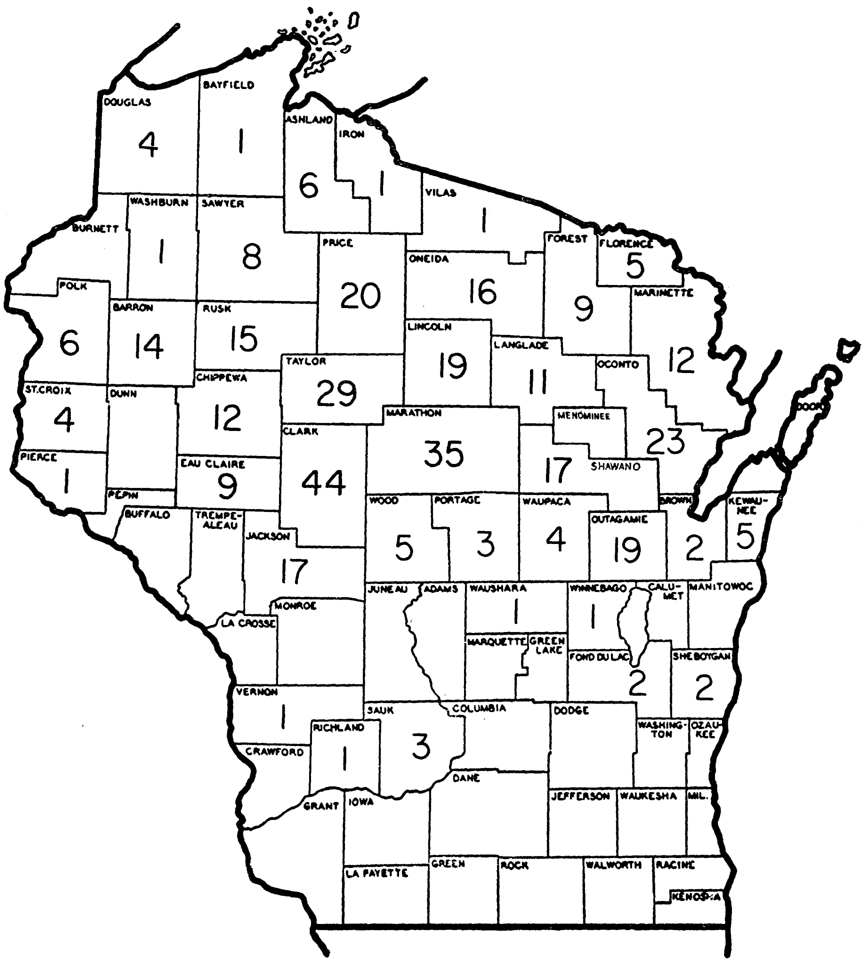

FIGURE 4. Number of windfalls by county. (before settlement)

flow patterns changed between the early 1800's and recent times, and that the changes took place between 1870 and 1880.[9] In making the comparison one must keep in mind that the windfalls are only for the part of the state unsettled and under virgin forest at the time of the survey, that a skipping tornado could leave a number of windfalls, and that some of the windfalls were probably the result of straight line winds.

Outstanding tornadoes are arbitrarily defined in this paper as meeting one or more of the following criteria: (1) loss of life to the extent of at least five, (2) property damage amounting to at least $500,000, (3) and path at least twenty-five miles in length. (Figure 5, Table 4) Wisconsin's "tornado alley" is clearly located in the west central counties, it appears to be approximately in line with the tornado gradient increasing southwest through Iowa into Kansas and Oklahoma. (See Figure 6). A large number of eastern

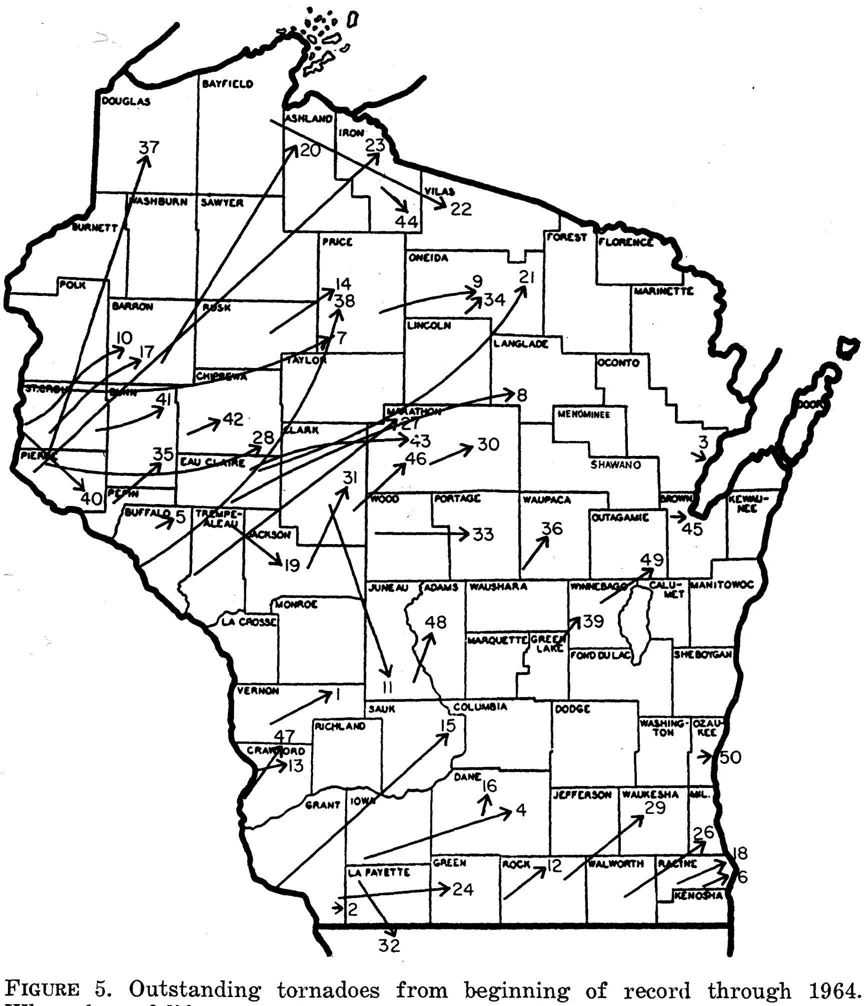

FIGURE 5. Outstanding tornadoes from beginning of record through 1964. Where loss of life was at least 5, or property damage was at least $500,000, or path was at least 25 miles long.

TABLE 4. OUTSTANDING TORNADOES FROM BEGINNING OF RECORD TO 1964. (WHERE LOSS OF LIFE WAS AT LEAST 5, PROPERTY DAMAGE WAS AT LEAST $500,000, OR PATH WAS AT LEAST 25 MILES LONG)

No.	Date	Counties	Time of Occurrence	Lives Lost	Injured	Estimated Property Damage	Length in Miles
1	1865, June 28	Vernon	4:00 PM	24	100	$ 200,000	40
2	1876, March 10	Grant	4:30 PM	9	15	46,000	5
3	1877, July 7	Oconto	6–7 PM	8	30	300,000	6
4	1878, May 23	Iowa to Dane	3:00 PM	19	45+	130,980	150
5	1881, Sept. 29	Buffalo	afternoon	12			
6	1883, May 18	Racine	7:00 PM	25	100	200,000	3
7	1884, Sept. 9	St. Croix to Price	5:00 PM	6	75	4,000,000	120
8	1898, May 18	Eau Claire to Clark, Langlade	4:00 PM	17	100	710,000	110
9	1898, May 18	Price, Oneida	6:30 PM	7	15	200,000	50
10	1899, June 12	St. Croix to Barron	6:30 PM	117	125	600,000	45
11	1907, July 3	Clark to Juneau	4:45-6:30 PM	26		100,000	95
12	1911, Nov. 11	Rock	2:00 PM	9	10	500,000	30
13	1915, June 12	Crawford	5:30 PM	7	25	100,000	20
14	1918, May 19	Rusk, Price	1:00 AM	1	2	50,000	40
15	1918, May 21	Grant, Iowa, Richland, Sauk	6:30 PM	8	100	650,000	85
16	1921, Aug. 19	Dane	4:15 PM	0	2	620,000	—
17	1922, June 15	St. Croix to Barron	7:00 PM	8	100+	500,000	50
18	1924, June 20	Racine	7:30 AM	0	12	500,000	30
19	1924, Aug. 7	Trempealeau, Jackson	6:30 PM	4	100	200,000	27
20	1924, Sept. 21	Barron to Ashland	2:00 PM	10	50	250,000	90
21	1924, Sept. 21	Eau Claire to Oneida	2:20 PM	26	150	564,000	120
22	1926, July 16	Bayfield to Vilas	6:15 PM	3	16	90,000	85
23	1929, April 5	Pierce to Iron	5:45 PM	12	100	725,000	170
24	1929, April 6	Grant to Green	4:30 PM	0	25	250,000	45
25	1930, May 1	Trempealeau to Monroe	7:30 PM	1		202,000	33
26	1930, May 1	Walworth to Milwaukee	11:00 PM	0		30,000	40
27	1930, June 13	Trempealeau to Marathon	5:30 PM	0	0	600,000	80
28	1930, June 13	Pierce to Chippewa	5:30 PM	6	80	1,000,000	125
29	1931, Sept. 21	Rock to Waukesha	7:30 PM	1	9	300,000	50
30	1935, July 5	Marathon	7:15 PM	0	0	125,000	25
31	1942, May 13	Jackson, Clark	3:00 PM	1	1	100,000	35

TABLE 4. OUTSTANDING TORNADOES FROM BEGINNING OF RECORD TO 1964. (WHERE LOSS OF LIFE WAS AT LEAST 5, OR PROPERTY DAMAGE WAS AT LEAST $500,000, OR PATH WAS AT LEAST 25 MILES LONG)—Continued

No.	Date	Counties	Time of Occurrence	Lives Lost	Injured	Estimated Property Damage	Length in Miles
32	1944, June 22	Lafayette	6:30 PM	7	65	1,000,000	36
33	1945, Sept. 19	Wood, Portage	3:00 PM	0	2	25,000	25
34	1950, June 25	Oneida	9:00 PM	2	50	500,000	12
35	1951, Sept. 12	Pepin, Dunn	11:30 AM	0	2	127,000	30
36	1951, Sept. 26	Waupaca	3:50 AM	6	3	250,000	20
37	1953, May 10	Pierce to Douglas	6:30 PM	4	27	1,000,000	100
38	1953, May 10	Buffalo to Price	6:30 PM	0	10	1,000,000	100
39	1956, April 3	Green Lake, Winnebago	2:05 PM	7	50	1,000,000	12
40	1958, May 24	St. Croix, Pierce	2:25 PM	0	5	385,000	50
41	1958, June 4	St. Croix–Dunn	5:30 PM	19	110	7,000,000	32
42	1958, June 4	Chippewa County	6:45 PM	4	56	1,000,000	12
43	1958, June 4	Eau Claire to Marathon	7:30 PM	4	3	750,000	60
44	1958, July 14	Iron	2:45 PM	0	0	75,000	25
45	1959, May 10	Brown	8:50 PM	0	3	500,000+	6
46	1960, Nov. 15	Clark to Marathon	2:25 PM	0	1	5,000+	35
47	1964, May 4	Crawford	8:00 PM	0	2	50,000+	25
48	1964, May 8	Juneau, Adams	5:15 PM	0	0	50,000+	25
49	1964, May 8	Winnebago, Outagamie	6:30 PM	0	5	500,000+	35
50	1964, Aug. 22	Ozaukee	3:55 PM	0	30	500,000+	1

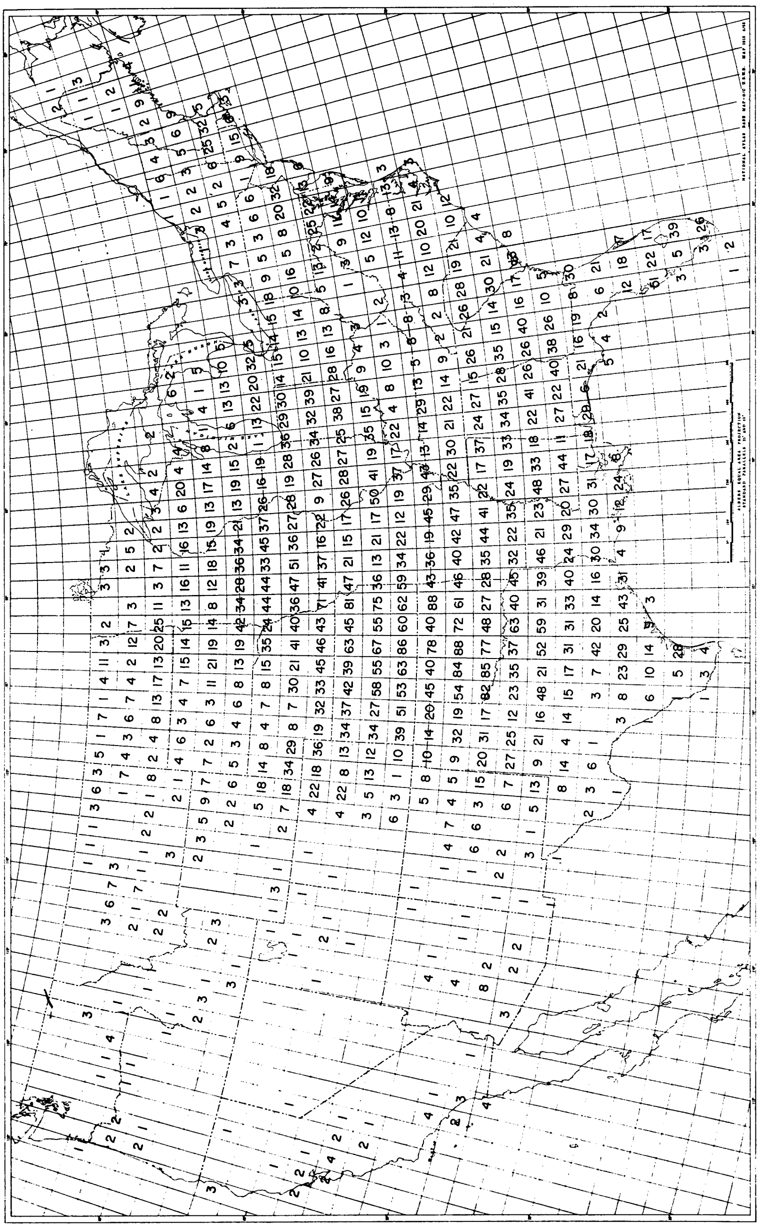

FIGURE 6. Number of reported tornadoes in the United States by 1° "squares", 1916–61. Based on the first point of contact with ground of 11,053 tornadoes.

counties have never been crossed by an outstanding tornado, as defined above. Fortunately, the heavier populated and industrialized part of the state has largely escaped the longer paths of whirling destruction. Figure 5 is in sharp contrast to Figure 3, number of tornadoes by county, where, although the greatest frequency is in west central counties, there is a general geographic distribution with gradual decreases outward from the maxima.

A waterspout is a tornado occurring over water. (Table 5) It is not unusual for a tornado to change to a waterspout or vice versa. The funnel-shaped cloud dips to the water where upon the water may appear to boil and turn white as it rises in the funnel. Most authorities say that the funnel of a waterspout is composed of condensed water and is not, as is popularly thought, a column of water.

TABLE 5. WATER SPOUTS, 1843–1964

PLACE	DATE	TIME	
Lake Michigan	August 20, 1843	Morning	Near Kenosha
Lac LaBelle	May 31, 1851		Near Oconomowoc
Lake Michigan	July 31, 1867	Dawn	Near Milwaukee
Lake Winnebago	July 22, 1938	12:30 PM	
Lake Koshkonong	July 6, 1954	PM	Near Madison
Sturgeon Bay	August 21, 1955	2:30 PM	Riley's Point near Little Sturgeon
Lake Winnebago	July 1, 1956	Noon	2 water spouts
Lake Winnebago	June 28, 1960	10:35 AM	
Green Bay	June 23, 1962	4:30 PM	Near Point Sauble
Big St. Germain	May 4, 1964	6:00 PM	Crossed over Vilas County lake drawing water to an estimated 200 feet
Lake Michigan	May 8, 1964	8:37 PM	Northeast of Milwaukee
Lake Winnebago	July 27, 1964	4:15 PM	Near High Cliff

To make this report complete, a list of reported funnels is included. (Table 6) A funnel is defined as a whirling inverted cloud cone, most frequently found under cumulo-nimbus clouds. When the funnel touches the earth's surface, it is called either a tornado or waterspout. Most funnels never develop to the point of touching the earth, this phenomenon is often confused with mammatus or distant virga. Little or no record of funnels was kept until the late 1950's. Many of the funnels listed were part of a weather system that was generating tornadoes.

TABLE 6. FUNNELS 1916–1964

Place	Date	Time	
	1932		
Polk County	Aug. 10	4:45 PM	Town of Clayton
	1937		
Columbia County	June 15	1:30 PM	
	1956		
Brown County	July 1	12:00 PM	Bellevue
Brown County	July 1	12:00 PM	De Pere
Waushara County	July 15	6:47 AM	Plainfield
Beaver Dam	July 21	4:00 PM	3 funnels
	1957		
La Crosse 25 SE	May 31	1:30 PM	
Northfield	May 31	4:29 PM	
Madison N	July 7	12:36 PM	
Green Bay 5S	July 11	1:00 PM	
Madison 5 S	July 12	9:20 AM	
Madison 8 S	July 12	4:02 PM	
	1958		
Green County	May 31	3:30 PM	
St. Croix County	June 22	3:25 PM	
Walworth	June 22	7:50 PM	
Taylor County	July 14	3:15 PM	
Columbia County	Oct. 9	4:30 PM	
Dodge County	Oct. 9	5:30 PM	
	1959		
Eau Claire 35 NNE	May 4	10:05 AM	
Waupaca County	May 5	12:30 PM	
Eau Claire 4 W	May 5	7:25 PM	
Spring Valley	May 5	7:40 PM	
Rusk County	May 5	7:30 PM	
Chippewa Falls	May 5	7:45 PM	
Chippewa Falls	May 5	8:04 PM	
Eau Claire 6 NE	May 5	8:09 PM	
Ripon 5 N	May 28	3:05 PM	
Arlington	May 28	3:45 PM	
Green Bay	May 28	3:52 PM	
Lancaster	May 29	6:45 PM	
Menomonie	June 26	1:44 PM	
Eau Claire 15 NNE	June 26	5:55 PM	
Manitowoc County	Aug. 14	Evening	
Green Bay 15 S	Aug. 29		
Eau Claire 30 E	Sept. 22	5:30 PM	
Milwaukee 25 SW	Sept. 28	2:23 PM	
Germantown	Oct. 8	4:45 PM	
Milwaukee 40 S	Dec. 9	5:15 PM	
	1960		
Milwaukee	May 8	10:32 AM	
La Crosse 18 ENE	May 27	4:00 PM	
Madison 45 NNE	June 28	5:52 PM	
Madison 35 SE	July 2	5:30 PM	
Milwaukee 10 S	July 2	8:25 PM	
Madison 45 NNW	July 27	8:00 PM	

TABLE 6. FUNNELS 1916–1964—Continued

PLACE	DATE	TIME	
Green Bay	Aug. 13	8:55 PM	
Madison 40 NE	Aug. 20	10:00 AM	
Milwaukee 20 NW	Aug. 20	3:00 PM	
Green Bay 60 WSW	Aug. 28	6:10 PM	
Green Bay 25 SW	Aug. 28	6:40 PM	
Summit Lake 6 W	Sept. 7	5:00 PM	
Racine County	Sept. 24	4:25 PM	
Belleville	Nov. 15	6:15 PM	
	1961		
Milwaukee 50 W	May 14	4:00 PM	
Neillsville	May 14	Afternoon	
Winchester	May 14	Late afternoon	
Lone Rock	June 10	5:30 PM	2 funnels
Eau Claire 40 NE	June 21	2:56 PM	
Ladysmith	Aug. 4	Evening	
Sheboygan 1 W	Sept. 22	1:50 PM	
	1962		
Eau Claire 10 N	May 14	2:00 PM	
Appleton 16 SE	June 8	9:22 PM	
Columbus 7 N	June 17	5:00 PM	
Butte des Morts	June 17	7:15 PM	2 funnels over lake
Portage County	June 17	7:30 PM	
Lake Winnebago	June 18	10:00 AM	2 funnels over northern part of lake
Oshkosh 30 SW	July 11	2:58 PM	
Eau Claire 6 S	July 17	3:45 PM	
Eau Claire 10 SW	July 17	3:45 PM	
Eau Claire 20 WNW	July 17	3:45 PM	
La Crosse 30 SE	July 22	6:40 PM	
Green Bay	July 24	7:40 PM	2 funnels northeast of Green Bay
Madison 35 NE	Aug. 29	9:10 PM	
	1963		
Hartland	June 8	7:45 PM	
Burlington 10 SW	June 8	8:00 PM	3 funnels
Madison	Sept. 2	5:25 PM	
	1964		
Blue River	June 22	11:30 AM	

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6. Two of several descriptions in Increase A. Lapham's letter to General A. J. Myer, Chief Signal Officer, May 1872.
7. Quotation from Increase A. Lapham papers.
8. Since there are no times of tornado occurrences given by windfall records, Lapham's "tornadoes" interpretation would have been more correctly labeled "tornado paths", which may or may not have occurred in the same storm.
9. PROFESSOR REID A. BRYSON, Dept. of Meteorology, University of Wisconsin, "Personal Communication", 1965.

REGIONALISM IN THE THREE SOUTHS

*Kimball King**

Every corner of America in the late nineteenth century boasted its share of regional writers, but the local color movement in the South was especially significant. The South had produced so few novelists and poets before the Civil War that their appearance in large numbers afterwards was observed with particular interest. Southern writers recorded the passing of a way of life and the resulting social upheaval. The rest of the nation watched with the proverbial interest of the conqueror in the conquered. The most popular literary descriptions of Southern life appearing after the Civil War were nostalgic eulogies of a vanishing chivalric world. Such oversimplified appraisals of Southern institutions gained public acceptance but failed to reflect the complexity of the South and its literature.

The plantation literary tradition and its chief spokesman, Thomas Nelson Page, tended to overshadow the contributions of Southern writers who were concerned with the future of their region and who protested that the real South lay undiscovered. By investigating the myths of Southern life and the seldom recognized attempts of a few Southerners, such as George W. Cable and Mary Murfree, to refute these myths we learn a good deal about our nation as a whole and also about one of its more "curious" regions. It is interesting that a just survey of Southern literature reveals themes which appear in the Midwestern stories of Hamlin Garland. A closer look at the Southern literature of this period will illustrate the common bonds between dissimilar localities.

Southern literature is not the product of one, but of three regions: the Tidewater and Atlantic coastal South, the mountaineers' South, and the deep South. Before the first World War the literary image of the South was dominated by accounts of life on the Tidewater plantations. More recently the Southern image has been shaped by writers describing Mississippi, Alabama, and Louisiana. A meaningful survey of Southern letters involves the consideration of authors from all three regions.

Although the early settlers of the Southern Atlantic states prided themselves on their cultural sophistication, they were strangely unconcerned with reading or authorship. Page apologetically declared that the role of the planter class in shaping a democratic

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government and an equitable system of law interfered with a purely belletristic attitude toward letters. Less than five percent of the white population of the South were slave-holders[1] and only a minute portion of these comprised the so-called planter class. Yet it was the men with the greatest commitments to the plantation system and to self-government who became the literary spokesmen for their region. Nearly all significant ante-bellum literature therefore has as its focus plantation life. Francis Pendleton Gaines, surveying this field of literature in 1925, notes the long tradition of plantation literature beginning with John Pendleton Kennedy's *Swallow Barn* in 1832. *Swallow Barn* is a series of sketches in the tradition of Washington Irving's *Bracebridge Hall* (1822). As such it portrays the happier aspects of old-time society in the South. The author's concern is in illustrating regional types rather than in developing believable personalities. Two decades after *Swallow Barn* and Kennedy's later novels, *Horseshoe Robinson* and *Rob of the Bowl,* Philip Pendleton Cooke and his brother, John Esten Cooke, added some glamorous chapters to the plantation legend. Philip Cooke's stories of Virginia life and John Cooke's novels, *Leather Stocking and Silk* (1852) and *Virginia Comedians* (1854), exaggerated the virtues of the Southern landowner. Page accused John Cooke of "writing through the rose-colored lenses of Sir Walter Scott,"[2] and George W. Bagby in 1859 declared his intention to bring about "the unkind but complete destruction"[3] of Cooke's reputation. Later Bagby turned romancer himself in "The Old Virginia Gentleman" (1877) ; he and Page did more to encourage ancestor worship and nostalgia for the Old South than any of their literary predecessors. As an example, note Bagby's description of the plantation mistress which was the inspiration for Page's heroines in *Red Rock* (1898) and *In Ole Virginia* (1887) :

> The ways of the great world had ceased long ago to be her ways. She lived in a little world of her own. She could not keep pace with the fast-changing fashions, which, in her pure mind, were not always for the better. Her manner was not, in the usual sense, high-bred; for hers was the highest breeding, and she had no manner. But her welcome as you entered her door, and her greeting, meet her where you might, on the endless round of her duties, in-doors or out, was as simple and genial as sunshine, and as sweet as spring water.[4]

William Gilmore Simms was more involved in sponsoring a Southern literary renaissance than in praising the aristocracy. With James Wright Simmons he founded the *Southern Literary Gazette*

[1]H. R. Floan, *The South in Northern Eyes:* 1831–1861, (Austin, Texas, 1958), p. viii.

[2]Quoted by J. O. Beatty, *John Esten Cooke,* pp. 67–70.

[3]Spiller, Robert E., Willard Thorp, Thomas H. Johnson and Henry Seidel Canby, eds., *Literary History of the United States,* pp. 848–49.

[4]G. W. Bagby, *The Old Virginia Gentleman,* (New York, 1911), p. 20.

"to encourage the efforts and to do justice to the claims of native genius."[5] Simms' novels, such as *Martin Faber* (1832), *Beauchampe* (1842) and *Charlemont* (1856), were based on historical incident, as was his most widely read book, *The Yemassee* (1835), which deals with an Indian uprising and is often compared to James Fenimore Cooper's stories of the frontier. Simms believed the future of Southern letters depended on a judicious use of local materials to present themes of universal interest. In his preface to *The Wigwam and the Cabin* (1856) he made some prophetic remarks about the proper goals of regional authors:

> To be *national* in literature one must needs be *regional*. No one mind can fully or fairly illustrate the characteristics of any great country; and he who shall depict one section faithfully has made his proper and sufficient contribution to the great work of national literature.[6]

Simms nevertheless recognized the need to justify Southern institutions to a national reading public. He wrote to B. F. Perry that he was supporting the *Southern Quarterly Review* so that "we may have at least one organ among ourselves to which we may turn when it becomes necessary to express Southern feelings and opinions."[7] The *Southern Quarterly Review* supported the social and economic ideals of the plantation system. So, too, did the Uncle Remus stories of Joel Chandler Harris, the short stories of Armistead Gordon and the poetry of Irwin Russell.

Page was unquestionably the most eloquent spokesman for the plantation system. Although Page followed Kennedy, the Cookes, Bagby, and Simms in a well-established literary tradition, Gaines has noted that Page surpassed his predecessors in embellishing the image of an ideal society:

> [Page is] far more passionate in the maintenance of a hypothesis of departed glory, paints in more glowing colors, is uniformly more idealistic, descends less frequently—if ever—from the legends of romantic vision.[8]

From the works of Page it is possible to construct the image of an aristocratic society which Americans in other regions accepted as an accurate picture of the ante-bellum South. Beginning with "Uncle Gabe's White Folks," a dialect poem Page wrote in 1876, the Virginia author gained an eager audience throughout America. His popularity resulted partly from the interest of Northeastern and Midwestern readers in the recently defeated South. Page gave detailed accounts of an heroic people and their unusual customs and heritage. Edmund Wilson has observed that the nation was

[5]E. W. Parks, *William Gilmore Simms as Literary Critic,* (Athens, Ga., 1961), p. 89.

[6]W. G. Simms, *The Wigwam and the Cabin,* (Chicago, 1856), pp. 4–5.

[7]Quoted by Parks, pp. 101–102.

[8]F. P. Gaines, *The Southern Plantation,* (New York, 1925), p. 77.

anxious to suppress unhappy memories of the Civil War and that Page's idealized view of the South suited the public's demand that "the old issues be put to sleep."[9] Page's stories and novels were written in the spirit of reconciliation. Although he extolled the bravery of Confederate soldiers, he noted the original reluctance of his heroes to become involved in war and praised their gracious acceptance of defeat and their renewed allegiance to the Union after the War. In an infrequently cynical moment Page accounted for his literary success to Grace King:

> Now I will tell you what to do; for I did it. Just rip the story open and insert a love story. It is the easiest thing to do in the world. Get a pretty girl and name her Jeanne, that name always takes! Make her fall in love with a Federal officer and your story will be printed at once! The publishers are right; the public wants love stories. Nothing easier than to write them.[10]

Page's allusion to "the publishers" is significant. Scribner's and other important national magazines welcomed the sentimental tales of local color writers. Northern magazine editors encouraged their Southern contributors to take part in creating a mythical kingdom below the Mason–Dixon line. The unwitting contribution of abolitionists in the early nineteenth century to ante-bellum glory is often forgotten. Mrs. Stowe, William Lloyd Garrison, Wendell Phillips and Whittier in their vehement denunciations of Southern institutions sketched the outlines of a mythical society which would later inspire partisans of the Southern cause. The abolitionists generally had a scanty first-hand knowledge of the South and overemphasized the aristocratic basis of plantation life. The plantations they described were more lavish than great European estates while the landlords were as rich and autonomous as English noblemen. Howard R. Floan has called attention to Phillips' beliefs that the slaveholders possessed a terrible but magnificent domain:

> He conjured up a land of whipping posts and auction blocks, a feudal society in which newspapermen, politicians, and clergymen were vassals. The nobility controlled family, church, and government. The slave power he described as a cable of three strands: the prejudice of race, the omnipotence of money, and the almost irresistible power of the aristocracy. Nobility and aristocracy were evocative terms in the New England of his day, and the most summary abstraction of them all was Phillips' epithet, "the South is the thirteenth and fourteenth centuries."[11]

Page applied new value judgments to the abolitionists' collective portraits. He emphasized the medieval concepts of *gentilesse,* the exalted position of women, and the chivalric behavior of the

[9]Edmund Wilson, *Patriotic Gore,* (New York, 1962), p. 613.

[10]Quoted by J. B. Hubbell, *The South in American Literature: 1607–1900,* (Durham, N.C., 1954), p. 735.

[11]Floan, p. 13.

landlords. The wealth and power of the Virginia planter is magnified in Page's fictional representations, and his descriptions of the Tidewater country possess more the aura of Augustan Rome than of colonial America. In the creation of an ideal civilization Page blended the history and folk-lore of Virginia with his boyhood memories of plantation life. He believed in an ordered society, roughly based on the principles of the Chain of Being but modified by Christian charity and paternalism. The harmony of civilization depends, he believed, upon a stratified society whose leaders are guided by duty and honor. While Page's view of society was anachronistic and his attitudes toward art derivative of English culture, he recognized the value of tradition[12] which so many chauvinistic regional writers denied. One recalls Garland's narrow-mindedness in *Crumbling Idols* (1894) where he tends to dismiss the accomplishments of the past, asserting that "to apply ancient dogmas of criticism to our life and literature would be benumbing to the artist and fatal to his art."[13]

Page's noble characters are often romantic stereotypes, but we must remember that the passing of a civilization is an epic subject. Individuals too realistically defined would detract from the author's eulogy of the Old South. As Corra Harris observed, Page's legendary figures are unlike "real men or women, but they are created in the spiritual, mettlesome likeness of ten thousand who did live in the South at that time."[14] One explanation for the unqualified nobility of Page's heroes is that they are cast in the image of Robert E. Lee. Lee was to Page the ideal Virginian. The shadow of the Confederate leader, gigantic in the sunset of an era, became for Page the measure of a gentleman. Lee's attributes are reflected in the author's most important fictional spokesmen, such as Dr. Cary in *Red Rock*. Dr. Cary loses his only son in the war he hoped to avoid fighting; he is evicted from his plantation when he cannot pay the property taxes. But he proudly resigns himself to life in his former overseer's cabin and attends to the sicknesses of his poverty-stricken neighbors and ex-slaves. His last act of Christian charity is a visit to an ailing carpetbagger whose cruelty has subjected the Cary family to innumerable privations. The doctor's subsequent death demonstrates the aristocrat's unremitting sense of duty.

Page indicates the two-sided aspects of paternalism in his works. Negroes remain loyal to their masters after the Emancipation, and the masters offer their protection and trust in return. In Page's story, "Meh Lady," the mistress of the plantation on her deathbed

[12]Note Page's lifelong interest in classics and his book-length study of Dante written just before his death.

[13]Hamlin Garland, *Crumbling Idols,* (Chicago, 1894), p. 66.

[14]Corra Harris, "The Waning Influence of Thomas Nelson Page," *Current Literature,* XLIII (August, 1907), 171–172.

entrusts her daughter's well-being and her material possessions to her butler, Unc' Billy. The author's most famous tale, "Marse Chan," is a vivid illustration of the principle of *noblesse oblige.* Colonel Channing is blinded when he runs into a burning barn to save one of his slaves. Similarly young Marse Chan's Negro manservant, Sam, risks his own life to accompany the young soldier to battle and to bring home the boy's body when he is killed. "Marse Chan" was Page's first published story, and it epitomizes the spirit of the author's eighteen-volume Plantation Edition of novels, stories, poems and essays. Sam tells a passer-by that life on the Channings' plantation before the War "wuz de good old times, marster, de bes' Sam ever see."[15] Sam recalls the lavish hospitality of the plantation and the gallant behavior of the young aristocrats. He glories in the recollection of Marse Chan's bold courtship of Anne Chamberlain; he notes with pride the boy's knightly impetuosity, his quick defense of Colonel Chamberlain's honor. While Sam's narrative gives the story the ring of authenticity, the reader is aware of the tenuous line between myth and reality. Gerald W. Johnson referred to Page's South as "the recrudescence of the Arthurian legend of loyalty, love and derring-do all compact—in short, romance."[16] The spirit of romance which suffuses the stories of Page and his many imitators after the War satisfied the demands of a nation exhausted by realities. The plantation tradition with its emphasis on an idealized feudal order became the most widely accepted expression of Southern life.

The early French and Spanish settlers of Florida and Louisiana and the Gulf Coast states fostered a way of life which differed considerably from the Atlantic coastal plantation society extolled by Page and his literary predecessors. Early inhabitants of the Louisiana territory, for example, had no control over their government which was run by France and which was autocratic rather than democratic. Louisiana's law was based on Roman rather than English common law; the prevailing customs and institutions of the state were continental in spirit. Creole landowners did not possess the agricultural estates of the Virginia planters although they were frequently more worldly and more adept at mercantile pursuits. The first literary endeavors were written in French, and even spoken English was shunned by the leaders of the community. Charles Gayarré is notable as one of the earliest Creoles to write proficiently in English. American literary history in the Mississippi region begins therefore in 1830 when Gayarré published his "Essai historique sur la Louisiane." Gayarré's *Fernando de Lemos: Truth*

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[15]T. N. Page, *In Ole Virginia,* (New York, 1908), p. 13.

[16]G. W. Johnson, "To Live and Die in Dixie," *Atlantic Monthly,* CCVI (July, 1960), 31.

and Fiction (1872) is the first novel of consequence to come from the deep South. This region did not excite much literary interest until after the Civil War when the Creoles were described in the novels of George W. Cable, Kate Chopin and Grace King. Mrs. Chopin and Miss King were primarily concerned with Creole customs and Louisiana's exotic settings. Cable emphasized the decadence of New Orleans' upper class and the social destructiveness of miscegenation. Clement Eaton believes that the literature of this region is distinctive because it has "the flavor of a semi-tropical civilization affected by Negro slavery and by the Latin temperament."[17] While Eaton does not define what he means by "Latin temperament", he suggests that the mixed French and Spanish ancestry of the Creoles resulted in an aristocratic order quite different from the feudal society of predominantly Anglo-Saxon Virginia.

Grace King presents a favorable study of Creole society in *Monsieur Motte* (1888), *Tales of Time and Place* (1892) and *Balcony Stories* (1893). She acknowledges the pride and vanity of the Creoles, but she credits them with warm-heartedness and wisdom. In matters of race she plays down the cruel treatment of Negroes by the Creoles and stresses the loyalty of docile, ignorant slaves to their masters. A testimony to the social interest of her region, however, is Miss King's treatment of Louisiana's quadroon caste, which is separated from both the black and white communities by its mixed blood. In "Madrilene: or, The Festival of the Dead," she tells of a servant girl rescued from the degradation of slavery by the unexpected discovery that her parents are white.

Kate Chopin revealed the prideful nature of the Creoles as Miss King had done. A Creole in "A Gentleman of Bayou Têche" (1894) refuses to accept two badly needed dollars from a photographer in search of "local color" characters for his magazine. The Creole fears he might be mistaken in a photograph for an Acadian or a poor white. Mrs. Chopin's Creoles are childish, fun-loving people. She avoids the less savory aspects of their life, such as race prejudice and miscegenation.

Unlike Miss King and Mrs. Chopin, Cable does not minimize the faults of the Creoles. When he speaks of them in the aggregate, Cable condemns their basic attitudes toward society and questions their morality and wisdom. Especially he deplores their inhumanity to the Negroes. The kindly paternalistic masters of Page's Hanover County are replaced in Cable's Louisiana by capricious masters who flog their male slaves, seduce their female slaves and shoot any slave who becomes troublesome. Cable's concern for the Negro inspired his best writing. *Old Creole Days* (1879), *The Grandissimes*

[17]Clement Eaton, *A History of the Old South*, (New York, 1949), p. 196.

(1880), and *Madame Delphine* (1881) mark Cable as an ardent supporter of civil rights. He shows that society falls victim to horrible perversions when these rights are ignored. In *The Grandissimes* an old Negro woman is shot down in cold blood because she has trespassed on a Creole plantation. When an African prince, Bras-Coupé, disobeys his white master, his ears are cut off and he dies. The vengeance of Bras-Coupé's mulatto wife and the attempt of a Creole, Honoré Grandissime, to make retribution for his family's cruelty provides a framework for the novel. Richard Chase says that the Bras-Coupé episode "anticipates Faulkner"[18] in intensity of atmosphere and exploration of guilt. The tragic consequences of miscegenation which are examined in *The Grandissimes* also remind one of the guilty behavior of white supremacists. Cable applied the scientific method to the race question, repeatedly denying that racial superiority could be proved. He challenged the Creoles' belief that racial "instinct" alienated Negroes and whites.

While the defenders of the old regime recalled the glories of the Southern past, Cable urged the "New South" to keep abreast of modern scientific and social developments. He realized that the plantation system was doomed, not only by the emancipation of the slaves but by the revolutionizing influences of technology. Unlike Cable many Southern authors after the Civil War refused to consider the relationship of the races on a scientific basis.[19] Instead they appealed to a white reactionary audience which felt its political, social, and economic power threatened by the abolition of slavery. In most Reconstruction literature the re-establishment of the Union was accepted with grace, but the welfare of the Negro was still considered a regional problem. Cable, however, in all of his novels and essays railed against Southern autonomy in handling the race problem. In *Lovers of Louisiana* (1918) Rosalie Durel's Creole father expresses a common Southern attitude toward the freedman's position: "We call it a strictly Southern question, which we will take care of if the rest of the country will only let us alone."Durel is refuted by a Scottish friend who answers wryly, "But it isn't and ye don't."[20] The Scot comprehends that Negro rights are an American, not a Southern problem. He is also the

[18]Richard Chase, "Cable and his Grandissimes," *Kenyon Review,* XVIII (Summer, 1956), 374.

[19]Clement Eaton in *Freedom of Thought in the Old South* (Durham, N.C., 1940), p. 309, comments that very few Southerners were concerned over Darwin's hypothesis of evolution, largely because they were too involved in sectional controversies. Eaton does mention, however, that before Darwin published *On the Origin of the Species* (1859) Langdon Cheves of South Carolina advanced the theory of the origin of the species by transmutation and the survival of the fittest. Cheves was refuted by Agassiz's pupil, Le Conte.

[20]G. W. Cable, *Lovers of Louisiana,* (New York, 1918), p. 27.

author's spokesman in a haunting prophecy when he maintains that the race question is not solved:

> T'isn't dead, I say. It's but lost its place in the line and has been sent back to the wurrld's tail end . . . and there's a day ahead, whether far or near God only knows, when that question—and they that are out o' fashion wi' it—will come round again, as big and ugly as hoop-skirts.[21]

Along with improving the status of the Negro, Cable envisioned other social reforms for America. He advocated education for the masses, a revision of the penal system, and worked to elevate the nation's cultural interests by establishing Home Culture Clubs.[22] The heroes in Cable's fiction enthusiastically embrace the doctrine of progress and re-evaluate their traditions. Philip Castleton in *Lovers of Louisiana* notes that "we who dearly love them [our traditions] ought to have a well-shapen, rational policy for speeding them on, instead of a shapeless, emotional one for holding them back."[23] Cable's ideas on human progress evolved slowly, thoughtfully and reservedly. He was too aware of the frailties of human nature to anticipate the millenium. His social goals were reasonable ones and his hopes for the future were always modified by his regard for the more honorable traditions of the past.

Cable's respect for the past, however, did not hinder his opposition to a Creole minority's domination of Louisiana. He battled the forces which chose to leave the Acadians in poverty and ignorance when he wrote *Bonaventure* (1888). Earlier in *The Grandissimes* he had ridiculed the Creoles' distrust of the Anglo–Saxons. Because the maintenance of a privileged society depended on autonomous statehood, the Creole characters in Cable's fiction are fiercely opposed to the Union and refer contemptuously to their neighbors of the North, East, and West as "les Américains." In *The Grandissimes* Agricola Fusilier's dying words, "Louisiana Forever," epitomize the old guard Creole's rejection of federal government. Cable was opposed to sectionalism in government or in literature. One of his most eloquent pleas for national unity is contained in an address to the University of Mississippi on the state of letters in the South (1883):

> . . . We shall no more be Southerners than we shall be Northerners. The accidents of latitude shall be nothing to us. We shall be the proud disciples of every American alike who adds to the treasures of truth in American literature and prouder still if his words reach the whole human heart and his lines of light run through the varied languages of the world. Let us hasten no longer to be a unique people. Let us search provincialism

[21]*Ibid.*, p. 224.
[22]See Philip Butcher, *George W. Cable: the Northampton Years*, (New York, 1959).
[23]Cable, *Lovers of Louisiana*, p. 264.

out of the land as the Hebrew housewife purged her dwelling of leaven on the eve of the Passover.[24]

Cable's belief that an author could work with regional materials and yet avoid provincialism is similar to theories which Garland expressed in *Crumbling Idols*. Garland urged that "local art must be raised to its highest expression."[25] Though Garland was sixteen years younger than Cable, the two men were good friends and frequently exchanged ideas.[26] Both writers were raised in penurious circumstances and recorded the hardships of their youth in their novels. They were initiated into authorship as local color writers but soon established themselves as social realists. Their novels were the work of reformers. Garland, impressed by Henry George's *Progress and Poverty* (1879), proposed specific economic platforms to alleviate the hardships of the farmer's life. Cable discussed economic problems in *Dr. Sevier* (1885); in nearly all of his books his primary concern was equality for all races.

The Southerner and Midwesterner agreed on the role of the novelist as an artist who recorded life as factually as possible but was motivated by strong moral convictions. On March 13, 1894, Cable met with Garland and Hamilton Mabie to discuss the problem of realism vs. romanticism. The debate was summarized the next day on the New York *Times* editorial page. Garland made some astute observations on French realism:

> So-called French realists are rarely veritists. They deal too largely and too often with the abnormal and the unwholesome. On the other hand American veritism has the breath of the pine forest. It is psychological rather than pathological.[27]

Garland separated realism from veritism as Cable did. Cable analyzed society objectively and dispelled the romantic myths of antebellum Southern life. He refused to paint in the merely sordid or obscurely decadent details of that period, but there are few social or personal evils which are omitted from his canvas. Garland defended the reticence of Cable and other realists in not depicting the salacious side of life:

> It is as fully within the jurisdiction of realistic fictionists to write of the wholesome as well as the impure or the erotic, to deal with the happy, though commonplace, domestic lives, that are without great incidents, as to deal with murder or forgery. Imagination may explore the light as well as the dark.[28]

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[24]Quoted by Arlin Turner, "George W. Cable's Revolt Against Literary Sectionalism," *Tulane Studies in English*, V (1955), 20–21.

[25]Garland, *Crumbling Idols*, p. 66.

[26]It is possible that Cable's familiarity with Darwin, which was an apparent influence on his scientific thought though never acknowledged, began in his talks with Garland and Haljimar Boyeson.

[27]See the New York *Times*, March 14, 1894.

[28]*Ibid.*

Here, possibly for Cable's benefit, Garland appeared to be distinguishing between realism and grossness. Cable indicated that he preferred realism in lieu of naturalism. What he objected to in writing was a slavish devotion to detail at the expense of imagination. He distrusted fiction which represented the minutiae of life but lacked a moral purpose:

> Facts are realistic but truth is higher, is beautiful, is romantic. It is the business of fictionists not to testify to fact alone, but more to truth . . . The eternal verities of the human heart are without restriction to the petty facts of the everyday round.[29]

Cable was a true Southerner in his love of his region but he was an objective social critic. His ability to group new trends of thought and re-evaluate traditional prejudices enabled him to predict the future of the South. He absorbed the current ideas of evolution, heredity and environment and accepted the doctrine of progress. Cable was twelve years older than Page, but his viewpoint was nevertheless more contemporary than the conservative Virginian's. Cable was the first Southern writer to challenge the aristocratic bias of the plantation tradition and to describe its institutions realistically.[30]

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[29]*Ibid.* Here it is interesting to note the similarity between Cable's literary theory, as expressed here, and the ideals which Faulkner, as a contemporary Southern realist, expressed in his Stockholm address: "He (the writer) must teach himself that the basest of all things is to be afraid; and, teaching himself that, forget it forever, leaving no room in his workshop for anything but the old verities and truths of the heart, the old universal truths lacking which any story is ephemeral and doomed—love and honor and pity and pride and compassion and sacrifice."

[30]Cable was the most prominent Southern liberal to earn a literary reputation after the War, but several other Southern writers approached the problems of their region realistically. Virginius Dabney in *Liberalism in the South* (Chapel Hill, N.C., 1932) cites the following writers, along with Cable and Mary Murfree, as forward-looking Southerners:

Sidney Lanier (1842–1881) liberalized Southern literature by promoting sound scholarship and honest criticism and by experimenting with metrical patterns and unusual imagery in his own poetry. He published his first novel, *Tiger Lilies,* in 1867 and his first collection of poetry, *Poems,* in 1877.

Joel Chandler Harris (1848–1908) recognized the appeal of the plantation tradition, but in his Uncle Remus stories he introduced the Negro as the central character of his fiction. He did not hesitate in his stories to discuss "the darker aspects of slavery, such as the sufferings of fugitives, the tragedy of mixed blood, the separation of families or the occasional cruelties of overseers."

William Peterfield Trent (1862–1939) wrote a controversial biography of Simms in 1892 in which he asserted that "secession was wrong in itself." His book caused a furor, but he was retained at Sewanee where he founded the enlightened *Sewanee Review* (1892).

Henry Watterson (1840–1921) became editor of the Louisville *Courier–Journal* in 1868 and made it one of the most politically influential newspapers in the South. He advocated free trade and conciliation between the North and South and opposed the Ku Klux Klan. In *The Compromises of Life* (1906) he defended his bold political opinions and also satirized America's superficial "Four Hundred" society. In his declining years he reversed many of his liberal opinions, however, and opposed woman suffrage and the League of Nations.

Walter Hines Page (1855–1918) was decidedly more liberal in his political opinions than his cousin, Thomas Nelson Page. He ridiculed his fellow North Carolinians for their worship of the Confederate dead, their strict adherence to religious orthodoxy, and their fear of the Negro. In his novel *The Southerner* he made harsh but constructive criticisms of his native region.

While Page defended and Cable challenged Southern traditions, both men focused on the white landowners and Negro slaves and freedmen of their respective regions. The poor white families of the South intrigued them less, although Page in "Little Darby" and "Run to Seed" and Cable in *Bonaventure* described with some accuracy the existence of average citizens who lived apart from the plantation system. Tales of the small farmer seemed tepid, perhaps, to a reading public accustomed to chivalrous Virginians and haughty Creoles. Yet there was a small, persistent number of writers who attempted to depict the spirit of the plain people. Most of them chose the frontier areas as settings for their stories.

Augustus B. Longstreet's *Georgia Scenes,* which appeared in 1835 and 1840, describes the Georgia Crackers. Longstreet visited the rural areas as a circuit judge and his earthy, humorous tales were widely read in the South. There are occasional notes of condescension in Longstreet's treatment of crude back country characters. He usually prefaced a racy dialogue with the comment, "I should certainly omit such expressions as this could I do so with historic fidelity . . ."[31] Also in 1840 William Tappan Thompson wrote *Major Jones's Courtship,* a comic story composed of letters describing episodes in rural Georgia. More than two decades passed before another Southerner wrote a significant book about the poor whites. George W. Harris's *Sut Lovingood Yarns* appeared in 1867 and was a major contribution to American humor. Harris was the first Tennessean to write of the Appalachian mountains. His chief character, Sut Lovingood, is a rough mountaineer of the Great Smoky region who speaks irreverently of the dances, funerals, and camp-meetings he has attended. Lovingood's dialect is more comic than accurate, and his Rabelaisian humor and love of the practical joke indicate that he is intended to burlesque mountain life rather than create an authentic atmosphere.

Mary Noailles Murfree, who wrote under the pseudonyms of R. Emmet Dembry and Charles Egbert Craddock, became a more important chronicler of the mountaineers than Harris. Miss Murfree's stories and novels are conscientious studies of a people who, according to Lucy Lockwood Hazard, "approximate the rank and file of the pioneers more closely than do any other contemporary Americans."[32] Feuds, gambling and revivals provide the chief recreation for Miss Murfree's pioneers and she records their superstitions and customs with amused sympathy. The bleak lives of her characters are contrasted ironically with the grandeur of the Tennessee mountains. She acknowledges her fondness for setting

[31]Quoted by John D. Wade, *Augustus Baldwin Longstreet,* (New York, 1924), p. 164.

[32]L. L. Hazard, *The Southern Frontier,* (New York, 1927), p. 81.

in an unpublished letter she wrote to L. M. Hosea in 1886. Hosea had sent Miss Murfree some water-colors to remind her of the mountains after she had returned to St. Louis to write. Miss Murfree writes in this letter:

> I have just received the charming water-color sketches of Tuckaleechee Cove and Little River with the Great Smoky in the background, which you kindly sent to me. They are so imbued with the spirit of the locality that I have only to glance at them to feel I am again among the mountains.[33]

Miss Murfree's first volume, *In the Tennessee Mountains* (1884), is a collection of eight stories which had previously appeared in the *Atlantic*. The book was an instant success and went through fourteen editions. The individual stories in the volume are impressionistic sketches, as F. L. Pattee has observed:

> Strictly speaking, her short stories are not short stories at all save in the one element of their shortness. She records simple, everyday incidents in their natural sequence and stops when the space alloted to her has been filled. She moves leisurely from incident to incident in the monotonous vacuity of mountain life, as a minutely written journal might move.[34]

The first novel which Miss Murfree wrote was her most popular. *The Prophet of the Great Smoky Mountains* (1885) tells the story of Hiram Kelsey, a religious leader who loses his own faith. Kelsey and the rakish Mink Lowrey of Miss Murfree's *In the Clouds* (1886) are mountain men without literary parallels in other areas of the South. The women in Miss Murfree's books resign themselves stoically to hard work and boredom, and they remind us of Garland's long-suffering farm wives in Wisconsin and the Dakotas. Consider Garland's description in *A Son of the Middle Border* of his own mother's duties:

> . . . With the widening of the fields came the doubling of the harvest hands and my mother continued to do most of the work herself—cooking, sewing, washing, churning and nursing the sick from time to time . . . Even on Sunday . . . she was required to furnish forth three meals, and to help Frank and Jessie dress for lunch. She sang less and less, and the songs we loved were seldom referred to.[35]

Miss Murfree did not share Garland's interest in economic reform; she limited herself to sympathetic observations of a people she respected. The quality of her work is uneven and the best of it is dated now by excessive geographical description and sentimentality. But her accomplishment is significant if we consider her as a spokesman for a forgotten segment of society.

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[33]Mary Murfree, Letter to L. M. Hosea written on March 1, 1886, in St. Louis. Unpublished letter, permission of Southern Historical Collection, University of North Carolina.

[34]F. L. Pattee, *The Development of the American Short Story*, p. 272.

[35]Garland, *A Son of the Middle Border*, (New York, 1962), pp. 132–33.

The fiction of the deep South and the Appalachian Mountain territory is as much a part of the whole South as the literary tradition of the Tidewater. But the myths of plantation life better suited the public demand for romance after the Civil War. The preference of readers from the South, North, Midwest and far West for idealized rather than realistic studies of Southern life indicates a national reluctance to face the issues raised by the War and bears testimony to the complicity of the whole nation in keeping alive a tottering legend.

SURFACE-DRIFT INSECTS AS TROUT FOOD IN THE BRULE RIVER

*Robert L. Hunt**

Food obtained from the water surface can be important in the diet of trout during certain months. Studies by Metzelaar (1929), Needham (1930), Dimick and Mote (1934) and Benson (1953) in the United States, Ricker (1930) and Idyll (1942) in Canada, and McKeown (1934) and Butcher (1945) in Australia consider use of this food resource by trout in streams, and those of Leonard (1949) in Michigan, Allen (1938) in England, and Nilsson (1954) in Sweden by trout in lakes. O'Donnell and Churchill (1954) analyzed the stomach contents of 440 trout collected from several stretches of the Brule River during 1944. They stated: "The trout food consists of insects principally; the proportion of aquatic forms being very high during the spring and decreasing during the summer. In late summer and early fall land insects are the predominant food." None of these investigators related utilization of surface-drift food to any measurements of its abundance. Hess and Schwartz (1940) proposed the concept of "forage ratios" to compare the abundance of various foods of fish in the environment and in fish stomachs, but they did not use surface-drift food in these comparisons.

My investigation concerned: (1) utilization of surface-drift food by trout in one stretch of the Brule River during a 10-week period, (2) daily changes in the composition of this food resource during the period, and (3) consumption of this resource by trout in relation to its daily abundance. The study was conducted in the "Spring Lake" section of the Brule River (Section 3, T46N, R10W) in Douglas County, Wisconsin, the last of three such broad reaches on the upper river. The depth of "Spring Lake" varies from a few inches to several feet, and the substrate is composed of sand, muck, and organic debris. Rooted aquatic vegetation is usually abundant by July and becomes enmeshed with thick growths of filamentous algae as summer progresses. The river banks are lined by a strip of white cedar in association with white birch, speckled alder, and aspen. Elevation of the river at this point is approximately 995

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feet, or 27 feet lower than the source. The river drops approximately 440 feet over its 49-mile length. A thorough description of the river and its watershed has been published in a series of papers in the Transactions of the Wisconsin Academy of Sciences, Arts and Letters, Volumes 36 and 37.

Wild populations of brook trout *(Salvelinus fontinalis)*, brown trout *(Salmo trutta)* and rainbow trout *(Salmo gairdneri)* are present in Spring Lake but little is known about their abundance.

Methods and Materials

Using the drift-net described by Needham (1928) as a guide, a net 15 feet x 3 feet was constructed from No. 2 bolting cloth. A hole was made at its center and a standard No. 2 plankton-net was attached to serve as a central collecting basket. During the period of June 16–September 7, 1958, this net was used to make 33 one-hour collections of organisms drifting on the surface of the river. All collections were made at the same site. Stream width at this point was 67 feet, average depth was 26 inches, and average surface velocity was approximately 1 foot per second. Each collection consisted of three 20-minute samples. A sample was taken near each bank and the third in midstream. It was necessary in practice to reduce the net-length from 15 feet to 7 feet for more convenient handling. The net was tended while staked in place and periodically cleaned of debris to reduce disruption of normal current-flow into the net. The contents of each 20-minute sample was transferred to a temporary container and preserved in alcohol. All collections were made between 10 a.m. and 12 noon.

Immediately following the surface-drift collection a sample of trout was collected with fly-fishing gear. Fishing was limited to a two-hour period. Trout stomachs were preserved in alcohol. Species, length, and weight data were recorded for each specimen.

In the laboratory each hourly collection made with the drift-net was poured into a white porcelain pan and organisms were sorted from the debris. For convenience these organisms will hereafter be collectively referred to as "insects" since this Class accounted for 99 percent of the total. Each collection of insects was portioned into two categories:

1. subsurface insects that lived on the bottom of the stream or in midwater
2. Surface-drift insects that consisted of:
   a. mature forms that had emerged from the water after completing their aquatic stages of development
   b. mature and immature terrestrial insects

Insects in the first category were discarded. Insects in the second category were counted and assigned to subtotals a) and b) listed above and classified to Order. Data for hourly collections were compiled into weekly, monthly, and seasonal series.

Food in each trout stomach was also assigned to subsurface and surface-drift categories. Numbers of insects in each category were recorded and the volumes of each category were measured to the nearest 0.1 ml. by water displacement. Insects in sub-surface fractions were not classified; those in the surface-food fraction were classified to Order. Data for individual stomachs were grouped for each species of trout and for all three species combined.

FINDINGS AND DISCUSSION

When the numbers of surface-drift insects in hourly net catches were paired with mean numbers of surface-drift insects per group of stomachs obtained on corresponding days, a positive correlation was indicated. Utilization of surface food appeared to be directly related to its abundance. This relationship between numbers of surface-drift insects in net catches and trout stomachs, illustrated in Figure 1, is statistically highly significant ($r = 0.47$, $F = 8.78^{**}$, d.f. $= 30$). Collectively the daily groups of stomachs represented in Figure 1 are a composite 179 rainbow trout, 56 brown trout, and 36 brook trout. Correlations between surface-drift insects in net collections and trout stomachs grouped by species are statistically significant at the 95 percent level for brown trout ($r = 0.58$) and at the 99 percent level for brook trout ($r = 0.90$) and rainbow trout ($r = 0.47$).

Of the 293 stomachs retained for analysis, one was empty, 21 contained food that had been digested to an unrecognizable condition, and 271 contained identifiable items of food. Distribution of this last group according to collection date and species is summarized in Table 1. The number of trout stomachs in daily groupings varied from 3 to 16. Mean sample size was 7 in June, 7 in July, 9 in August, and 10 in September.

Numbers of surface-drift insects netted per hour ranged from 30 to almost 6,000. Peak numbers were collected during the second and third weeks of August (Table 2) with reproducing and dying Ephemeroptera *(Trycorythodes sp.)* accounting for 98 percent of all surface-drift insects netted during this two-week period.

Surface-feeding activity also reached peak intensity during this period. Stomachs of trout collected were grossly distended. The stomach of a 10-inch rainbow trout caught on August 9 contained 3,380 adult mayflies.

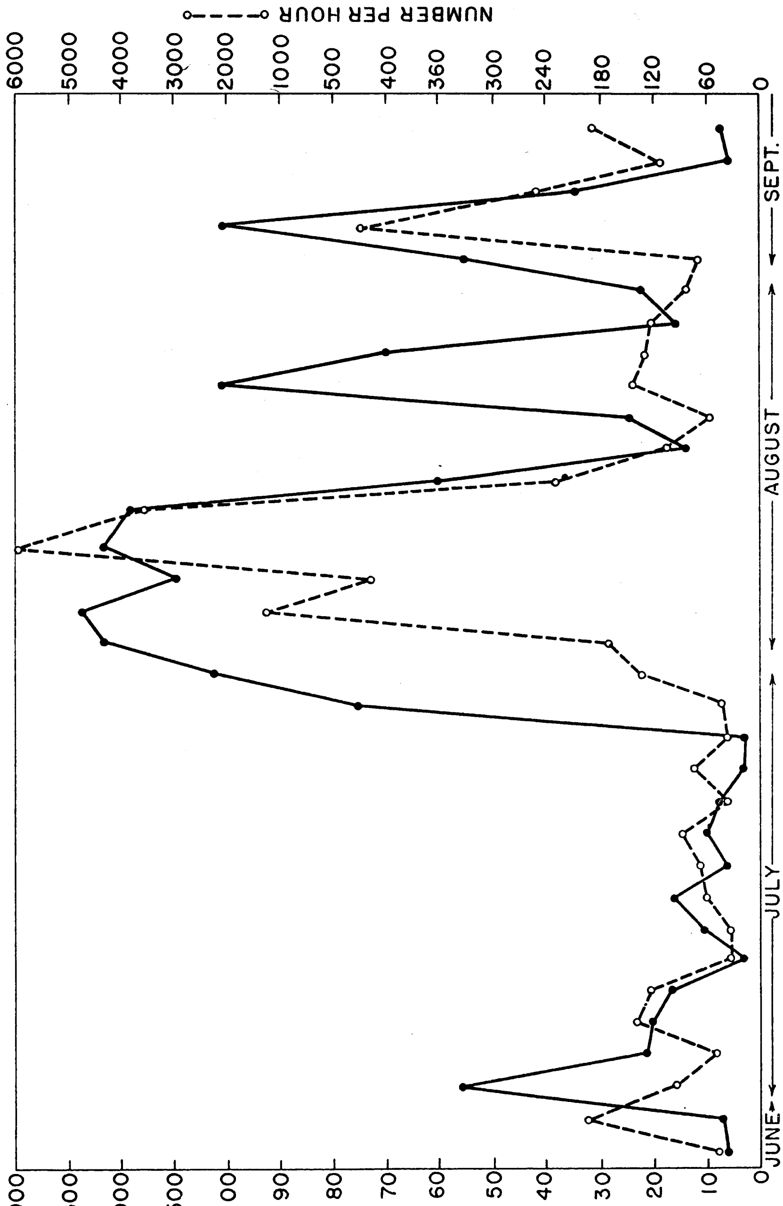

FIGURE 1. Relation between the mean number of surface-drift insects per group of stomachs and the number of surface-drift insects captured per hour by catch-net. (Based on 271 stomachs—Brook, Brown, and Rainbow)

TABLE 1. A SUMMARY OF THE CATCH DISTRIBUTION BY MONTH AND DAY OF 271 TROUT USED FOR STOMACH ANALYSIS

Month	Day	Number of Trout				Mean Sample Size for Month
		Rain-bow	Brown	Brook	Total	
June	26	3	—	—	3	
	27	10	1	—	11	
Total		13	1	—	14	7
July	1	1	4	—	5	
	3	5	—	—	5	
	5	8	1	3	12	
	7	1	1	4	6	
	9	3	—	1	4	
	10	8	—	2	10	
	14	6	3	5	14	
	17	2	1	2	5	
	18	4	3	2	9	
	21	4	1	1	6	
	22	4	1	—	5	
	24	2	1	—	3	
	29	4	1	—	5	
	31	4	5	—	9	
Total		55	22	21	98	7
August	4	3	4	—	7	
	7	8	8	—	16	
	9	7	2	2	11	
	13	7	—	1	8	
	17	10	—	—	10	
	19	6	3	1	10	
	21	3	2	1	6	
	23	5	3	—	8	
	25	4	3	2	9	
	26	8	1	1	10	
	28	6	1	1	8	
	30	6	—	—	6	
Total		73	27	9	109	9
September	1	10	—	1	11	
	2	5	2	1	8	
	4	13	1	—	14	
	6	4	2	3	9	
	7	6	1	1	8	
Total		38	6	6	50	10

Approximately 86 percent of the food present in the total collection of 271 stomachs consisted of surface-drift insects. Within weekly groupings of stomachs the numerical contribution of surface-drift insects ranged from 8 percent during the last week in June to 98 percent during the second week in August. The 10-week mean was 56 percent. On a volumetric basis surface-drift insects accounted for 76 percent of the food in all stomachs and 29–98 percent of the volume in weekly collections. The 10-week volumetric mean was 59 percent. In 6 of the 10 weeks both the number and volume of surface-drift insects consumed exceeded consumption of subsurface food (Table 3).

Approximately 31 percent of the surface-drift insects in stomach samples consisted of terrestrial insects. In the net catches terrestrial insects constituted an average of 26 percent of the weekly col-

TABLE 2. NUMBER OF SURFACE-DRIFT INSECTS COLLECTED PER HOUR WITH A CATCH-NET AND THEIR ORIGIN ACCORDING TO TERRESTRIAL OR AQUATIC SOURCES

Month	Week	Day	Total Number per Hour	Terrestrial		Aquatic	
				Number	% of Total	Number	% of Total
June	4	26	48	30	62	18	38
		27	192	119	62	73	38
Weekly Average				74	62	45	38
July	1	1	159	8	5	151	95
		3	60	22	37	38	63
		5	144	15	10	129	90
		7	134	50	37	84	63
Weekly Average				24	19	101	81
	2	9	30	4	13	26	87
		10	30	14	47	16	53
		14	68	32	47	36	53
Weekly Average				17	39	26	61
	3	17	72	34	47	38	53
		18	87	50	57	37	43
		21	45	27	60	18	40
Weekly Average				37	54	31	46
	4	22	70	34	49	36	51
		24	37	17	46	20	54
		29	46	8	17	38	83
		31	130	4	3	126	97
Weekly Average				16	22	55	78

TABEL 2. NUMBERS OF SURFACE-DRIFT INSECTS COLLECTED PER HOUR WITH A CATCH-NET AND THEIR ORIGIN ACCORDING TO TERRESTRIAL OR AQUATIC SOURCES—Continued

Month	Week	Day	Total Number per Hour	Terrestrial		Aquatic	
				Number	% of Total	Number	% of Total
August	1	4	169	23	14	146	86
		7	1,224	15	2	1,209	98
Weekly Average				19	3	678	97
	2	9	414	17	4	397	96
		13	5,936	15	1	5,921	99
Weekly Average				16	1	3,159	99
	3	17	3,582	17	1	3,565	99
		19	224	26	12	198	88
		21	96	33	34	63	66
Weekly Average				25	2	1,913	98
	4	23	41	14	34	27	66
		25	136	30	22	106	78
		26	126	15	12	111	88
		28	112	21	19	91	81
		30	75	12	16	63	84
Weekly Average				18	19	79	81
September	1	1	64	23	36	41	64
		2	447	199	45	248	55
		4	240	74	31	166	69
		6	72	9	13	63	87
		7	180	86	48	94	52
Weekly Average				78	39	122	61
10-Week Totals and Mean of Weekly Means			14,490	1,097	26.0	13,393	74.0

lections of surface-drift insects but only 8 percent of the total of 14,490 surface-drift insects from all 33 hourly samples (Table 2). Most of the insects floating on the river were adult forms having aquatic stages of development. Some were still in the final stages of maturation, while others had returned to deposit eggs or had died and fallen to the surface. Carried along by the current they formed the bulk of the daily supply of surface food during the sampling period. The numbers of aquatic and terrestial insects in each hourly collection of surface-drift and their percentages of each total sample are summarized in Table 2.

TABLE 3. NUMERICAL AND VOLUMETRIC CONTENT OF SUBSURFACE FOOD AND SURFACE-DRIFT FOOD

Month	Week	No. of Stomachs	Subsurface Food Averages				Surface-drift Food Averages			
			No.	%	Vol. ml.	%	No.	%	Vol. ml.	%
June	4	14	54	92	0.5	71	5	8	0.2	29
July	1	28	25	44	0.2	25	32	56	0.6	75
	2	28	27	73	0.3	75	10	27	0.1	25
	3	20	33	89	0.3	75	4	11	<0.1	25
	4	22	53	36	0.5	50	93	64	0.5	50
Monthly Total		98								
or Average			34	61	0.3	56	35	39	0.3	44
August	1	23	20	2	0.1	2	1,302	98	4.1	98
	2	19	12	2	<0.1	4	788	98	2.5	96
	3	26	42	11	0.2	14	328	89	1.2	86
	4	41	60	50	0.3	43	59	50	0.4	57
Monthly Total		109								
or Average			34	16	0.2	16	619	84	2.1	84
September	1	50	37	45	0.2	50	45	55	0.2	50
10-Week Total		271								
and Mean of Weekly Means			36	44	0.3	41	267	56	1.0	59

Ephemeroptera and Diptera ranked first and second in abundance in net collections and stomach samples. Ephemeroptera accounted for 52 percent of the number of surface-drift insects netted per week and 65 percent of the number of surface-drift insects in weekly groupings of trout stomachs.Diptera accounted for 22 percent of the weekly net catches and 11 percent of the weekly consumption of surface-drift insects. Nine orders of insects plus Araneida (spiders) were represented in the surface-drift collections (Table 4).

According to O'Donnell and Churchill (1954), two of the most common fish in the Brule River other than salmonids are the white sucker *(Catostomus commersonnii)* and the mottled sculpin *(Cottus bairdii)*. In 32 collections of fish obtained with electro-fishing gear white suckers were approximately twice as numerous as trout. Sculpins, plus minnows and darters, were five times as numerous as trout. While some minnows and darters utilize surface-drift food, suckers and sculpins do not (Starrett, 1950 and Dineen, 1951). It was not the intent of my investigation to determine the degree of competition for food between trout and associated species of fish in the Brule River. However, this investigation has shown that surface-drift constituted an important food resource for trout during the summer months, and that it was utilized in approximate relation to its abundance. Therefore, if competition for subsurface food does exist, the surface-feeding behavior of trout takes on added importance. Surface-drift insects account for a major fraction of their total food consumption during the summer, and when trout rise to feed at the surface they no longer have to compete with the white sucker and mottled sculpin for food.

TABLE 4. TAXONOMIC COMPOSITION OF SURFACE-DRIFT INSECTS IN WEEKLY NET COLLECTIONS AND STOMACH SAMPLES

ORDER IN	% OF TOTAL NUMBER OF INSECTS										MEAN OF WEEKLY MEANS
	June	July				August				Sept.	
	4	1	2	3	4	1	2	3	4	1	
Arancida—Net	1.7	—	3.1	2.4	1.0	—	<0.1	—	0.2	0.2	0.9
—Stomachs	2.9	0.2	1.0	2.2	0.1	—	—	—	<0.1	0.1	0.6
Coleoptera—Net	27.6	6.0	5.5	10.3	5.3	0.2	0.1	0.2	1.7	11.2	6.8
—Stomachs	27.9	1.5	7.6	13.5	0.5	—	<0.1	<0.1	0.2	0.7	5.2
Diptera—Net	30.1	29.3	45.3	48.5	20.3	3.6	0.3	3.4	23.1	14.3	21.8
—Stomachs	32.4	24.3	8.2	29.2	0.3	<0.1	—	<0.1	11.5	3.4	10.9
Ephemeroptera—Net	5.4	54.2	11.7	5.4	53.3	94.8	99.2	95.6	56.8	47.5	52.4
—Stomachs	2.9	64.0	5.2	3.4	98.2	99.7	99.9	99.9	83.4	91.8	64.8
Hemiptera—Net	—	0.2	0.8	3.4	7.0	0.1	0.1	—	2.0	1.3	1.5
—Stomachs	—	0.3	1.0	7.9	—	—	—	—	0.2	0.4	1.0
Homoptera—Net	6.7	2.4	6.2	6.4	3.3	0.6	0.1	0.3	7.2	11.3	4.4
—Stomachs	16.2	4.8	30.2	19.1	0.2	<0.1	—	—	1.2	0.9	7.3
Hymenoptera—Net	13.4	4.6	19.5	13.7	4.7	0.4	0.1	0.3	3.5	7.9	6.8
—Stomachs	2.9	1.7	15.8	9.0	0.4	—	—	<0.1	0.4	1.2	3.1
Lepidoptera—Net	0.4	—	—	—	—	—	—	—	—	—	0.1
—Stomachs	1.5	—	—	—	—	—	—	—	—	<0.1	0.1
Psocoptera—Net	—	—	0.8	1.5	—	—	—	—	1.5	1.4	0.5
—Stomachs	—	0.1	2.4	2.2	—	—	—	—	0.2	—	0.5
Trichoptera—Net	14.6	3.2	7.0	7.8	3.0	0.3	0.2	0.2	3.9	4.8	4.5
—Stomachs	13.2	3.1	22.7	5.6	0.4	0.3	<0.1	<0.1	2.8	1.3	5.0
Unidentified —Stomachs	—	0.1	5.8	7.9	—	—	—	—	—	—	1.4

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THE CONTRIBUTION OF *DIE FREIEN GEMEINDEN* TO SCIENCES, ARTS AND LETTERS IN WISCONSIN

*Berenice Cooper**

In the record of Wisconsin's contribution to sciences, arts and letters, the part of a small group of nearly forgotten liberals deserves recognition. No group of pioneers in the 1850 to 1880 period of state history was more devoted to the encouragement of the intellectual life than were *die Freien Gemeinden,* the Free Congregations, in the German–American settlements. In the midst of a rugged physical struggle against the hardships of pioneer life, they never lost sight of the need to nourish the mind as well as the body; their ideal was to promote a continuous search for more and more knowledge and to use that knowledge for the general welfare.

These forgotten humanists of 1850–80 were devoted to the principle expressed later by the Regents of the University of Wisconsin in their 1894 report:

> Whatever may be the limitations which trammel inquiry elsewhere, we believe that the great State University of Wisconsin should ever encourage that continual and fearless sifting and winnowing by which alone the truth can be found. (II, 110.)

Die Freien Gemeinden were minority groups in the German–American settlements which were established in Wisconsin from 1848 to 1880: the majority of the German immigrants were orthodox Lutherans or Catholics who did not approve of the Free Congregations. The history of these Free Congregations had begun in Germany between 1840 and 1844, when groups within both Protestant and Catholic churches had declared their independence from orthodoxy in church dogma and authoritarianism in church government. It was the victory of the conservative forces after the failure of the German Revolution of 1848 which influenced many members of *die Freien Gemeinden* to join the immigration of Germans to the United States.

During the next twenty-five or thirty years after the first migration of 1848, societies of *die Freien Gemeinden* were found in many German settlements from New York to San Francisco, and subscription lists published in their monthly magazine, *Blätter für*

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freies religiöses Leben, show individual members as far south as Texas. The strongest *gemeinden* were those established in Philadelphia, St. Louis, Sauk City, Milwaukee, and San Francisco, but smaller ones existed for a time in communities in Ohio, Michigan, Indiana, Illinois, and Minnesota. Wisconsin had 32 in 1852, according to Eduard Schröter, who traveled about the state giving lectures on the principles of the Free Congregations and organizing the smaller groups. But by 1862, he was lamenting the decrease in membership and the apathy within the groups (I, Dec., 1862, 91). Today the only active groups in Wisconsin, and perhaps in the United States, are Sauk City and Milwaukee.

Although the Free Congregations have been fading away in Wisconsin and in the rest of the United States, they made a contribution to the intellectual life of the period in which they were active forces in some of the German–American settlements. Their contributions of a lively interest in nineteenth century science, in encouragement of music, debate, and drama, in the study of philosophy, history, and literature deserve recognition.

It is the purpose of this paper to present evidence of the contribution of *die Freien Gemeinden* to the Wisconsin philosophy of untrammeled inquiry in the search for truth and to the encouragement of the sciences, arts and letters in the 1850–1880 period in the history of Wisconsin. The examples that follow come from the constitutions of these societies, from their statements of belief, and from the content of their monthly magazine, *Blätter für freies religiöses Leben,* published from 1856 to 1876.

The constitutions of the two surviving Free Congregations of Wisconsin contain many phrases affirming the intellectual freedom of the individual, the importance of continuous search for truth through the study of nature and history, the belief that knowledge of truth grows from age to age, and the ideal that increasing knowledge should be used to make the world a better place for human beings.

Sauk City Free Congregation, in its constitution adopted in 1853, expresses its belief in freedom of thought for the individual member:[1]

> There shall be no doctrine formally stated and authoritatively proclaimed or laid down as by a church . . . The object of this organization is, therefore, not the subjection of man to extraneous authority of one person or one book for the purpose of rendering him blest, but on the contrary, the *intellectual and moral freedom of man,* his independence and individuality in thinking, deciding, and acting . . . *We have no doctrines or creeds established for all time,* but instead *fundamental principles and views of life which are subject to continual reclarification and examination.* (IV)

[1]In all quotations which follow the italics are mine and are intended to call attention to the emphasis upon the right of free injuiry, the continuous search for truth, and the tentative character of all statements of belief.

The Milwaukee Constitution emphasizes the importance of education and the use of science to make a better world:

> Conscious of the limitations of the human mind and aware of our dependence upon forces known and unknown amid which our brief lives are spent, we seek nevertheless *through education and dissemination of the truths of science to dispel ignorance and mysticism and destroy superstitions* --
>
> --
>
> *to establish through observation and experience* a system of philosophy wide as the world and embracing all men, which will attempt to ascertain *man's relation to the universal forces about him* and place him in harmony with such forces mentally and physically.
>
> Through knowledge of his common origin, his common end, and a realization of his common needs and tasks, to which we subscribe, man will eventually be able *to make of this earth, which is his home, a place where the good and true and beautiful will survive.* (III)

In 1856, Friedrick Schünemann–Pott, speaker of the Philadelphia *Gemeinde* and editor of the *Blätter* . . ., wrote an article to answer the question "What do the *Freie Gemeinde* of Philadelphia believe?" After stating that they do not tie themselves to a creed, he says:

> We say that the *Freie Gemeinde* wishes the rule of reason or rests upon the unconditional freedom of the human spirit revealing itself in moral acts, or it aspires toward the universal development of human beings in the way of knowledge and the moral life . . . . .
>
> But to answer the requests for a *Freie Gemeinde* creed, with the understanding that no one is bound by it for all time and that it is a gradually developing belief, I will set down the following:
>
> --
>
> --
>
> We do not wish to form a new sect but to reconcile the unhappy conflict of men about the forms of religion by promoting reasonable beliefs.
>
> In this sense all religions of past and present appear to us as a part of the spiritual development of mankind.
>
> For us religion consists in the reasonable knowledge of the world and its laws, especially the knowledge of the earth and of developing human nature and the consistent application of this knowledge upon the form of our own life and society's, or in other words the essence of all truth, justice, and love.
>
> We do not inclose the content of our religion in any narrowing limiting creed or hold any external customs, but consider the entire life itself in its manifold evidences an expression of moral and reasonable world view.
>
> We have no holy book, no holy places, holy times, holy customs, no holy priesthood. Instead of a holy book, nature and history; instead of holy places the entire and unified world, instead of holy times, the whole life of humanity from the beginning to the end; instead of holy customs every good and beautiful thing born of perception . . .; instead of privileged priesthood there is with us the independence of all members with equal rights, who choose by their own free judgment their speakers, teachers, and all officers.

When the *Freie Gemeinde* of Plymouth, Wisconsin, reorganized in 1870 after a period of inactivity, they summarized their philosophy of life in a statement which shows the influence of nineteenth century science and rationalism:

> We place reason above revelation; in place of faith, free search for knowledge; in place of two world, one (of whose existence we are certain); in place of miracle, natural law; in place of God's providence, man's own providence; in place of predestination, fate; in place of man torn between body and soul, the unified, harmonious man; in place of trust in God, self-confidence; in place of humility, the consciousness of human dignity; in place of abstinence, the moderate use of pleasure; in place of desire for reward, the love of good for its own sake; in place of heaven on the other side, heaven on this side (in the hearts, homes, the societies, the states) among the people; in place of values on the other side, values on this side; in place of inexplicable secrets (mysteries), unsolved problems; in place of the Bible, the book of nature and history; in place of the pulpit, the speaker's platform; in place of the preacher, the speaker; in place of supernatural salvation of the soul, the natural education of the spirit and heart; in place of prescribed ritual, free customs; in place of the Christian school, the free Humanisitic school. We strive for welfare, education, freedom for all without distinction in religion, in race, in nation, in rank, in sex.
>
> Our religion is free Humanism, for it has its origin in man, including his development and continuing education through humanity, and consists essentially in the perception of and reverence for humanity.
>
> This is our present general rule and plumb-line. *But there are no irrevocable conclusions of faith.* We can make for our thought and life in the future better rules and plumb-lines as it may be possible to do. Each age is its own law-giver.

The above statements show that in the nineteenth century conflict between fundamentalist religion and science, *die Freien Gemeinden* supported the new science. Further evidence of the Free Congregations' interest in science is contained in the list of the topics for lectures given at the meetings of the Sauk County Free Congregation and in the contents of the monthly magazine *Blätter für religiöses Leben.*

Mrs. Clara Runge lists among the lecture topics the following: "Bacteria, their Relation to Agriculture"; two lectures by the famous University of Wisconsin scientist, Max Otto, "Darwinism," and "Mentality of the Higher Apes"; lectures on such scientists as Kepler, Copernicus, Galileo, and Alexander Humboldt (IX, 20–26).

The table of contents of the *Blätter* . . . includes many articles on scientific topics: "New Discoveries About Sun and Sunlight," "On the Meaning of the Process of Decay in Nature," "The Wonders of Astronomy," "Recent Research into the Formation of Meteors," "What Chemistry Can Do and Can Not Do," "The Evolution of Organic Forms and the Evolution of Man," "Science and

Darwinism," "Progress or Rotation in Human Evolution," "The Laws of Evolution in Human History," "The History of the Earth," "The Ice Age."

The emphasis upon the evolution of the universe and of man in the lectures and the magazine articles is consistent with the statements of belief in the book of nature and history as the source of authority and in the evolution of man's knowledge about his environment, which are asserted in the constitutions of Sauk County and Milwaukee and the statement of principles by Plymouth.

In the *Blätter* . . . one finds also exerpts from new books on science of that period: M. J. Schleiden's *Plants and Their Life;* Hudson Tuttle's *History of the Laws of Creation;* a chapter, "People of the Amazon," from Humboldt's *Journey in the Region of the Equator;* the chapter "Fossils," from Bernard von Cotta's *Geology.* There are two articles by Alexander Humboldt on the study of nature: "The Influence of Knowledge of Nature upon the Enjoyment of Nature," and "The Importance of the Study of Nature for the Culture and Life of the People."

Scientific interest extended into the study of language; in the issue of January 1870, the *Blätter* . . . carried an article on "A Few Differences Between the Chinese Language and the European Languages."

Examples such as these are part of the evidence that the Free Congregations in Wisconsin encouraged the spirit of continuous search for more and more truth about the nature of the world and man's relation to it.

In the *Blätter* . . . and in their *gemeinden* activities *die Freien Gemeinden* did not neglect arts and letters. They included articles upon philosophy and literature, such as "Zur Erinnerung an Lessing," "Talents and Innate Ideas," "Difference Between Traditional and Scientific Ideas," "Greeks and Barbarians," "Pantheism and Our World Philosophy," "The Faust Legend." Mrs. Runge's list of lectures at Sauk City includes "The Grimm Brothers," "Emerson the Idealist," "Koerner the Poet," "Tolstoi," "Schiller's Life and Works," "Goethe's Faust," "Voltaire," "Anatole France" (IX, 20–26). Eduard Schröter in his reminiscences speaks of working on lectures on Fichte for the meetings of his congregation (I, Aug. 1862, 21–24).

A typical *gemeinde* participated in singing societies: men's, women's, and mixed choruses rehearsed regularly and gave concerts. Milwaukee still continues its musical activities, as the announcements in its monthly magazine, *Voice of Freedom,* show. In 1962 Milwaukee sent a chorus to the International Song Festival in Germany.

In addition to musical organizations, dramatic performances and evenings of declamation and debate encouraged the speech arts in any *gemeinde* large enough to manage such a program. Although Sauk City is now too small to keep up such activities, the scenery still stored in the balcony of their hall testifies to their former interest in drama. Like the Turner societies, the Free Congregations were eager to keep alive their heritage of German literature and music, and considered the education of the next generation an important responsibility. (VI, 59–71).

The interest of the members in the world of letters was stimulated by their libraries. Even so small a society as Bostwick Valley established a little library (VI, 67). The reports of a *gemeinde* to the National Association always included the number of books in the library along with a list of musical and literary activities carried on (VI, 59–71). Milwaukee and Sauk City still hold typical *gemeinde* libraries containing the works of great German writers, histories of Germany and of the United States, volumes on the science of the mid-ninteenth century, encyclopedias, dictionaries, and, of course, many books and pamphlets on the principles of Free Religion and Humanism.[2]

The membership of the Free Congregations was a group interested in the life of the intellect. Some were professional people, some were prosperous merchants, some were skilled artisans. They were all people of independent minds. When they settled in Wisconsin, even those who took up land and had to become pioneer farmers in order to make a living in their new home, continued their interest in intellectual activities. Eduard Schröter tells of his visit in the farm home of Herr Collip on "a half-island on Silver Lake, near Portage." Collip had come to "this lonely island before the Forty-eighters and in the roughness of the wilderness had made his dwelling a little temple of culture. In his study he had the works of Lessing, Hegel, and Schiller" (I, Nov. 1868, 71–72).

In Schröter's own case, there was a powerful conflict between the intellectual life and the need to keep up a little farm to supplement the salary of only $150 per year as speaker at Sauk City. At one time he was preparing a lecture on Fichte for the regular meeting of the congregation but was much aware of the fact that the corn needed hoeing. The conflict between the two duties oppressed his spirits, but after thinking it over, he decided that the more important duty was to be well-prepared for his lecture. "I remained with Fichte," he tells us (I, Aug., 1862, 21–24).

[2]The Milwaukee *Freie Gemeinde* published a catalogue of its library in March, 1945. The writer of this paper has had opportunity to work in the library of the Free Congregation at Sauk City, which is not catalogued, and to make a partial bibliography of the books on the history of *die Freien Gemeinden* in Germany and in the United States.

These two pictures of the scholar-farmer are typical of the *Freien Gemeinden* members, who made a place in their busy pioneer lives for intellectual growth and for enjoyment of literature and music.

No one can make the claim the *die Freien Gemeinden* were a major influence upon the history of Wisconsin's contribution to sciences, arts and letters. But as a minority group who valued the cultivation of the intellectual life and sought to free religion from all that was inconsistent with developing knowledge in science and history, these forgotten humanists deserve recognition. No one who reads their records of beliefs and activities can deny that they were a part of those who encouraged the untrammeled search for truth and stimulated the study of sciences, arts and letters in the state of Wisconsin.

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PINE INTERNODES AS INDICATORS OF NON-DETERMINABLE ENVIRONMENTAL INFLUENCES

*S. A. Wilde**

The morphology of red pine, *Pinus resinosa,* white pine, *P. strobus,* and several other American pines exhibits a unique feature of annually produced single whorls of branches. The whorls sharply delineate internodes or segments of the tree trunk which represent the height increment of trees during one growing season.

The length of the interwhorls or internodes is determined by the inherent growth capacity of trees and by conditions of the habitat. In a reduced light and on soils deficient in water, air, or nutrients, the internodes measure but a few inches; in a favorable environment they may be longer than 4 feet.

In young plantations established on open lands, the light factor plays a small part and the height growth usually reflects the edaphic and biotic influences. A deficiency of nutrients in the depleted surface soil layers and consumption of water by weeds are the most common conditions depressing the early growth of planted trees. More than 7 internodes below the breast height reveal a pronounced depression of young red and white pines.

With advance of age, the growth relations of the plantation undergo profound changes. Closing of the canopy and extention of roots aggravate the competition of trees for moisture and nutrients. Simultaneously, however, the overshading reduces competition of ground vegetation, and the growing roots encounter deeper soil layers of varying productive potentials. In consequence of all these changes, the growth of current internodes may be either retarded or accelerated. In turn, the sequence of internodes presents a conspicuous record of the chronological growth pattern of trees induced by environmental factors (Figure 1).

As our investigations have disclosed, the single readily determinable value which expresses the influence of site and soil factors is the ratio of the total height of trees of average diameter to the length of five internodes above breast height, or so-called "five-year intercept" (Wakeley and Marrero, 1958). Both components of this

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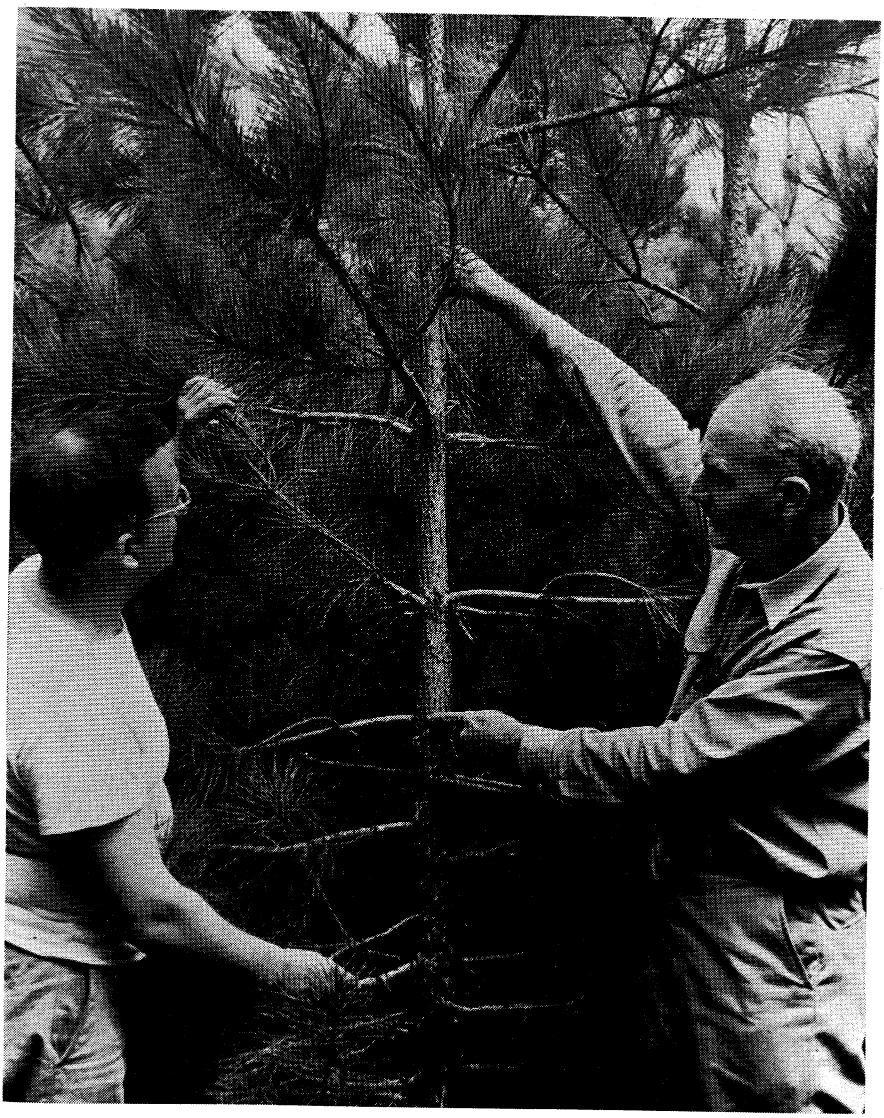

FIGURE 1. The chronological growth pattern of red pine marked by the length of internodes and including a period of starvation of the tree on a nutrient-deficient soil and an explosively accelerated height growth induced by an application of fertilizer. Courtesy of Prof. S. O. Heiberg, New York State University College of Forestry. (Photo by C. Wesley Brewster, Syracuse 10, N.Y.)

quotient can be rapidly and accurately measured by means of a hypsometer and an expandable 10-foot rod.

To facilitate calculations, the heights and intercepts are recorded in inches on per year basis, i.e., average height of measured trees over age (H) and the total length of the intercept over 5 (I). For example, a 20-year-old stand with average height of 25 feet and total length of the 5-year intercept of 100 inches has the H/I ratio of (25 x 12 ÷ 20) ÷ (100 ÷ 5) or 0.75. A discussion of the influence of weeds, composition of soil profiles, and ground water on the growth of trees follows.

The Height-Intercept Quotients of Plantations on Different Sites

Plantations established on areas which are reasonably free from weeds as a rule show a rapid height growth during the first ten to fifteen years, that is, during the period which determines the size of the 5-year intercept. A few years after closing of the canopy, the height growth usually begins to decline because of the increased competition of larger trees for water and nutrients. As a result, forest plantations between 15 and 40 years exhibit a fractional H/I quotient. In more than 75 per cent of surveyed red pine plantations of Wisconsin, the H/I quotient varies from 0.5 to about 0.9. The low H/I values are particularly common to plantations established on non-podzolic sandy soils underlain by purely siliceous substrata of fluvial deposits. This soil group is exemplified by members of *Boone* and *Sparta* series (Hole and Lee, 1955). According to observations in New York (Stone, 1963), a low H/I ratio is also characteristic of red pine plantations on poorly drained soils; on such sites a seemingly normal growth is followed by a drastic decrease in height increment and even death of trees.

A reverse of this stem morphology is caused by competition of weeds, which at times is especially severe on fine textured soils, e.g., those of *Miami, Casco, Dubuque, Kennan,* and *Ontonagon* series. On such sites, the early growth is retarded until the trees suppress weeds by their canopy. In consequence, the H/I ratio approaches or exceeds 1.0 at the plantation's age of 25 or 30 years.

A similar pattern of stand growth is common to plantations located on sandy soils with surface layers depleted in organic matter and nutrients by severe fires or prolonged agricultural use, but with fertile substrata enriched in alumino-silicate minerals. Particularly striking examples of such soils are the *Omega* and *Superior* soils, formed in blanket-like post-glacial deposits of aeolian sand, covering granitic outwash or lacustrine clays.

The most conspicuous irregularity in the pattern of height growth, expressed by the H/I ratio between 0.9 and 1.3, is found on naturally subirrigated soils with ground water at depths of from 4 to 9 feet (Wilde and Iyer, 1963). A contact of roots with the capillary fringe of these soils is manifested by a rapid acceleration of the height increment.

The two extreme patterns of tree morphology induced by ecological conditions are outlined schematically in Figure 2.

Although the H/I ratio varies with the age of stands, its amplitude is delineated by conditions of the habitat. Plantations on soils of quartzitic substrata show during their growth from 15 to 40 years a very narrow range of H/I values, descending from 0.8 to 0.6. Plantations of a similar age span on subirrigated soils also exhibit a limited H/I range, ascending from 0.9 to 1.3. On the other hand, weed-invaded soils and soils with depleted or strongly podzolized surface layers may show a very wide amplitude of the H/I quotient, ranging from 0.6 to more than 1.0. At the age between 40 and 50 years, the ratio attains an equilibrium and then begins to decline. A cursory examination of the habitat usually leaves no doubt as to the significance of the immediate H/I ratio.

Chronological Pattern of Stand Growth and Concept of Site Quality

As indicated in Figure 2, under the influence of soil, two stands can attain the same average height growth, let us say 40 feet at 30 years, by increments following diametrically opposed concave and convex curves. One of the stands can grow 25 feet during the first 15 years and 15 feet during the second 15 years of its life; another stand can grow 15 feet during the first and 25 feet during the second 15-years. In consequence, the stands of the same immediate site index may exhibit intercepts of 100 and 60 inches, and corresponding H/I ratios of 0.8 and 1.3, revealing essentially different chronological growth patterns. This information is of critical importance in understanding soil-forest relationship and in constructing yield tables; it indicates the necessity of a rigid ecological stratification of mensuration data of the stands even though they exhibit the same immediate height and site quality. A failure to comply with this requirement unavoidably leads to distortion of the polymorphism of natural growth curves, complication of statistical analyses by erratic data, and gross inaccuracies in the values of yield tables.

If Scotch pine and Norway spruce had as distinct internodes as some American pines, the two hundred-year-old European silviculture might have made greater progress in the two closely related fields of forest mensuration and ecology. Thus far it is only the Finnish school of Cajander (1909) and Ilvessalo (1923) that

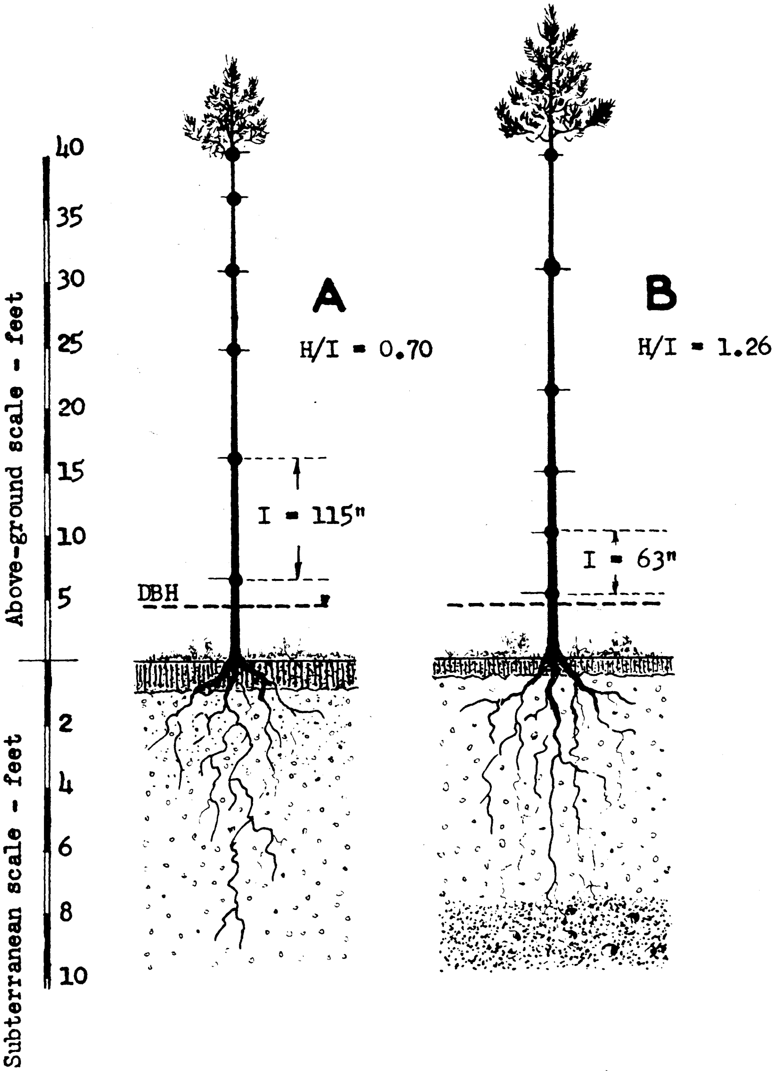

FIGURE 2. Growth patterns of red pine plantations imparted by soil conditions: A. Progressively declining height growth resulting from inadequate supply of water and nutrients in a soil with an infertile quartzitic substratum; B. Explosively accelerated growth caused by a contact of roots with water- and nutrient-bearing fine textured layer. Horizontal lines mark 5-year growth periods. Both plantations exhibit at the age of 30 years an identical site index of 58.

has placed mensuration on a natural ecological basis and thus liberated yield tables from empiricism and unwarranted generalities.

The Role of Internodes in the Appraisal of the Habitat

With availability of modern hypsometers, the determination of the H/I ratio makes possible a quick silvicultural appraisal of stands composed of internode-forming trees. The height-intercept relationship broadens the understanding of the kinetic aspects of forest growth and helps to visualize the intermittent growth-retarding and growth-promoting effects of soil profile.

A forester of the old school might have said that the H/I ratio helps one "to read the book of nature." In a large degree, his statement would be true because the chronological growth pattern of trees does not reflect only the potential of the growing stock and the effect of determinable properties of surface soil layers; it reveals also the unmeasurable influences of fluctuating ground water, nutrient bearing strata located beyond the depth of practicable excavation, and the competition of ground vegetation. The effect of these latter factors on the growth of trees is obvious and easily detectable, but it cannot be expressed in concrete figures with means at our disposal. These factors form the axiomatic foundation underlying the study of forest entities, many aspects of which cannot be cast into a regression equation and calculated, electronic computers notwithstanding. In part this is because "the world was created out of things which do not appear" (Barnett, 1952). A neglect of the non-calculable functions of environment and of the entire principle of mathematical uncertainty can only lead to a non-scientific juggling of figures and a regression from reality.

Summary

The stem morphology of internode-forming pines presents a conspicuous record of environmental conditions which influenced the growth of trees during different periods of their life. The ratio of the total height of trees (H) to the length of five internodes above breast height (I) reflects the chronological growth pattern of trees and provides a clue to the effects of competing vegetation, make-up of the soil profile, and ground water.

Within the age range of 20 to 40 years, plantations established on soils underlain by infertile substrata or a shallow water table are characterized by low values of H/I quotient descending with age from 0.8 to 0.6. Plantations of the same age span established on weed-invaded soils, especially those of fine texture, soils with depleted surface layers, but underlain by substrata enriched in

aluminum-silicate minerals, and soils with ground water at depths from 4 to 9 feet exhibit high values of the quotient, ascending with age from 0.9 to 1.3.

The paper emphasizes the importance of the chronological pattern of growth and the polymorphism of natural growth curves, indicated by the H/I quotient. In turn, rigid ecological stratification of mensuration results is suggested as a means of reducing complications of statistical analyses by erratic data and eliminating gross errors in appraisal of young plantations on the basis of their immediate site index.

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THE USE OF HISTORY IN BISHOP HURD'S LITERARY CRITICISM

*Stephen J. Curry**

A curious, persistent notion still circulates about literary criticism in the mid-eighteenth century. This is the period, we remember, that brought to public attention the diversified personalities of Richard Hurd, Joseph and Thomas Warton, Samuel Johnson, and Joshua Reynolds. It is a period in which the mainstream of bookish thought seems for a while to alter its course, changing as it were into little whirlpools that gather force as 1798 draws near. The basic problem as so often happens is a difficulty in terms. We run into the labels "preromantic" and "neoclassical," and depending on our own predilictions, we too often fail to observe the simple truth that the word is not the thing. In this paper I shall attempt to show that the really significant critical work of these middle years is not involved in a battle of words; the problem is more subtle. The Augustan critics are still making their presence felt; but the new critics at this time, almost as a justification for the brilliant work of the past, merely serve to broaden and deepen understanding of all English works that would appear to be drowned were it not for the fact of their gigantic intuitive appeal. Richard Hurd shows this deepening of critical appreciation, and we turn to him as a representative figure not because he is the best, but because he is often the least understood. Hurd does not espouse any kind of preromanticism. If we take the English manipulation of "neoclassical" (and the term is dangerous only if we use it as condemnatory), we cannot, except by great stretches of the imagination, call this man a forerunner of the early nineteenth century.

Our first task, then, is to avoid the idea that the middle part of the eighteenth century is not in itself valuable. What posterity does with its ideas is one thing; what the critics of the time attempt to do for themselves is quite another. To treat Hurd, the Wartons, and Bishop Percy only as direct contributors to the following century is ridiculous; the period does, after all, have value in itself. Critics and scholars need to review and to interpret what went on at that time. To be sure, the notion of "preromanticism," if we look at it in one way, has its own validity: Joseph Warton liked nature; so did Coleridge. But if we are to simplify the character of literary movements, then we must ultimately relinquish their in-

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dividual meaning and importance. No one will argue that Johnson suffers the same kind of dejection as Coleridge. And even disregarding the notable difference of character in these two authors, we can separate out elements in their thinking that are specifically appropriate to the main areas of thought in their time. But the aim of this article is not to prolong a dispute that is unanswerable by means of simple terminology. Rather, we are concerned here with the shape of thinking about various literary ages. This often maligned and frequently neglected middle period of the eighteenth century has a shape of its own, and we can see it clearly in the speculations of Bishop Hurd.

* * *

More than any other work from the mid-eighteenth century, Hurd's *Letters on Chivalry and Romance* (1762) has been hailed as a harbinger of Romantic criticism. Because it has so often been classified as "preromantic," it has never been analyzed at length except to show its real or supposed affinities with nineteenth-century thought.[1] What has been consistently neglected is the importance that the work may claim in its own right as sound criticism today. Upon a close reading of this work and others by Hurd, the reader immediately meets an odd fact: Hurd's edition of Horace, published before the *Letters,* and his edition of Addison, published after the *Letters,* are read as perfectly conservative by critics from Saintsbury to the present, whereas the *Letters* has been considered by a great majority to be in advance of its age, if not actually prophetic. And, to be sure, Hurd's work on Spenser differs widely from that of critics from Dryden through Thomas Warton. The difference does not lie in appreciating Spenser's "sublimity," "fancy," and ability to tell stories, or in explaining the nature of the plot in the *Faerie Queene.* Dryden had already explained that the plot was based upon a way of life which still existed in the court of Elizabeth; Prior had praised Spenser's plot, imagery, and even his diction and versification. Hughes, taking the lead from Dryden, remarks that the plot of the *Faerie Queene* has a solid basis but, being unfinished, is confused; and Upton praises the fact that Spenser treats unreality consistently—that is, he follows Aristotle's "probable impossible." As far as showing that the Romances of Spenser (in addition to those by Chaucer, Tasso, and Ariosto) are based on reality, Warburton expands a hint given by Dryden and Hughes into an eight-page explanation of Cervantes'

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[1]The following works are some of the main studies of Hurd as a precursor of Romanticism: Aisso Bosker, *Literary Criticism in the Age of Johnson* (Groningen, 1953); Audley L. Smith, "Richard Hurd's *Letters on Chivalry and Romance,*" *ELH,* VI (1939), 58–81; Edwine Montague, "Bishop Hurd's Association with Thomas Warton," *Stanford Studies in Language and Literature,* ed. Hardin Craig, 1941, pp. 233–256.

satire in *Don Quixote*. Even fuller accounts of the historical background of the Romances were to be found in two works, the first definitely, the second possibly, a source for Hurd's *Letters:* Sainte-Palaye's "Mémoirs sur l'Ancienne Chevalerie" and Chapelain's "Sur la Lecture des Vieux Romans."[2]

This kind of source-hunting often goes on indefinitely; other writers whom Hurd used for ideas in the *Letters* and Hobbes, Locke, Addison, and the three classical critics that Hurd, like his contemporaries, used constantly, Horace, Aristotle, and Longinus. Saintsbury (more than his followers) realizes that the *Letters* is derivative; he makes a point highly relevant to our study: "Scraps and orts of Hurd's doctrine may of course be found earlier—in Dryden, in Fontenelle, in Addison, even in Pope; but, though somebody else may know an original for the whole or the bulk of it, I, at least, do not."[3] Even though the "originality" Saintsbury finds has been proven derivative by later critics, it is perfectly true that something in the *Letters* makes the reader feel that there is something new being said. The main reason for this feeling is the sense of excitement running throughout this treatment of Spenser and the Italians; the critical reaction to Hurd's tone is that no one can talk so emphatically about the literature of "imagination" without being at least partly "Romantic." And, after all, in the history of taste such an emphasis upon Spenser, though rare in any age, is especially noteworthy in the eighteenth century, when Spenser was generally praised and criticized in a few lines or paragraphs. Previous to Hurd, extended discussions on Spenser are present only in his editors (Hughes and Upton) and Thomas Warton.

Yet the extreme nature of Hurd's praise ought to be balanced against a passage given as epigraph to the edition of Addison containing Hurd's notes, a passage which saddened Saintsbury:[4]

> I set out, many years ago, with a warm admiration of this admirable writer [Addison]. I then took a surfeit of his natural, easy manner; and

[2]John Dryden, "A Discourse concerning the Original and Progress of Satire," *Essays*, ed. W. P. Ker (Oxford, 1900), II, 28. Matthew Prior, *Literary Works*, ed. H. Bunker Wright and Menroe K. Spears (Oxford, 1952), I, 231–232, 307–308. John Hughes, ed., *The Works of Mr. Edmund Spenser* (London, 1715), I, xxvi–xxvii. Relevant material from Upton's edition is reprinted in William R. Mueller, ed., *Spenser's Critics* (Syracuse, 1959), p. 42. Warburton's work on Cervantes is reprinted in his edition of Shakespeare, (London, 1847), vol. II (unnumbered pages after *Love's Labours Lost*). Sainte-Palaye's work may be found in *Memoires de L'Academie des Inscriptions et Belles-Lettres,* XX (Paris, 1753), 595–847; Hurd refers to this study three times as a source for his information: *Works* (London, 1811), III, 190, 191; IV, 261. References to Hurd's writings, unless otherwise noted, will be given in the text and will refer to this edition. Because the *Letters on Chivalry and Romance* is available in so many editions, I shall cite only the Letter involved. Chapelain's essay (first printed in 1728) is given in Scott Elledge and Donald Schier, *The Continental Model* (Minneapolis, 1960), pp. 31–54. On the possible influence of Chapelain, see Victor M. Hamm, "A Seventeenth-Century French Source for Hurd's *Letters on Chivalry and Romance*," *PMLA,* LII (1937), 820–828.

[3]George Saintsbury, *A History of Criticism* (Edinburgh, 1949), p. 78.

[4]Saintsbury, p. 72. The edition of Addison was published in 1811.

> was taken, like my betters, with the raptures and high flights of Shakespeare. My maturer judgment, or lenient age (call it which you will), has now led me back to the favorite of my youth. And, here, I think, I shall stick: for such useful sense, in so charming words, I find not elsewhere. His taste is so pure, and his *Virgilian prose* (as Dr. Young styles it) so exquisite, that I have but now found out, at the close of a critical life, the full value of his writings.

This passage gives us a clue to one of Hurd's main traits as a critic: he has not given up Shakespeare; he is merely giving Addison as much praise as possible, for he speaks highly of Shakespeare in the edition of Addison itself.[5] The truth is that Hurd gives high praise to any great writer who succeeds completely in any type of writing; in the same way Horace is praised in Hurd's edition of the *Ars Poetica* and Cowley in Hurd's edition of his selected works. Others so praised in Hurd's criticism include Chaucer, Pope, Dryden, Tasso, Ariosto, Richardson, and many classical writers. One modern critic finds such catholicity of praise to be eclectic,[6] but Hurd would not have agreed, for he had a sound theory on which to base his admiration for many types of literature. In Letter X of the *Letters* we find a passage given so diffidently that we are apt to pass over it without realizing that it is central to all of his criticism; we refer to the description of three main types of poetry: those appealing to the judgment, to the heart, and to the imagination. Thus Addison, Cowley, and Spenser (or Shakespeare) are all great because each achieved near perfection in following the rules of a particular type of poetry. Such a view based upon empirical psychology may be "eclectic," but it is not necessarily disorganized, unphilosophical, or romantic.

That the *Letters* is typical of neoclassicism has also been shown clearly by critics who have emphasized Hurd's use of *a priori* reasoning, of determining rules through psychology, and of applying these rules according to genre.[7] However, such criticism, though it aids to balance the view of Hurd as a romantic, does not show why people differ in interpreting his criticism of Spenser and the Italian poets. It is obvious that Hurd has modified the neoclassical system of his predecessors in such a way as to make the nature of his critical system unclear to modern readers. Hurd's underlying assump-

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[5]See Hurd's note to line 67 of "An Account of the Greatest English Poets" in the edition of Addison.

[6]René Wellek, *A History of Modern Criticism,* I (New Haven, 1955), p. 130: Hurd "could not escape an unreconsiled dualism between head and heart." We might note that Hurd would not want to escape; his theory of the three types of poetry reflects the best philosophical and psychological thought of his time, especially the work of Hobbes and Locke.

[7]The neoclassical foundations of Hurd's criticism are outlined by Hoyt Trowbridge, "Bishop Hurd: A Reinterpretation," *PMLA,* LVIII (1943), 450–465. An excellent though general commentary on Hurd's type of criticism is included in R. S. Crane, "On Writing the History of English Classicism, 1650–1800," *University of Toronto Quarterly*, XXII (1953), 376–391.

tions have been clearly shown by modern critics, but his unique contribution to the history of critical methods has not. This contribution we may call the recognition of history and its influence on art; he is the first to give a convincing demonstration of how neoclassical rules need modification if the critic is to accept the influence that environment had upon writers of the past. And Hurd presents his case for accepting this modification by basing his criticism upon recent literary, theological, historical, and philosophical developments.

Hurd gives the rationale for his use of the historical method in the opening epistle of the Letters: "Nothing in human nature . . . is without its reasons. The modes and fashions of different times may appear, at first sight, fantastic and unaccountable. But they, who look nearly into them, discover some latent cause of their production." Hurd then shows that the oddities in Spenser and the Italian poets are results of their historical environment and are not artistic flaws. He maintains that once the surface dissimilarity is removed, a reader may ascertain the rules of their works and judge these poets in their proper standing in relation to classical and modern writers of imaginative poetry. We are now able to see that Hurd is not making a defense of individuality or of the uniqueness of the poet's vision; rather he is arguing the classical belief that human nature is universal, even though local manners vary. Certainly no preromanticism exists in this view, which is the most typically eighteenth-century attitude in Hurd. Art is universal, but the reader must use two ways to understand the artist's aim: "Sometimes a close attention to the workings of the human mind is sufficient . . .: sometimes more than that, the diligent observation of what passes without us, is necessary" (Letter I). The second method, historical, is needed for Spenser and others similar to him, and is important because "the greatest geniuses" of modern poetry—Ariosto, Tasso, Chaucer, Spenser, Milton, Shakespeare—have been "seduced by these barbarities." To show why these great poets used material from "Gothic" romance, the critic must explain the "rise, progress, and genius of Gothic chivalry" (Letter I). It is possible, in other words, for an artist to write poetry in accord with the necessary rules for intellectual, emotional, or epic works while following modes, techniques, or subject matter different from that emphasized by earlier French and English critics. Such latitude does represent a change in the literary climate, a transitional element that in the next century permits far greater license than the eighteenth century ever dreamed of. But at the same time, nothing in his theory can possibly be distorted into a case for preromanticism. Hurd is still highly derivative; his rules are relatively strict, though his taste may be more catholic. It is this change in taste, the emphasis upon a set of poets different from those stressed in the times of Dryden and Pope, that shows a movement towards the nineteenth century. The theory and rules of this criticism by Hurd is totally neoclassical.

The most derivative part of the *Letters* (II–V) deals with a historical account of chivalry and a proof that chivalric manners are more "sublime" (by which Hurd seems to mean a combination of the pictorial and the terrifying or strange) than classical ones. The critical idea informing these epistles may be conveniently summed up by one comment: "*Jerusalem* was to the *European,* what *Troy* had been to the *Grecian* heroes" (Letter V). This is Hurd's first defense of the medieval and Renaissance Romance: the material imitated in these works is as valid as that in the works of Homer and Virgil. But not all works dealing with this legitimate material are praiseworthy as art; they merely contain the raw material which must be transformed by a great artist. The quality of "sublimity" (or greatness, a meaning Hurd frequently gives this word) is not automatically in the subject matter but is rather a rhetorical quality gained by the skill of the poet joined to appropriate material. Thus nothing in the medieval Romances is worthy of praise as art; Hurd uses Milton as an authority who praises Chaucer and Spenser, "not the writers of *Amadis* and *Sir Launcelot of the Lake*" (Letter VII). The writings of Chaucer and Spenser "may incline us to think with more respect than is commonly done, of the *Gothic manners;* I mean, as adapted to the uses of the greater [i.e. epic] poetry" (Letter VII). This last comment is important; for Hurd, as for neoclassic critics in general, art is always a process of changing or ordering actuality. In his witty attack on Hobbes (the Letter to Davenant), Hurd shows this belief that greatness in art lies not only in subject matter but also in the ability or genius of the artist:

> I readily agree to the lively observation, 'That impenetrable armour, inchanted castles, invulnerable bodies, iron men, flying horses, and other such things, are easily feigned by them that dare.' But, with the observer's leave, not so feigned as we find them in the *Italian* poets, unless the writer have another quality, besides that of courage (Letter X).

Hurd's main attempt to deal with this other "quality" begins with Letter VIII, the most important section dealing with the *Faerie Queene* and its unifying elements; here the notion of the Classical–Gothic parallel is carried into literary criticism of a very high order. Hurd finds two types of unity possible in an epic poem: the classical or Aristotelian unity of action and the Gothic unity based upon a "design" of multiple actions. This section of the Letters has received high praise from a recent Spenser critic, John

Arthos, who considers his own book to be a continuation of Hurd's work: "Bishop Hurd's discussion of the unity of the *Faerie Queene* is one of the most fruitful that has been offered." The critic points out that Hurd, by saying that unity of design brings the whole "under one view," "avoids treating design as a form of unity with an existence of its own." To illustrate Hurd's view, Arthos discusses comments by other neoclassical critics on this type of unity, showing that it is "derived . . . from the peculiar interests of the poet, his temperament and his way of imagining or dreaming . . . . Except for a certain sophistication of philosophy . . . all of these ideas appear to have been part of the great debates in Italy in the sixteenth century" and were all considered by Tasso himself.[9] This comment is of great interest in a study of Spenser and the romantic epic, but its applicability to Hurd is at best doubtful.

Actually there are enough English precedents for this use of the word *design:* Hughes uses the word but does not apparently think of the *Faerie Queene* as being unified.[10] The use of the word that is closest to Hurd's is that of William Warburton in his discussion of the unity of the *Aeneid:* he finds a lack of unity in the action, but a unity of design in political allegory.[11] Warburton does not give a "picture" of the design, however, as does Cinthio, who claims that the epics of Tasso and Ariosto have a unity shaped like a human figure. Hurd's picture of the structure of Spenser's poem is more like a wheel than Cinthio's figure, but the two ideas are otherwise similar:

> This *Gothic* method of design in poetry may be, in some sort, illustrated by what is called the *Gothic* method of design in gardening. A wood or grove cut out into many separate avenues or glades was among the most favorite of the works of art, which our fathers attempted in this species of cultivation. These walks were distinct from each other, had, each, their several distination, and terminated on their own proper objects. Yet the whole was brought together and considered under one view, by the relation which these various openings had, not to each other, but to their common and concurrent center. You and I are, perhaps, agreed that this sort of gardening is not of so true a taste as that which *Kent* and *Nature* have brought us acquainted with; where the supreme art of the designer consists in disposing his ground and objects into an *entire landskip;* and grouping them, if I may use the term, in so easy a manner, that the careless observer, though he be taken with the symmetry of the whole, discovers no art in the combination (Letter VIII).

The picture of the *Faerie Queene* is of a wheel: the spokes are the adventures of the twelve knights; the hub is the feast of the

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[9]John Arthos, *On the Poetry of Spenser and the Form of Romances* (London, 1956), pp. 189–192.

[10]Hughes, I. lii–liii.

[11]William Warburton, *The Divine Legation of Moses Demonstrated* (London, 1755), I, 251 (on types of unity other than that of action), 276 (on "design" as opposed to unity of action).

Queen. Arthos is wrong, however, in claiming that Hurd's notion of Gothic unity is based on a sense of the individual nature of an artist's vision. Hurd's notion is far simpler and more concrete: the unity of the poem "consists in the relation of its several adventures to one common *original,* the appointment of the *Fairy Queen;* and to one common *end,* the completion of the Fairy Queen's injunctions" (Letter VIII). The unity of the poem lies solely in the fact that its twelve stories were meant to begin and end together; Hurd seems to have taken into account Spenser's interest in the unity of the whole, not Spenser's talent in individualized stories and peculiar method of story-telling. The traditional nature of Hurd's critical system here is shown by another aspect of his gardening metaphor: Kent's method "may be the truest taste in gardening, because the simplest." in other words, Homer's classical unity of action is the truest although the Gothic unity of design has an inferior beauty which can at times be highly successful.[12]

This judgment that classical and simple unity supercedes the Gothic and complex is highly revealing. For one thing, it shows Hurd remaining true to his neoclassical standards. But, more importantly, it shows his method, an approach characteristic of many critics who follow him. The historical method is used to arrive at a point where one can put the traditional rules into practice. Unlike Lord Kames, who uses the new empiricism to arrive at rules for art, or Dr. Johnson, who uses his awareness of "nature," Hurd (like Thomas Warton and Bishop Percy) uses his knowledge of history to arrive at rules and value judgments, and he uses it in his theological writings in addition to his critical ones. As a matter of fact, it is possible that the traditional form of Anglican sermons has influenced this entire historical movement in the eighteenth century; three of the most important historical critics were bishops: Hurd, Percy, and Warburton. An example of this theological method is seen in one of Hurd's sermons when Hurd is discussing the text for the day: "If there be any difficulty in these words, it will be removed by considering the *manners* of that time, in which Jesus lived, and the *ideas* of those persons, to whom he addressed himself" (VI, 1). To develop this passage, Hurd has to discuss the primarily agricultural nature of life at that time, the monetary distresses that resulted from such a system, and the nature of the various textual references that were obscure to his listeners; like a good preacher of any age, Hurd makes the passage specifically applicable to his listeners: "We, of this nation, have

[12]Hurd goes on to criticize Spenser for weakening his "Gothic" unity by using three other devices: the adaptation of Ariosto's method of interwoven stories; the use of Prince Arthur in an attempt to gain classical unity of action; the didactic use of allegory. The result is "a perplexity and confusion, which is the proper, and only considerable defect of this extraordinary poem" (Letter VIII).

not been so happy as to want examples of such distresses" (VI, 16). He then explains the character of a particularly horrible type of Antinomianism which caused trouble about the time of the Restoration and the nature of the "Popery" and "Atheism" which reigned after the former menace had been dispelled.

This sermon is an example in little of the same method Hurd uses in the *Letters* and in many other works of criticism, especially his editions of Horace and Cowley, the Preface of his *Dialogues*, and many passages in his theoretical essays and letters to friends.[13] The shape of Hurd's thought may perhaps best be described with an equation: as post-Restoration heresy is to disorders in Biblical times, so supposed defects in Spenser's poetry are to supposed beauties in Homer's. We might put this another way and say that merely because a passage in the Bible is obscure, we are not to decide that the Bible does not follow the rules of writing; the fault lies in our imperfect knowledge. The relevance to literary criticism is clear and shows Hurd's method of thought: Spenser, Tasso, medieval Romances, and Chaucer all seem strange to eighteenth-century readers, but it is the latter who are in error owing to their lack of historical information. Hurd has used his knowledge of historical theology well in his writing of historical criticism.

So far we have seen Hurd using history to show that Spenser and the Italian poets based their fictions, even many of their supposed miracles (see the first half of Letter X), upon actual happenings of their age. But his argument changes in the middle of Letter X to a discussion of the poems as art rather than as reflections of history: "this is not the sort of defence I mean chiefly to insist on. Let others explain away these wonders, so offensive to certain philosophical critics [he is thinking especially of Hobbes, whom he mentions twice in this letter]. They are welcome to me in their own proper form, and with all the extravagance commonly imputed to them." After quoting Addison on "the Fairy way of writing," Hurd sums up his argument about the poetic use of the supernatural; this passage is generally given as one of the most "romantic" in the *Letters:*

> So little account does this wicked poetry make of philosophical or historical truth: all she allows us to look for, is *poetical truth:* a very slender thing indeed, and which the poet's eye, when rolling in *a fine frenzy,* can but just lay hold of. To speak in the philosophic language of

[13]The edition of Horace (London, 1749) uses the method to show that the *Ars Poetica* was intended as a work of drama; the Preface to the edition of Cowley (1772, 1777) explains Cowley's false wit in terms of its age. The essays on imitation show the historical learning requisite to distinguish imitations of nature from imitations of other writers. One of his letters shows his knowledge of the historical method in his denial of the authenticity of Ossian: the letter is addressed to Warburton (December 25, 1761) in William Warburton, *Letters from a Late Eminent Prelate to One of his Friends* (New York, 1809), pp. 247–248.

> Mr. HOBBES, it is something much *beyond the actual bounds, and only within the conceived possibility of nature* (Letter X).

To understand this quotation, we ought to give another in the same Letter; this following passage is generally ignored by those who emphasize Hurd's "Romanticism":

> We must distinguish between the *popular belief,* and *that of the reader.* The fictions of poetry do, in some degree at least, require the first (they would, otherwise, deservedly pass for *dreams* indeed): but when the poet has this advantage on his side, and his fancies have, or may be supposed to have, a countenance from the current superstitions of the age in which he writes, he dispenses with the *last,* and gives his reader leave to be as sceptical and as incredulous, as he pleases (Letter X).[14]

This limitation upon the poet's ability to "create" is central to Hurd's criticism and shows his agreement with the majority of French and Italian critics of the epic. The first quotation above, in addition, shows a revealing use of the comment by Hobbes. First of all, Hurd characteristically adds *much* to intensify the idea; if the poet is to go "beyond the actual bounds," then he should go as far as possible; Hurd never advocates half measures. Secondly, he misuses Hobbes's comment, which originally meant that the poet ought to use idealized creations, a principle closer to Reynolds's "general nature" than to the Gothic use of supernatural beings. Hurd shows by the order of argument in Letter X that he knows what Hobbes's comment means; here he enjoys turning the great philosopher's words against himself.

Hurd continues his argument about the supernatural when he claims that the epic poet is not restricted to "the known and experienced course of affairs in the world" but "has a world of his own, where experience has less to do than consistent imagination" (Letter X). "Experience" for Hurd is always treated as material to be changed by the poet; as Hurd says in an essay written in the same year as the *Letters,* poetry "assembles, combines, or corrects its ideas, at pleasure; in short, prefers not only the agreeable, and the graceful, but, as occasion calls upon her, the vast, the incredible. I had almost said, the impossible, to the obvious truth and nature of things" (II, 9). Such poetry must be "consistent," must be tied well together with suitable images which are

[14]This quotation can raise an interesting question in view of Hurd's ironic reference to fiction which "would . . . pass for *dreams* indeed." We can ask what he would have thought of Coleridge's poetry of the supernatural. A poem like *Kubla Khan* would be beyond his ken because Hurd assumes that only the known world is ever a fit subject for art. This limitation upon the use of the supernatural is discussed in H. T. Swedenberg, Jr., *The Theory of the Epic in England,* 1650–1800, in *University of California Publications in English,* XV (Berkeley, 1944), 110, 139n.; also see Trowbridge, p. 460.

not contradictory.[15] This kind of criticism may well appear revolutionary if compared to the Preface by Pope to the 1717 edition of his works, but the comparison would be false, for Hurd is not here discussing pastorals and imitations but the epic. The similarity of idea in Pope and Hurd is much closer when we recall Pope's Preface and notes to the *Iliad*, especially the stress in the Preface upon Homer's matchless "invention." Neither critic, however, has in mind anything like Coleridge's notion of the imagination; the two eighteenth-century critics think of "invention" as a new mirroring of actuality (if we can consider superstitions and exaggerations as being "actual"), not as a uniquely personal response to, or creation of reality.

Possibly the finest touch in the *Letters* is Hurd's casual[16] introduction of the three types of poetry; this passage in Letter X, seemingly unconnected to the rest of the *Letters*, is actually the rationale behind the entire defense of Spenser and the Italians. He divides all poetry into the poetry of "men and manners," the poetry that addresses itself to the heart "through the *passions*," and the poetry of the imagination. The first two are restricted to the believable (the first must be true historically, the second true of human nature), but the third is not because the imagination permits "fanciful exhibitions." Just as imitations of historical and social fact and representations of emotion have their own rules, so the imagination, which does not represent things directly to the eyes (as the drama does), has rules based upon what the reader is able to feign to himself. This leads Hurd to his belief that imaginative art must be based upon beliefs or superstitions of the poet's age. He is thus able to conclude his argument in a suitably traditional manner by claiming that no epic can succeed without "admiration"; this quality "cannot be affected but by the marvellous of celestial intervention, I mean, the agency of superior beings really existing, or by the illusion of the fancy taken to be so." As proof of his assertion he gives the failure of two epics which attempt to reach greatness without using the supernatural: Vol-

[15]What Hurd means by "consistent imagination" is clarified by a remark by Upton in his Preface to Spenser: "'tis required that the fable should be probable. A story will have probability, if it hangs well together, and is consistent: And provided the tales are speciously told, the probability of them will not be destroyed, though they are tales of wizards or witches, monstrous men and monstrous women; for who, but downright miscreants, question wonderful tales": Mueller, p. 42.

[16]One difficulty we find in analyzing the *Letters* is the lack of systematic thought displayed throughout; Hurd is writing differently from what is usual in a critic who is generally over-systematized. But Hurd, always respectful of genre, is writing in the "Epistolary mode of writing," which has three rules: there must be "an unity in the subject"; there must also be "a connexion in the method"; it is imperative "that such connexion be easy" (I, 24). This passage is from the edition of Horace; the Preface contains elaborate rules for the epistle, all of which are relevant for Hurd's style and organization in the *Letters*, including his casual organization, familiar style, and ironic or mocking comments. Hurd, in other words, looked upon this defense of imaginative poetry as more than literary criticism; it was to be a work of art itself.

taire's *Henriade* and Davenant's *Gondibert*.[17] This breakdown of all poetry into types which correspond to the empirical division of the human faculties (judgment, imagination, and passion) is the most admirable theoretical doctrine in the *Letters;* by a consistent application of his theory of the three types of poetry Hurd is able to clarify many neoclassic confusions over the relation of judgment and fancy.

Finally, this defense of imaginative poetry shows what might be considered Hurd's most classical attribute as a critic—his insistence that each work of art achieve its proper effect and no other. This attitude permeates Hurd's criticism (we have seen it operate in the discussion of conflicting unities in the *Faerie Queene),* but it is stated most bluntly, even obsessively, in his essay "On the Provinces of the Drama": "though *mixed dramas* [tragedies using persons of low estate, comedy with those of high estate] may give us pleasure, yet the pleasure, in either kind, will be LESS in proportion to the mixture. And the *end* of each will be then attained MOST PERFECTLY when its character, according to the ancient practice, is observed" (II, 84). Such a desire for purity, for simplicity of one type of means leading to one end, besides being part of Hurd's personality, is an essential part of the classical view of art. Even though English art has rarely attempted this kind of unity, it is a high ideal as the dramas of the Greeks and Racine testify, and it is the only ideal that Hurd, at least in theory, ever accepted despite his love of Shakespear, Spenser, and Chaucer: Hurd always claims that the great poets of English literature would have been even greater if they had strictly observed unity.

We are now able to make one generalization that seems to cover Hurd's position on literary criticism: that is, the rules are rules only when they take into account all the relevant literature that has been found to be effective. This is a doctrine very important to the future development of practical criticism because it opens a critic's eyes to what is actually in a work of art before the critic decides what should be there. Thomas Warton does not subscribe to this kind of latitude; he finds pleasure in Spenser, but he also believes that the *Faerie Queene* is corrupt because it does not adhere strictly to the form found in classical writers.[18] Hurd would say that if the reader is satisfied, the rules have been followed to

[17] The notion that a successful epic must contain the "marvellous" was common in the period; Pope attacked Voltaire's epic for this reason: see Austin Warren, *Alexander Pope as Critic and Humanist* (Princeton, 1929), p. 219.

[18] Warton's inability to make his taste and rules consistent is discussed fully by Raymond D. Havens, "Thomas Warton and the Eighteenth-Century Dilemma," *SP*, XXV (1928), 36–50. We should note, however, that Havens's thesis does not apply to the entire period; as we have seen, Hurd refuses to admit a conflict between theory and effect.

the extent of the poet's success with the reader; it is impossible to please in spite of the rules because Hurd claims that only rules followed correctly create pleasure. Suppose a reader were to find some literary work to which the so-called rules do not apply; Hurd would find that such a judgment means the rules in question either are not rules or are not interpreted well by the critic. Directly owing to this flexible attitude toward the rules, Hurd is able to make his main contribution to the development of literary criticism: his successful use of the historical method in the form which is basically the same as that which is used today. It is not his actual rules that are in any way original, for these are typical of neoclassicism in England; most critics of Hurd's century would find nothing odd in his notions of genre; of the ordering of a story; of the purpose of imagery, description, and versification. These rules are all deduced and all apply to all poetry. Hurd's importance lies in his realization that the specific application of these rules always depends upon the work being discussed. In this manner Hurd finds that much art of the past, which had previously been poorly analyzed by critics, follows the essence of neoclassical rules. His criticism is not romantic because his view of art is the same as that found in Dryden, Pope, and the other English Augustans. Hurd's difference lies in his full discovery of how to use history as an important adjunct to criticism.

THE INSECT PARASITES OF THE EUROPEAN PINE SHOOT MOTH, *RHYACIONIA BUOLIANA* (SCHIFFERMÜLLER) (LEPIDOPTERA:TORTRICIDAE) IN WISCONSIN WITH KEYS TO THE ADULTS AND MATURE LARVAL REMAINS

*Torolf R. Torgersen and Harry C. Coppel**

The European pine shoot moth, *Rhyacionia buoliana* (Schiffermüller), was introduced accidentally into North America. It was first discovered damaging pines at Great Neck, New York in 1913, but it was not definitely identified until 1914 (Busck, 1914). Transportation of infested nursery stock resulted in the rapid spread of the shoot moth, and by 1951 it was present throughout the Northeast, southward to Virginia, and westward to Wisconsin and Illinois. The shoot moth was first reported in the Pacific Northwestern United States in Washington in 1959 (U.S.D.A., Pacific N.W., 1960). By 1961, infested ornamental pines had been discovered in several cities in Washington and Oregon, and in northern California (U.S.D.A., Pacific N.W., 1962; U.S.D.A., Pacific S.W., 1962).

The preferred hosts of the shoot moth are the hard pines. In North America the most commonly attacked species are *Pinus resinosa* Ait., *P. sylvestris* L., and *P. mugho* Turra. Although the shoot moth does not usually kill trees, larval feeding in buds and elongating shoots inhibits their growth and deforms them so that they are unsuitable for future harvest.

R. buoliana has been present in Wisconsin since 1951. In 1953, four counties reported infestations, and by 1959, pine plantations in 27 southern and eastern counties had infestations (Wis. Conserv. Dept., 1953, 1959; Benjamin *et al*, 1959). In 1960, a project was undertaken to investigate the bionomics of the shoot moth in Wisconsin, and to determine the structure of its parasite and predator complex. The information was compiled from field collections and laboratory studies of material collected during the summers of 1961–1963 from five forest plantations in the Point Beach State Forest, Two Rivers, Wisconsin.

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This paper deals with the known parasites of *R. buoliana* in Wisconsin. Keys for the separation of the parasites based on the remains left in the bud after the parasite has emerged; and for the separation of the parasite adults are given. Descriptions of the final-instar cephalic structures, and spiracles of Hymenoptera, puparia and buccopharyngeal armature of Diptera, and notes on the biology of the parasites are also included.

METHODS

The material upon which the keys are based consisted of adult parasites, and host and parasite remains from buds that could be positively associated with the parasites emerging from them. The adults were identified by the staff of the Insect Identification and Parasite Introduction Branch of the U. S. Department of Agriculture at Beltsville, Maryland.

Material used in the preparation of the key to parasite remains included host larval and pupal remains; empty egg chorions (in a few instances), cast larval and pupal skins, and cocoons of the hymenopterous parasites; and puparia with the included buccopharyngeal armature of the dipterous parasite. Cast larval skins of the hymenopterous parasites were removed from the buds, softened in 10 percent potassium hydroxide for 30 minutes to several hours, and washed in distilled water. Skins could be dyed lightly by first running them up to 70 percent alcohol, and then immersing them in a solution of iodine crystals dissolved in 70 percent alcohol; the skins were then mounted on microscope slides in non-resinous mounting medium (Turtox CMC–10) or in Hoyer's medium.

Illustrations of parasite remains were made with the aid of a projecting prism for gross characters and outlines, and an Ernst Leitz binocular compound microscope fitted with an ocular grid for fine details. The terminology used for the parts of the cephalic structures and spiracles of the final-instar larvae of Hymenoptera, and, in part, the buccopharyngeal armature of the Diptera is the same as that compiled from various authors by Finlayson (1960). Zuska (1963) was referred to for the terminology used in describing the puparium of the Diptera.

Drawings of the parts of adult parasites were made from pinned specimens with the aid of a Bausch & Lomb binocular dissecting microscope fitted with an ocular grid. Illustrations of wing venation were made with the aid of a prism projector, from wings mounted on microscope slides in non-resinous mounting medium.

PARASITES OBTAINED

The following parasites, including two species of Diptera and 18 of Hymenoptera have been reared from *R. buoliana* in Wisconsin:

DIPTERA

Chloropidae: *Oscinella conicola* (Greene).
Tachinidae: *Erynnia tortricis* (Coq.)

HYMENPTERA

Braconidae: *Apanteles* sp., *Bracon* n. sp., *Bracon gelechiae* Ashmead.

Ichneumonidae: *Exeristes comstockii* (Cresson), *Scambus tecumseh* Viereck, *Scambus* sp., *Itoplectis conquisitor* (Say), *I. ? evetriae* Viereck, *Coccygomimus annulipes* (Brullé)., *Gambrus* sp., Porizonini, *Atrometus* sp.

Eulophidae: *Elachertus pini* Gahan, *Hyssopus thymus* Girault.

Eupelmidae: *Eupelmus cyaniceps* Ashmead, *Macroneura vesicularis* (Retzius).

Pteromalidae: *Habrocytus thyridopterigis* Howard.

Eurytomidae: *Eurytoma pini* Bugbee.

Two keys have been prepared for the separation of the above species. The first is designed to aid in separating the parasites on the basis of the host and parasite remains left in the bud after the parasite has emerged. Twelve species of parasites, one dipteron and eleven hymenopterons, are included in the key to parasite remains. The remaining seven species have not been included because insufficient material was available. The second key is for the identification of the adults of the parasites of *R. buoliana.*

KEY TO THE PARASITES OF *R. BUOLIANA* BASED ON PARASITE REMAINS[3]

1. Internal solitary parasites emerging from fully developed pupae; parasite remains inside host pupal skin ______ 2
External solitary or gregarious parasites or hyperparasites of larvae or pupae; parasite remains in host gallery ____ 5

2.(1) Parasite remains a dipterous puparium (Figs. 1–4). ____
____________________________*Erynnia tortricis* (Coq.)
Parasite remains consisting of the shed larval skin of final-instar hymenopterous larva __________________ 3

[3]Final-instar larval skins of Hymenoptera, or dipterous puparia and buccopharyngeal armature.

3.(2) Hypostomal arms present (Fig. 18); atrium of spiracle nearly the same width as the stalk (Fig. 35) -- *Atrometus* sp.
Hypostomal arms lacking (Figs. 15, 16); atrium of spiracle not as above; atrium large, leading into a narrower stalk (Fig. 34), or directly into a closing apparatus by a small opening (Fig. 33) ---------------------------- 4

4.(3) Atrium of spiracle about three times as wide as the stalk; stalk ends in a well-developed closing apparatus (Fig. 34) -------------------------------- *Itoplectis ? evetriae* Vier.
Atrium of spiracle without a stalk; connected directly to a well-developed closing apparatus through a small opening (Fig. 33) --------*Coccygomimus annulipes* (Brullé)

5.(1) Cephalic structures reduced. only mandibles, or mandibles and clypeus, developed (Figs. 19, 21, 24) ------------ 6
Cephalic structures well-developed, not limited to the above -- 8

6.(5) Cephalic structures consisting of mandibles and a heavily sclerotized clypeus armed with denticles (Fig. 21) ------------------------------*Macroneura vesicularis* (Retz.)
Cephalic structures apparently consisting only of mandibles -------------------------------------- 7

7.(6) Atrium with chambers tapering gradually, ending at a distinct closing apparatus (Fig. 38) ---------------------------------------*Habrocytus thyridopterigis* How.
Atrium with chambers tapering sharply, ending in a long, thin, finely-annulated stalk; very small closing apparatus present (Fig. 36) ---------------*Hyssopus thymus* Gir.

8.(5) Mandibles armed with a single large denticle posteriorly (Fig. 27); cephalic structures limited to little more than pleurostomata bearing the superior and inferior mandibulary processes ------------------*Eurytoma pini* Bugbee
Mandibles armed with two rows of fine teeth, or several thin leaf-like teeth; cephalic structures consisting of epistoma, pleurostomata, hypostomata, and labial sclerite -- 9

9.(8) Mandibles armed with several thin leaf-like teeth in addition to the heavily sclerotized primary mandibular blade (Figs. 8, 11) --------------------------------------10
Mandibles armed with two rows of tiny hair-like teeth on the primary mandibular blade (Fig. 13) -------------------------------------*Exeristes comstockii* (Cress.)
Scambus (Scambus) tecumseh Vier.
and *Scambus (S.)* spp.

10.(9) Row of leaf-like teeth limited posteriorly by the posterior angle of the mandible which is drawn out into a tooth

(Fig. 8); spiracle with a distinct closing apparatus (Fig. 30) ------------------------------------ *Bracon* n. sp.
Row of leaf-like teeth not limited posteriorly by a tooth, posterior angle smoothly rounded (Fig. 11); spiracle without closing apparatus (Fig. 31) --*Bracon gelechiae* Ashm.

KEY TO THE ADULTS OF THE PARASITES OF *R. BUOLIANA*[4]

[4]*Apanteles* sp. and *Oscinella conicola* (Gr.) are included as questionable parasites of *R. buoliana*.

1. Wings extremely abbreviated, apparently absent; reduced to tiny opaque, nearly acute pads whose apical portion is bent erect --------------*Macroneura vesicularis* (Retz.)
Wings well-developed ---------------------------- 2

2.(1) One pair of wings; Diptera ------------------------ 3
Two pairs of wings; Hymenoptera ----------------- 4

3.(2) Thorax with a complete transverse suture; body with many bristles; insect much like a small (5 mm.) housefly in appearance -------------*Erynnia tortricis* (Coq.)
Thorax without a transverse suture; body covered with fine setae, only a few bristles; tiny (1 mm.), black shining flies ----------------------*Oscinella conicola* (Gr.)

4.(2) Wing venation reduced (Figs. 40–43); antennae geniculate -------------------------------------- 5
Wing venation well-developed (Figs. 44–46); antennae filiform --------------------------------------- 9

5.(4) Abdomen compressed, shining black; head and thorax coarsely punctate; venation as in Fig. 40 --------------
------------------------------*Eurytoma pini* Bugbee
Abdomen not compressed, more or less flattened ------ 6

6.(5) Stigma in forewing furcate (Fig. 43); tarsi 4-segmented; black minute insects --------------------------- 7
Stigma in forewing not furcate (Figs. 41, 42); tarsi 5-segmented; bright metallic green or blue insects ------ 8

7.(6) Stigma in forewing strongly furcate (Fig. 43); pro- and mesothoracic femora and tibiae nearly entirely fuscus --
------------------------------*Hyssopus thymus* Gir.
Stigma in forewing not so strongly furcate as in Fig. 43; pro- and mesothoracic femora and tibiae nearly white --
-------------------------------*Elachertus pini* Gah.

8.(6) Mesoscutellum (scl_2) acute anteriorly, axillae (ax) nearly touching medially (Fig. 51); marginal vein more than four times as long as stigmal vein (sv) plus stigma (st) (Fig. 42) ------------------*Eupelmus cyaniceps* Ashm.

Mesoscutellum truncate anteriorly, axillae widely separated (Fig. 52); marginal vein only slightly longer than the stigmal vein plus stigma (Fig. 41) ---------------------------------- *Habrocytus thyridopterigis* How.

9.(4) Forewing with a single recurrent vein (rv) (Figs. 44, 45) -- 10
Forewing with two recurrent veins (Fig. 46) -------- 12

10.(9) Forewing with both 2nd marginal (2nd M) and 2nd submarginal (2nd SM) cells present (Fig. 45) ---------- 11
Forewing with neither 2nd marginal nor 2nd submarginal cells present (Fig. 44) ------------------ *Apanteles* sp.

11.(10) Mesopleuron, and at least anterior half of mesonotum glabrous and shining black; abdomen mostly yellow-brown, sometimes with darker shading caudally; tergum of petiole and anterior medial portion of segment II black -- *Bracon* n. sp.
Mesopleuron and mesonotum not glabrous and shining, rather dull black, clothed in short grey hairs; abdomen entirely fuscus above; inner margin of eyes each marked with two yellowish semi-circles—*Bracon gelechiae* Ashm.

12.(9) Major axis of the petiole (ab_1) and that of the rest of the abdomen forming a distinct angle (Figs. 53, 54); petiole distinctly elongate ----------------------------------- 13
Major axis of the petiole and that of the rest of the abdomen more nearly parallel (Fig. 55); petiole not distinctly elongate --- 15

13.(12) Abdomen extremely compressed; petiole (ab_1) and the second abdominal segment (ab_2) about six times as long as their greatest diameter (Fig. 53); head and thorax patterned with yellow ----------------------- *Atrometus* sp.
Abdomen not markedly compressed; petiole and second abdominal segment as in Fig. 54 -------------------- 14

14.(13) Propodeum divided into several areas set off by propodeal carinae; abdominal segments mostly dark, terga of segments II and III each with fusco-testaceous areas laterally, sometimes joined medially -- Porizonini: Unknown species 1
Propodeum not divided into areas by propodeal carinae; abdominal segments I, II, III, and the anterior portion of segment IV ferruginous ------------------ *Gambrus* sp.

15.(12) Hind tibia dark at extreme base, i.e. tibia with apical and basal bands and a median pale band ---------------- 16
Hind tibia pale at extreme base, i.e. tibia with or without bands, but pale at base, or with apical and subbasal dark bands and median basal bands --------------------- 18

16.(15) Inner margin of eye weakly concave above antennal socket (Fig. 50); tarsal segments 1, 2, and 3 without distinct bands basally ---------*Coccygomimus annulipes* (Brullé)
Inner margin of eye rather strongly concave at antennal socket (Fig. 49); tarsal segments 1, 2, and 3 with distinct white bands basally ---------------------------17
17.(16) Abdominal terga with white or cream-colored posterior margins -------------------*Itoplectis conquisitor* (Say)
Abdominal terga entirely dark -*Itoplectis ? evetriae* Vier.
18.(15) Nervellus (nv) intersected by the discoidella (dsc) at or below the middle (Fig. 48) -------------------------19
Nervullus intersected by the discoidella near or above the middle (Fig. 47) ----------*Exeristes comstockii* (Cress.)
19.(18) Median pale band on hind femur incomplete ventrally -------------------------*Scambus (Scambus) tecumseh* Vier.
Median pale band on hind femur complete ventrally ------------------------------------*Scambus (Scambus)* sp.

NOTES ON PARASITE BIOLOGY AND DESCRIPTIONS

DIPTERA

Chloropidae

Oscinella conicola (Greene)

This tiny choloropid was recorded from *R. buolinana*-infested buds by Watson and Arthur (1959), who stated that it had previously been known to feed in red pine cones, and considered it as having a questionable role as a shoot moth parasite. Torgersen and Coppel (1962) reared two *O. conicola* from a shoot moth-infested bud and listed it as a parasite. No shoot moth emerged, and the bud was not dissected to ascertain the status of the association. According to Kulman (personal communication to H. C. Coppel), in West Virginia, *O. conicola* is very abundant in infested tips, but there appears to be no adverse effect upon the shoot moth. As members of this family may be parasitic or predacious as well as phytophagous (Borror and DeLong, 1960; Imms, 1960), it seems that the role of this insect is still not adequately clarified.

Tachinidae

Erynnia tortricis (Coq.)

Figs. 1–6

Four shoot moth pupae, collected in 1963, were parasitized by *E. tortricis*. Two pupae, from which the flies had already emerged, were collected on July 12. Two adults emerged on July 14 from host pupae collected on June 26 and 28.

E. tortricis is an internal parasite emerging from the pupa of *R. buoliana*. A puparium is formed within the host pupal skin, and two stigmatophores borne on a single variably shaped trunk protrude through the host pupal skin where the wing pads, legs, and antennae terminate (Fig. 1). Zuska (1963) stated that the stigmatophores are formed as late as during the pupation of the larva. This might account for the variable shape of the stigmatophore trunk since it may be exserted through the hard host pupal skin while still soft and pliable; hardening taking place as the exserted portion dries. Exit from the puparium is through an opening made by fractures along the horizontal and vertical sutures to form a dorsal and ventral flap. The host pupal skin is forced open along a line between head and prothorax, down one or both sides along the sutures separating the wings from the legs and mouthparts. The resulting flap may or may not remain attached to the host pupal skin.

Puparium (Figs. 2, 3) 4.61 to 5.12 mm. long, not including the stigmatophores; 2.05 to 2.56 mm. in diameter at widest point. Spiracular plate (Fig. 4) perforated by four to six orificia arranged in a roughly radial pattern. Number of orificia often variable between stigmatophores on a single individual; five orificia probably normal. Distance from anus to posterior spiracles (as defined by Zuska, 1963) slightly less than one one-third largest diameter of puparium. Buccopharyngeal armature (Figs. 5, 6) 0.39 to 0.45 mm. long; attached to inside of ventral flap at site of secondary mouth opening. Mandibular hooks moderately heavy, curving slightly anteroventrally; two or three teeth along ventral margin; in dorsal view (Fig. 6) each hook bears a denticle on either side. Lightly sclerotized salivary gland plate present. Articulation between mandibular hooks and intermediate sclerite difficult to distinguish even after lengthy clearing; no articulation present between intermediate and basal sclerites. Basal sclerite divided into two dorsal wings that become progressively less sclerotized posteriorly; distinctly veined posteriorly. Ventral wings fused medially to form lightly sclerotized flap.

HYMENOPTERA

Braconidae

Microgasterinae

Apanteles sp.

Fig. 44

A single specimen of *Apanteles* sp. was collected in the insectary on July 24, 1963. The specimen had escaped from a bag of *R. buoliana*-infested buds that had been collected the previous day. This species is included as a questionable parasite of *R. buoliana*.

FIGURE 1. Pupal skin of *Rhyacionia buoliana* (Schiff.) with the puparium of *Erynnia tortricis* (Coq.) *in situ.*

Braconinae

Bracon n. sp.

Figs. 7–9, 30

According to C. F. W. Muesebeck (personal communication) this species is apparently undescribed. The parasite develops externally on the shoot moth larva, one, two, or three to a host. Eight individuals were recovered from six host larvae. These emerged from July 1 to July 16. The collections of buds from which these parasites emerged were made from June 18 to June 24, 1963. In one instance, a single host larva supported three braconids of this species and six *H. thyridopterigis,* all of which emerged successfully. The pteromalids emerged nearly two weeks after the braconids.

Cocoon tan; a regular ellipse approximately 2 mm. by 5 mm.; exit hole cut at one end of cocoon about 1.25 mm. in diameter. Cocoon constructed near host remains; tied down by spreading mat of silk strands. Meconium, pupal skin, and mature larval skin are found in cocoon. Exit from host gallery through gallery entrance kept open by host larva before death.

Cephalic structure (Fig. 7) characterized by fusion of epistoma, pleurostomata, and hypostomata to form a vaulting arch over the mandibles, stipital sclerites, and labial sclerite. Superior mandibulary processes well-developed; inferior processes simple, each accompanied by a lacinial sclerite. Primary mandibular blade followed by several thin, leaf-like teeth posteriorly; these leaf-like teeth limited posteriorly by the posterior angle of mandible which is drawn out into a heavily sclerotized tooth (Fig. 8). Stipital sclerites form nearly a straight line with one another; encounter dorsal arms of labial sclerite at a point immediately below a line drawn through the labial palpi. Labial sclerite open dorsally; thickened along ventral margin; dorsal arms narrower than ventral margin, widened slightly at their ends where they enclose a silk press that is nearly as wide as long. Maxillary and labial palpi bear two sensoria each. Antennae about twice as long as basal diameter; antennal sockets not apparent. Larval skin densely covered with tiny spines (Fig. 9) and scattered setae 0.03 mm. long. Spiracle (Fig. 30) consists of a large atrium on a thick, nearly parallel-sided stalk that is clearly annulated; stalk ends at a distinct closing apparatus. Atrium sculptured on its inner walls by two sub-parallel rings made up of continuous lines of minute warts.

Braconinae

Bracon gelechiae Ashmead

Figs. 10, 11, 31, 45

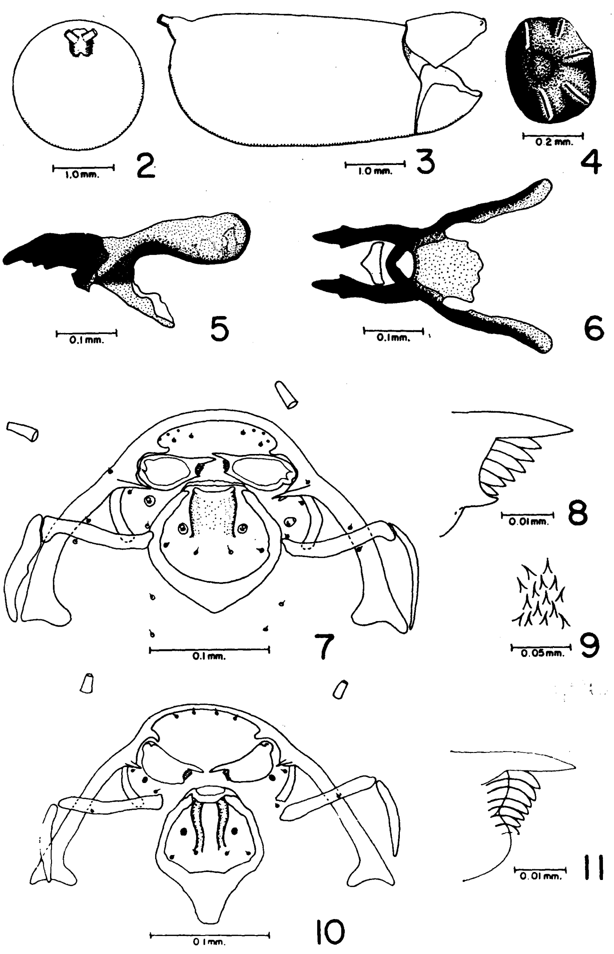
B. gelechiae was originally described as a parasite of gelechiids on oak (Muesebeck *et al*, 1951). It has since been recorded from *R. frustrana*, as *Microbracon gelechiae*, by Cushman (1927), and from *R. buoliana* by Schaffner (1959) in the Northeast, and by Watson and Arthur (1959) in Ontario. Miller and Neiswander (1955) in Ohio, listed *B. gelechiae* as a species of unverified status in connection with parasite rearings from bud collections containing *R. buoliana.*

Nine specimens of *B. gelechiae* developed on five shoot moth larvae. This species is a gregarious external parasite of the larva; from one to four parasites develop on a single host individual. The emergence period lasted from July 3 to July 17. Collections from which these individuals emerged were made from June 15 to July 3, 1963.

According to Cushman (1927) *M. gelechiae* develops as a solitary or gregarious external parasite on large larvae of *R. frustrana.* He stated that the pupal period is spent in a dense brown cocoon. In the material collected at Two Rivers, the cocoon of this parasite was very light, nearly white. The roughly elliptical cocoon is not closely associated with the host remains, and may be found as distant from the host remains as the entrance to the gallery. The cocoon is about 1.1 mm. by 4.1 mm.; exit from the cocoon is through a hole about 0.8 mm. in diameter cut at one end. Meconium, pupal skin, and the final-instar larval skin may be found in the cocoon, but they are often missing.

The cephalic structures of this species (Fig. 10) were prepared from a single damaged specimen, consequently the juxtaposition of its parts is not accurate. The general aspect of *B. gelechiae* is the same as the *Bracon* species above. In particular, this species differs from the former in the following respects; The cephalic structures are smaller overall; the dorsal arms of the labial sclerite are narrow as compared with the width of the ventral portion; the silk press is longer than wide; the mandibles bear several thin leaf-like teeth, however, they are not limited posteriorly by a tooth, but rather the posterior angle of the mandible is smoothly rounded (Fig. 11); the antennae are slightly less than twice their basal diameters in length. The larval skin, like that of *B.* n. sp., is covered with minute spines and a few scattered setae. Spiracle (Fig. 31) with a large atrium atop a scarcely tapering, distinctly annulated stalk ending in a short non-annulated, parallel-sided section;

there is no closing apparatus. Inner wall of atrium bears two rings of fine wavy lines around its lower half; these lines not composed of a series of warts as in the previous *Bracon* species.



FIGURES 2–6. Puparium and buccophyaryngeal armature of *Erynnia tortricis* (Coq.): 2, puparium, posterior view; 3, puparium, lateral view; 4, stigmatophore plate, dorsal view; 5, final-instar buccopharyngeal armature, lateral view; 6, final-instar buccopharyngeal armature, dorsal view. 7–11. Cephalic structures and spines of final-instar hymenopterous larval skins: 7–9, *Bracon* n. sp.; 7, cephalic structure, anterior view; 8, distal portion of right mandible, ventral view; 9, portion of skin showing spines; 10–11, *Bracon gelechiae* Ashm.; 10, cephalic structure, anterior view; 11, distal portion of right mandible, ventral view.

Ichneumonidae

Ephialtinae:Pimplini

Exeristes comstockii (Cresson)

Figs. 12–14, 32, 47, 55

Exeristes comstockii is a common parasite of lepidopterous larvae that feed inside the growing shoots or in the cones of pines (Townes and Townes, 1960). *E. comstockii* was recorded as a parasite of *R. buoliana* in Connecticut (Friend, 1935), Massachusetts, Rhode Island, New York, and New Jersey (Schaffner, 1959), Michigan (Miller, 1959), Ohio (Miller, 1953), West Virginia (Harman and Kulman, 1962), Wisconsin (Torgersen and Coppel, 1962), British Columbia (Mathers and Olds, 1940), and Ontario (Watson and Arthur, 1959). Among the other species that are often found in plantations infested with *R. buoliana,* and whose damage is sometimes attributed to the shoot moth, the following are known hosts of *E. comstockii: R. rigidana* (Fern.), *R. frustrana* (Comst.), *Dioryctria zimmermani* (Grote), *Petrova comstockiana* (Fern.), and occasionally *Pissodes strobi* (Peck) (Townes and Townes, 1960).

The biology of *E. comstockii* was studied by Cushman (1927), Miller (1953), and by Arthur (1963), who also illustrated the immature cephalic structures and spiracles. *E. comstockii* is a solitary external parasite on the shoot moth larva. There are two generations per year. The summer generation develops and overwinters on a host other than *R. buoliana,* but it is not known what species serves as the overwintering host at Two Rivers. In Ontario, the adults of the spring generation emerge between June 9 and 27 (Arthur, 1963). Miller (1953), in Ohio, recorded adult emergence from June 6 through July 15. Laboratory emergence at Two Rivers extended from July 2 through July 29. The average peak laboratory emergence date for three years' observations was July 14. The sex ratio is slightly less than 2:1 in favor of females.

From the earliest and latest host collection dates, and the earliest and latest emergence dates from 1961 to 1963, it was calculated that the development time for *E. comstockii* from egg to adult is from 22 to 26 days. Males are produced on the average, in 23 days; females in 26 days. These averages correspond exactly to those of Arthur (1963).

The parasite larva constructs a cocoon of loosely spun white silk. The cocoon is variable in shape depending upon its position in the gallery, and is commonly closely associated with the host remains.

Cephalic structure (Fig. 13) well-developed; epistoma complete, with two setae and one sensorium on either side; labial sclerite encloses labrum with several pairs of setae and at least two pairs of sensoria; suspensorial sclerite present medially behind mandibles. Superior mandibulary processes long, directed ventrad; inferior processes simple, each accompanied by a lacinial sclerite. Mandibles with long, slightly curved blades with two rows of fine hair-like teeth (Figs. 12, 13). Hypostomal arms extend laterad; hypostomal spurs long and narrow; stipital sclerites progressively less sclerotized laterally, most heavily sclerotized medially where they meet hypostomal spurs and labial sclerite. Labial sclerite nearly closed dorsally; ventral portion more than twice the width of the dorsal arms, and irregularly dentate along ventral margin; opening of silk press evident medially where dorsal arms bend inward. Maxillary and labial palpi with two sensoria each. Antennae long, approximately three times as long as average diameter. Vertex with four large pigmented areas, the median areas largest, lateral areas narrower and each accompanied by a much smaller area posteriorly (Fig. 14). Larval skin with fine warty appearance, and scattered setae. Atrium of spiracle (Fig. 32) bears closely spaced annulations and numerous projections on the inside upper one-half of chamber; chamber tapers to a stout stalk with parallel, finely-crenulate sides, enclosing a well-defined closing apparatus. The final-instar spiracle differs from that illustrated by Arthur (compare Arthur, 1963, p. 1086, Fig. 4). The material illustrated in this work had a greater number of annulations, and a stouter general aspect, with a more pronounced taper.

Scambus (Scambus) tecumseh Viereck, and *Scambus* spp.

Ichneumonids in this genus have been reared from shoot moth material rather commonly, but not in large numbers. Raizenne (1952) listed rearings from shoot moth collections made from 1938 to 1948 in Ontario. Also in Ontario, Watson and Arthur (1959) recorded a complex of *Scambus* species, *S. hispae* and *S. tecumseh,* as active parasites of the shoot moth. *S. hispae* was reared as a parasite of *R. buoliana* in the Northeast by Schaffner (1959). Miller and Neiswander (1955) listed *S. hispae* as an unverified parasite of *R. buoliana* in Ohio.

Collections made at Two Rivers, from 1961 to 1963, yielded five specimens in the genus *Scambus.* Three females, identified as *S. (S.) tecumseh* emerged during July of 1963. Emergence dates for these were July 3, 16, and 25, from hosts collected on June 18, 25, and 28, respectively. Two undetermined specimens of *Scambus* emerged on June 7, 1961 and Julyl 1, 1963, from shoot moth-infested buds collected on May 13, 1961 and June 22, 1963. All the *Scambus* species reared at Two Rivers were solitary, external, larval parasites. Incompletely formed pupae were also found associated with the parasite remains. *S. (S.) tecumseh* was sometimes a victim of the cleptoparasitic habit of *Eurytoma pini.*

The final-instar cephalic structures and spiracles of the *Scambus* species and *E. comstockii* are so similar that it was not possible to separate the two adequately. It is suggested that Arthur (1963) be consulted for separation of *E. comstockii* and the *Scambus* complex, since too little *Scambus* material was reared at Two Rivers to make valid comparisons.

Ephialtinae:Ephialtini

Itoplectis conquisitor (Say)

This ichneumonid is an extremely common parasite of lepidopterous pupae and prepupae, especially those exposed or weakly protected. Over 80 species of lepidoptera have been recorded as hosts for *I. conquisitor* (Muesebeck *et al,* 1951; Arthur, 1963). Townes and Townes (1960) stated that it may act as a secondary by parasitizing ichneumonids and braconids within their cocoons. It has been reared as a parasite of *R. buoliana* nearly everywhere this host occurs in North America. Finlayson (1962) illustrated the final--instar cephalic structure and spiracle. Arthur (1963) illustrated the first four larval instar cephalic structures and spiracles, and described the biology of the species. Other notes on the biology of *I. conquisitor,* as a parasite of a *Coleophora* species, were discussed by Doner (1936).

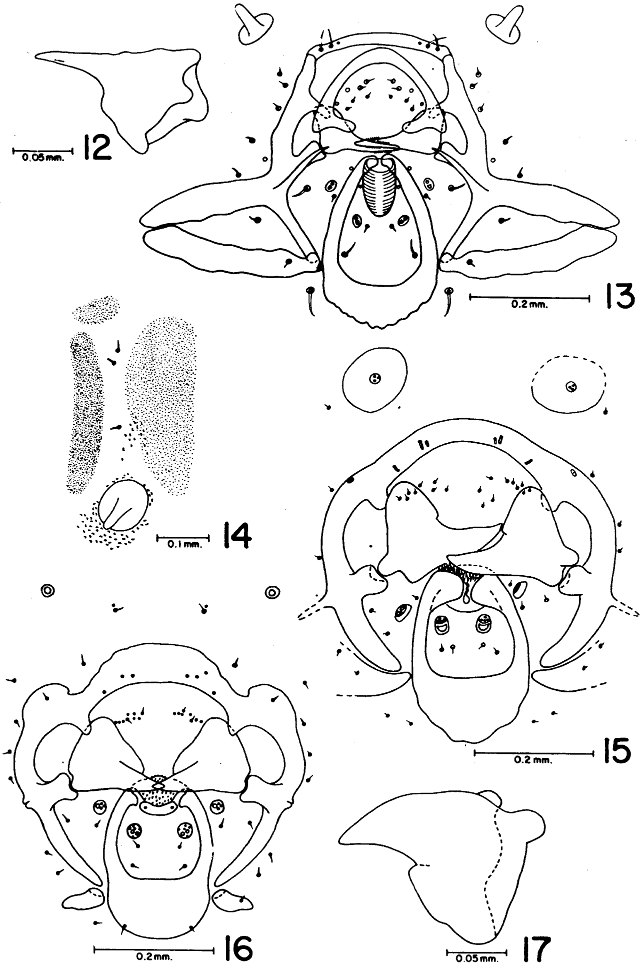
I. conquisitor was not recovered from the shoot moth at Two Rivers, but Wilkinson (1957) reared it from pupae of *R. buoliana* collected in Milwaukee County, Wisconsin. Individuals of *I. conquisitor,* including females apparently searching for hosts, were collected in flight in the plantations at Two Rivers. Field captures, during 1961 and 1962, were made from June 29 to October 8. Most of the individuals were caught in the early half of July of both years. In 1962, the peak flight activity was about ten days earlier.

Nests of *Archips cerasivorana* (Fitch) were numerous on *Prunus* spp. growing adjacent to some of the plantations. Several nests were collected and placed in rearing cages on July 17, 1962. Five individuals of *I. conquisitor* emerged between July 18 and 23.

Itoplectis ? evetriae

Figs. 16, 17, 34

Three individuals, two males and a female, emerged from shoot moth pupae in the summer of 1963. The emergence dates were July 12 and 13 for material collected on June 21; the female emerged on July 20, from a pupa collected on June 30. These specimens were tentatively identified, by L. M. Walkley. as possibly a



FIGURES 12–17. Cephalic structures of final-instar hymenopterous larvae: 12–14, *Exeristes comstockii* (Cress.); 12, right mandible, dorsal view; 13, cephalic structure, anterior view; 14, right side of vertex of head capsule, dorsal view; 15, *Coccygomimus annulipes* (Brullé), cephalic structure, anterior view; 16, 17, *Itoplectis ? evetriae* Vier.; 16, cephalic structure, anterior view; 17, right mandible, dorsal view.

new species near *evetriae,* but more specimens are needed to establish whether the separating characters are stable.

This species is a solitary, internal parasite emerging from the pupa of *R. buoliana.* No cocoon is present, and the host is empty except at the end of the abdomen where the parasite remains are found closely associated with the sclerotized portions of the host genital apparatus. Exit from the host pupa by the adult parasite is through a hole cut in the anterior end of the pupal skin. The exit hole has a jagged margin, and occurs on the pupa at about the middle of the scutellum. The adult parasite escapes from the host gallery by cutting a hole through the silk plug made by the host larva prior to pupation.

Cephalic structure of mature larva (Fig. 16) heavily sclerotized; epistoma, pleurostomata, and hypostomal spurs fused to form a ring broken ventrally by the labial sclerite. Superior mandibulary processes simple, articulate about one-quarter of the way down the articulating surface of each mandible; inferior processes indented to receive the large, blunt mandibular condyles. Hypostomal arms absent, two small projections present opposite the inferior mandibulary processes where the hypostomal arm would ordinarily arise. Hypostomal spurs long and narrow; stipital sclerites reduced. Labial sclerite broadly U-shaped, rectangular; ventral margin greatly widened; dorsal arms widely separated at their apices. Spiny hypopharyngeal region present, bounded laterally by dorsal arms of labial sclerite, and ventrally by pre-labial sclerite. No silk press evident. Mandibles (Fig. 17) heavy, without teeth, but each with a blunt protuberance posteriorly near base of primary blade. Maxillary palpi each with one large sensorium, and about three smaller ones; labial palpi each with two large sensoria, and about five smaller ones. Epistoma with three sensoria on each side. Antennae reduced to buttons. Vertex with two elongate pigmented areas that are more heavily sclerotized than the remainder of the vertex. Larval skin finely textured, with very short, hardly noticeable setae. Atrium of spiracle (Fig. 34) nearly round; numerous irregularly shaped protuberances scattered over its inner wall. Atrium borne on short annulated stalk about one-third its diameter; stalk with about eight rings; terminates at a distinct closing apparatus about twice as wide as the stalk.

Coccygomimus annulipes (Brullé)
Figs. 15, 33, 50

The rearing of *C. annulipes* from *R. buoliana* is a new host record (Torgersen and Coppel, 1962). It had previously been recorded from other Olethreutinae, including *Carpocapsa pomonella* (L). *Grapholitha molesta* Busck, *Gretchena bolliana* (Sling.), and *Laspeyresia nigricana* Steph. (Townes and Townes, 1960).

C. annulipes is a solitary internal parasite that emerges from the pupa of *R. buoliana*. A single female emerged on August 8 from an infested bud collected on July 24. The specimen emerged from a shoot moth pupa containing the remains of a fully formed moth. The thorax of the pupal case was split mid-dorsally, indicating that either the host had already begun to emerge when it was finally killed by the parasite, or the activity of the parasite in attempting to escape, caused the pupal case to rupture. Exit of the parasite adult is made by cutting through the posterior few segments of the pupal case, leaving a jagged margin.

Cephalic structure of final-instar (Fig. 15) heavily sclerotized; epistoma, pleurostomata, and hypostomal spurs form a ring broken ventrally by the labial sclerite. Superior mandibulary processes stout, articulate about one-quarter of the way down the articulating surface of each mandible; inferior processes simple, heavily-bodied, with apical depression in which mandibular condyle articulates. Hypostomal arms absent, lightly sclerotized projections present opposite inferior mandibulary processes where hypostomal arms ordinarily arise. Hypostomal spurs stout; reduced stipital sclerites distinct, heavily sclerotized medially, but less so laterally. Labial sclerite nearly elliptical, as opposed to that of *I. ? evetriae* which approximates a rectangle; widened ventral portion forms nearly a semi-circle; dorsal arms widen markedly apically; nearly meet medially; an indistinct silk press lies between apices of dorsal arms. Hypopharyngeal region bears long teeth. Mandibles heavily-bodied; without teeth, but each bears a protuberance at the base of the blade. Maxillary palpi each with at least two sensoria; labial palpi each with one large sensorium and four small sensoria. Labral sclerite absent, but labral area bears several small setae on either side. Antennae reduced to buttons, each with three sensoria; large sclerotized antennal socket surrounds each antenna. Vertex with two elongate pigmented areas. Atrium of spiracle (Fig. 33) nearly round; its inner wall without protuberances or patterning. Atrium not borne on a stalk; connected directly to a well-developed, deeply fluted closing apparatus.

Gelinae:Mesostenini

Gambrus sp.

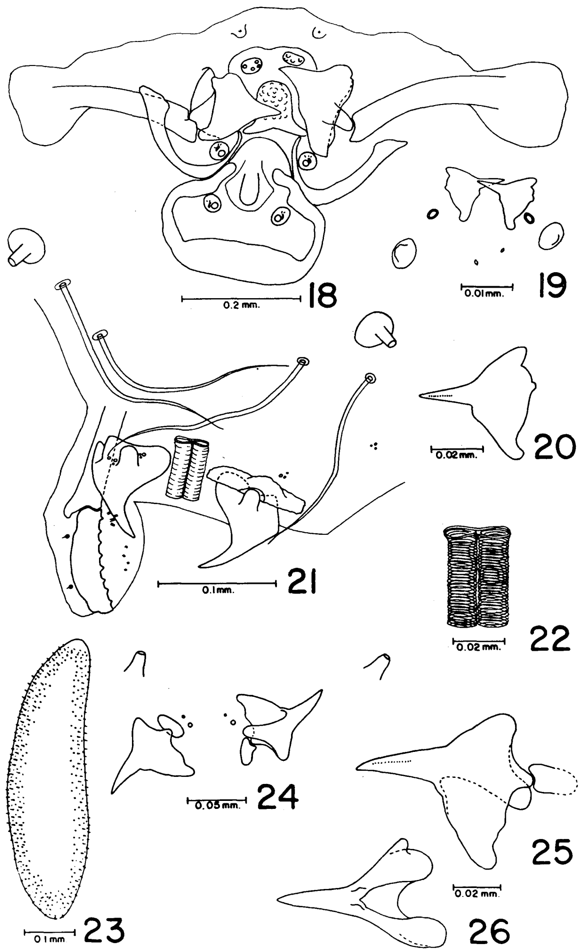
Fig. 54

Two individuals, one male and one female, of this species emerged on July 21, 1961. The buds from which they emerged were collected on July 18. Each specimen developed on a single host.

Ophioninae:Porizonini (=Campoplegini)

Unknown species 1

This tribe commonly parasitizes lepidopterous larvae (Muesebeck *et al*, 1951). Schaffner (1959) listed the rearing of several



FIGURES 18–26. Cephalic structures of final-instar hymenopterous larvae, and egg chorion: 18, *Atrometus* sp., cephalic structure, anterior view; 19, 20, *Hyssopus thymus* Gir.; 19, cephalic structure, dorsal view; 20, right mandible, dorsal view; 21, 22, *Macroneura vesicularis* (Retz.); 21, cephalic structure, dorsal view; 22, silk press, dorsal view; 23–26, *Habrocytus thyridopterigis* Howard; 23, egg chorion, lateral view; 24, cephalic structure, dorsal view; 25, 26, right mandible; 25, dorsal view; 26, posterior view.

campoplegine larvae collected in conjunction with studies of the parasites attacking *R. buoliana* in the Northeastern United States.

A single specimen of an unidentified species in this tribe was reared from shoot moth material collected at Two Rivers in 1961. A male emerged on August 18 from a shoot moth-infested bud collected on July 13.

Anomalini

Atrometus sp.

Figs. 18, 35, 53

The only *Atrometus* species that has been reared from the shoot moth is *A. clavipes,* recorded by Wolff and Krause (1922) in Europe, and by Watson and Arthur (1959) in Ontario. Besides *R. buoliana,* several other tortricids have been recorded as hosts of *A. clavipes.* These are: *Grapholitha molesta* Busck), *Spilonota ocellana* (D. and S.), *Acleris variana* (Fern.) (Muesebeck *et al.,* 1951), and *Ancylis comptana* Froh. (Watson and Arthur, 1959). The individual reared at Two Rivers was identified as *Atrometus* species near *clavipes* (Davis) and *paediscae* (Ashm.). One specimen emerged on July 17 from shoot moth-infested material collected on June 20, 1963. The specimen was a solitary, internal pupal parasite.

The adult parasite emerges from the pupa through a hole cut in the anterior end; the exit hole has a jagged margin around the pupa at about the anterior one-third of the scutellum dorsally, and across the middle of the labial palps ventrally. No cocoon is formed; the larval skin is found at the end of the pupa opposite the exit hole.

Cephalic structure of the final-instar larva (Fig. 18) characterized by a wide epistoma fused on either side with the pleurostomata and hypostomal arms; pleurostomata and hypostomal arms greatly widened, and extend laterally. Superior mandibulary processes stout, articulate in depressions at the dorsal end of the articulating surface of each mandible; inferior processes articulate with stout mandibular condyles. Mandibles heavily-bodied. Hypopharyngeal region with a cobblestone texture. Hypostomal spurs absent; stipital sclerites curve downward from hypostomal arms to meet the labial sclerite, and then curve upward to the hypopharnygeal region. Labial sclerite open, widened ventrally; dorsal arms widened slightly apically where they bend medially. U-shaped mouth of silk press evident between dorsal arms. Labial and maxillary palpi each have one large sensorium, one narrow crescent-shaped sensorium, and two or three small radiating sensoria, respectively. Epistoma with a single sensorium on each side; labral area with two palp-like organs each with four sensoria. Antennae were not located. Larval skin smooth, without setae, but has a few patches of very short stout spines. The condition of the single larval skin did not allow determination of the position of these spines on the larva. Atrium of spiracle (Fig. 35) small, opens directly into closing apparatus that is about equal in diameter to atrium.

Eulophidae

Elachertinae

Elachertus pini Gahan

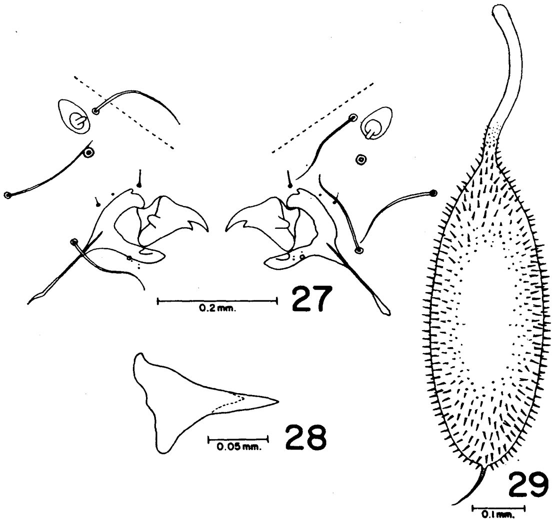
Three specimens of *Elachertus pini* were reared from shoot moth material collected in April and May of 1959 by H. C. Coppel, officers of the Wisconsin Conservation Department and the Plant Industry Division of the Wisconsin Department of Agriculture (Torgersen and Coppel, 1962). This was a new parasite record for *R. buoliana*. Previously this parasite had been collected only from a *Dioryctria* species and from *R. frustrana* (Peck, 1963).

Hyssopus thymus Girault

Figs. 19, 20, 36, 43

H. thymus is a very common parasite of *R. buoliana* especially in the Midwestern and Eastern United States, and has also been reared from shoot moth material in Ontario. Friend (1935), Friend and Hicock (1936), and Friend *et al* (1938) recorded it as the most common parasite of the shoot moth in Connecticut. Rearings from shoot moth material collected throughout the Northeast (Schaffner, 1959), showed a preponderance of this species, both in the number of collections yielding the parasite, and in the number of individuals reared. The number of individuals recorded by Schaffner probably represents many fewer hosts because this is a gregarious species, but is not so designated in his paper. However, the figures indicate the tremendous activity of *H. thymus* as a parasite of the shoot moth. At Natrium, West Virginia, *H. thymus* is the most commonly reared parasite of *R. buoliana* (Harman and Kulman, 1962).

The biology of *H. thymus* was studied by Miller (1953), Coppel *et al.* (1955), and Watson and Arthur (1959). This tiny eulophid is a gregarious, external parasite of the shoot moth larva; two generations, and a partial third generation are produced per year. Adults emerge in the spring after overwintering as pupae in the gallery of the dead host. The summer generation of *H. thymus* at Two Rivers emerges between June 18 and August 7. Peak emergence takes place during mid- and late July. From 95 parasitized hosts in 1963, 1,100 *H. thymus* emerged. The range in the number of individuals emerging per host larva was 1 to 86, with an average of 11.5. In 1961, when only 11 hosts were involved, the average was 6.2 parasites per host, with a range from 1 to 13. Longevity studies conducted at Two Rivers showed that adults can survive for an average of 47 days, range for five individuals was 46 to 49 days, if they have a source of food and water.



FIGURES 27–29. Cephalic structure of final-instar larva, and egg chorion of *Eurytoma pini* Bugbee: 27, cephalic structure, dorsal view; 28, right mandible, anterior view; 29, egg chorion, lateral view.

H. thymus emerged successfully from the same hosts with *Eurytoma pini, Habrocytus thyridopterigis,* and *Macroneura vesicularis.* When *H. thymus* develops successfully on a single host with *M. vesicularis,* it is probably due to the failure of the secondary to destroy all of the developing eulophids.

Dissections of buds from which *H. thymus* have emerged reveal the empty pupal skins. These skins are dark brown and fragment either at the time of emergence of the adults, or are broken by their movements following emergence. The final-instar larval skin is attached to the abdomen of the pupal skin or adheres to the gallery wall. The pupal skins are closely associated with the host remains. No cocoon is constructed by the parasite.

Cephalic structure of final-instar larva (Fig. 19) apparently limited to mandibles. Mandible (Fig. 20) with straight blade bearing a row of hair-like teeth. Antennae extremely flattened, much wider than long. Two pairs of sensoria, probably rudimentary palpi, present near the bases of mandibles. Due to shifting and flattening of mounted skins, the above characters may have variable positions. Larval skin smooth, and without setae. Atrium of spiracle (Fig. 36) large, funnel-shaped, and many chambered, ending in a long stalk with a small closing apparatus at the end.

Eupelmidae

Eupelmus cyaniceps Ashmead

Fig. 51

Eupelmus cyaniceps was recorded as a parasite of *R. buoliana* by Raizenne (1952). Only one specimen of *E. cyaniceps* was reared from shoot moth material collected at Two Rivers (Torgersen and Coppel, 1962). An adult female emerged on August 5, 1961 from a bud collection made on July 25. The host remains consisted of a partly devoured larva of *R. buoliana* accompanied by the larval remains of a final-instar *E. comstockii.* Therefore, it can be surmised that *E. cyaniceps* can be a secondary parasite of *R. buoliana* through *E. comstockii.* No cocoon is constructed. The fractured shed pupal skin of *E. cyaniceps* was recovered, but the final-instar larval skin was not found, either attached to the pupal skin, or loose in the gallery.

Macroneura vesicularis (Retzius)

Figs. 21, 22, 37

Macroneura (=Eupelmella) vesicularis is a solitary, external, primary or secondary parasite on a great variety of insects (Peck, 1963). Watson and Arthur (1959) recorded this species as a parasite of *R. buoliana* in Ontario. Only three other species of tortricids are known, or suspected hosts of *M. vesicularis* (Peck, 1963).

Notes on the biology, and illustrations of the immature stages of *M. vesicularis,* as a predator of *Microplectron fuscipennis* Zett. in the cocoons of *Neodriprion sertifer* Geoffr. in Europe, were prepared by Morris (1938). Phillips and Poos (1927) described and illustrated the egg and larval instars as *Eupelminus saltator* (Lind.), and Doner (1936), in Wisconsin, discussed its biology as a parasite of *Coleophora pruniella* Clem. Finlayson (1960) illustrated the final-instar cephalic structure of *M. vesicularis.* This species is thelytokous, and is easily distinguished from the other parasites of the shoot moth by the apparent lack of wings in the adult. The female paralyzes her host before ovipositing, and sometimes feeds at the puncture (Doner, 1936). The egg is similar to that of *Eurytoma pini,* with projections at either end. The two differ in that the eggs of *M. vesicularis* lack spines. According to Doner (1936), after a 36 hour incubation period, *M. vesicularis* takes 20 days to develop to the adult on *C. pruniella,* and emergence occurs from July 13 to 21. At Two Rivers, development takes no fewer than 30 days, and in some cases as many as 43 days; emergence is from July 19 to August 18, with the peak occurring between July 24 and August 2. A single field capture of an adult was made on June 25, 1962, fully a month ahead of laboratory emergence of this species. The lengthy developmental and emergence period is probably due to the cool springs and summers experienced at Two Rivers.

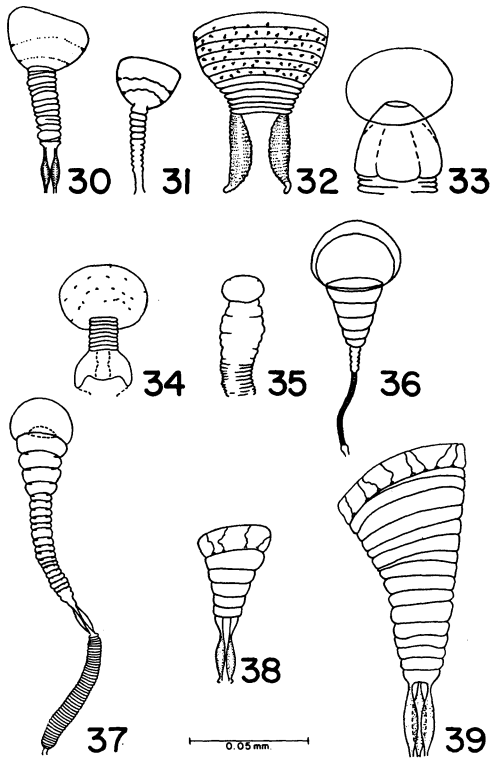
Laboratory dissections of buds from which *M. vesicularis* had emerged indicated that *E. comstockii* and *H. thymus* served as hosts for this secondary parasite. *E. comstockii* was more often the primary involved, possibly indicating *M. vesicularis* prefers the larger host. In a single case of multiple parasitism, both *M. vesicularis* and 20 *H. thymus* developed and emerged successfully on a single host. This case probably indicates a situation wherein the secondary simply overlooked some of its tiny competitors, or the secondary had not reached the voracious final-instar until after the *H. thymus* had pupated and emerged.

No cocoon is constructed by the parasite larva. The shed pupal skin is honey-colored, fragmented, and may or may not be closely associated with the host remains. Exit from the bud is made through a hole cut in the silk plug which was made by the host larva prior to death. The exit hole is about 0.75 to 1.00 mm. in diameter.

Cephalic structure of final-instar larva (Fig. 21) consists of mandibles and a heavily sclerotized clypeus with denticles along its ventral margin; labrum bears four pairs of papillae. Figure 21 shows a portion of the pleurostoma, also part of the inferior mandibular strut. Curved blade of mandibles without teeth. Inferior mandibular condyles stout, articulate in groove of inferior mandibular strut. Mandibular strut was called hypopharyngeal bracon by Phillips (1927). Lightly sclerotized silk press present; apparently consisting of two closely appressed tubes with fine spiral thickenings in its walls (Figs. 21, 22). Maxillary and labial palpi bear three sensoria each. Antennae slightly less than twice their basal diameter in length. Larval skin smooth, characteristically covered with scattered long setae, and a few short setae at the posterior end of the skin. Atrium of spiracle (Fig. 37) narrowly funnel-shaped, numerous chambers decreasing in size to the closing apparatus which is followed by a long annulated stalk.

Pteromalidae
Pteromalinae:Pteromalini
Habrocytus thyridopterigis Howard
Figs. 23–26, 38, 41, 52

R. buoliana was recorded as a host of *H. thyridopterigis* by Raizenne (1952) in Ontario, by Schaffner (1959) in the North-



FIGURES 30–39. Spiracles of final-instar hymenopterous larvae: 30, *Bracon* n. sp.; 31, *Bracon gelechiae* Ashm.; 32, *Exeristes comstockii* (Cress.); 33, *Coccygomimus annulipes* (Brullé); 34, *Itoplectis ? evetriae* Vier.; 35, *Atrometus* sp.; 36, *Hyssopus thymus* Gir.; 37, *Macroneura vesicularis* (Retz.); 38, *Habrocytus thyridopterigis* Howard; 39, *Eurytoma pini* Bugbee.

east, and as a questionable recovery from the shoot moth by Miller and Neiswander (1955) in Ohio. This species is a gregarious primary or secondary parasite of the shoot moth at Two Rivers. From 24 host larvae, 68 parasite individuals emerged; an average of 2.83 parasites per host (range 1 to 8). For three seasons, 1961 through 1963, the emergence period was from July 1 to August 15. The peak emergence period was in early August in 1961, and in mid-July in 1962 and 1963. Adults were captured in the field as early as June 9, weeks before this species emerged from laboratory collections.

When *H. thyridopterigis* acted as a primary, it was associated with the larva of the shoot moth. *E. comstockii* was the most common primary parasite hyperparasitized by *H. thyridopterigis*. Remains of *Eurytoma pini* and *H. thymus* were also recovered, indicating that these also served as hosts. This parasite emerged successfully with *H. thymus, Eurytoma pini,* and *Bracon* n. sp. from the same host individuals.

The larva constructs a silken cocoon which may or may not be closely associated with the host remains. The shed pupal skin is lightly golden brown fragmented, and sometimes found outside the cocoon. Mature larval skin does not always adhere to the shed pupal skin and may be loose in the host gallery. Egg elliptical (Fig. 23), more rounded at one end, and evenly patterned with tiny spines and papillae except for the pointed end where the chorion is smooth. Papillae are about equal in diameter to the bases of the spines.

Cephalic structure of final-instar larva (Fig. 24) apparently limited to mandibles, which, on the shed skin, project straight forward. Close examination reveals the presence of fragments of what are probably the superior mandibulary processes attached to the superior mandibular condyle of each mandible (Fig. 25). In Figure 26, the superior mandibulary process is omitted. Mandibles with slightly curved blades bearing a row of hair-like teeth. Palpi present near the bases of the mandibles; their position may vary with the disposition of the parts in handling the skin. Antennae tapered, slightly longer than basal width. Larval skin not distinctively textured; light in color, and with few setae. Atrium of spiracle (Fig. 38) with about seven gradually tapering chambers ending at a well-defined closing apparatus. Apical chamber of atrium patterned with very fine wavy lines.

Eurytomidae

Eurytoma pini Bugbee

Figs. 27–29, 39, 40

In much of the literature on the parasites of *R. buoliana, Eurytoma pini* has been listed as *E. tylodermatis* Ashm. (Friend and Hicock, 1933, 1936; Miller, 1953; Miller and Neiswander, 1955), or *E. appendigaster* (Swed.) (Sheppard, 1933). Bugbee (1958) believed that this species probably occurs wherever pines and its preferred host, *R. frustrana,* are present. It has been recorded as an active parasite of *R. buoliana* in Connecticut (Friend and Hicock, 1933, 1936), Ohio (Miller, 1953), West Virginia (Harman and Kulman, 1962), Wisconsin (Torgersen and Coppel, 1962), and Ontario (Arthur, 1961).

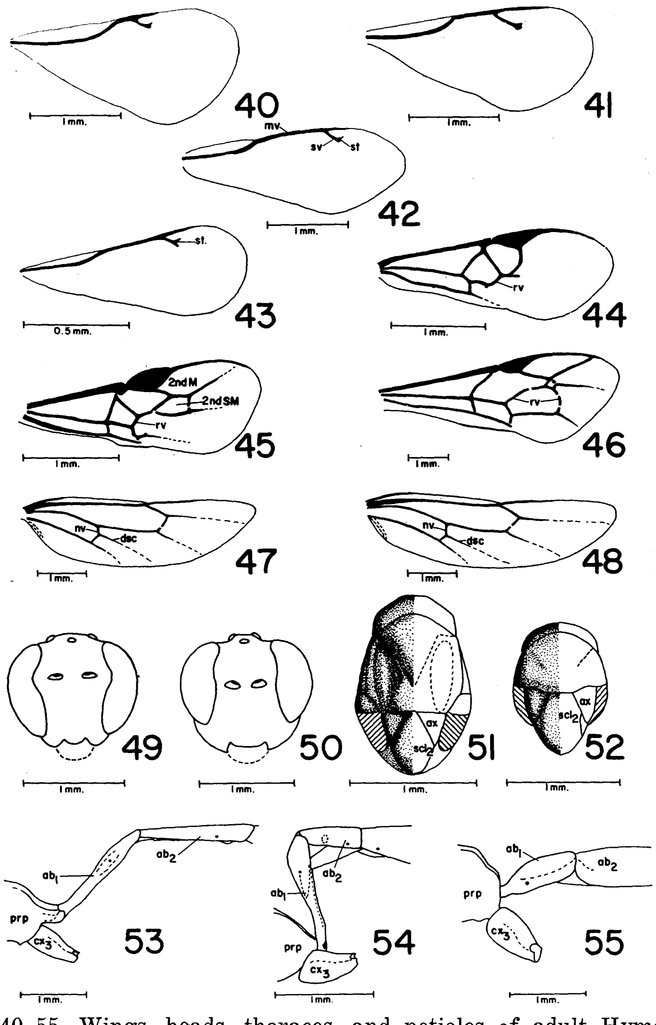
Arthur (1961) described the cleptoparasitic habits of *E. pini,* and illustrated the immature stages. He observed adults emerging from early June to late June, and Miller (1953), in Ohio, recorded emergence from June 21 to July 21. At Two Rivers, the earliest of 44 adults reared from parasitized *R. buoliana* during three years, emerged on July 5, the latest on August 11. Peak emergence occurred between July 18 and 21. The sex ratio is about 2:1 in favor of females; Miller (1953) observed a 3:1 sex ratio. *E. pini* was collected in flight in the field on June 18, about two weeks before emergence began in the laboratory. Unfed adults lived for about six days (range 3 to 12). A single male, fed on honey water, survived for 38 days.

The period required for development from egg to adult, calculated from earliest and latest collection and emergence dates, is approximately 28 days (range 21 to 34). Studies by Miller (1953) showed that, exclusive of the egg and larval feeding period, it takes an average of 18 days for development from the prepupal stage to emergence of the adult.

At Two Rivers, a single adult emerged from each host. Most authors have considered this species to be a solitary parasite, however, Arthur (1961) observed up to three adults emerging from a single host. *E. pini* usually develops on shoot moth larvae, but it is not uncommon to find that it has developed on a pupa; a situation also observed by Miller (1953). Dissections of buds from which *E. pini* had emerged revealed that this parasite had succeeded at the expense of the larva of *Scambus tecumseh* or, more commonly, the larva or pupa of *E. comstockii*. Remains of both *E. pini* and *E. comstockii* were found in buds from which *H. thyridopterigis* developed and emerged successfully. In addition, there was a single case wherein both *E. pini* and nine *H. thymus* emerged from one host larva; and one case in which *E. pini* and *H. thyridopterigis* successfully emerged, having developed either on, or at the expense of *E. comstockii*. From these observations it is possible to claim both secondary and multiple parasitic behavior for *E. pini*.

No cocoon is constructed for pupation. The parasite remains are closely associated with the host remains. The pupa is dark honey-brown, fragmented, and usually has the mature larval skin adhering to it. The adult escapes from the host gallery either by cutting through the silk or resin mass, or directly through a thin portion in the host gallery wall. The exit hole is 1.0 to 1.2 mm. in diameter.

Egg elliptical (Fig. 29); slightly more pointed at one end. Blunt end with a sharp barb-like process with a roughened surface; pointed end with a long, smooth, thin-walled closed tube that is slightly swollen at its tip. Chorion armed with numerous spines. The presence of these eggs in a great many of the galleries of *R.*



FIGURES 40–55. Wings, heads, thoraces, and petioles of adult Hymenoptera: 40, *Eurytoma pini* Bugbee, forewing; 41, *Habrocytus thyridopterigis* Howard, forewing; 42; *Eupelmus cyaniceps* Ashm., forewing; 43, *Hyssopus thymus* Gir., forewing; 44, *Apanteles* sp., forewing; 45, *Bracon gelechiae* Ashm. forewing; 46, *Itoplectis ? evetriae* Vier. forewing; 47, *Exeristes comstockii* (Cress.), hind wing; 48, *Scambus tecumseh* Vier., hind wing; 49, *Itoplectis ? evetriae* Vier., head, anterior view; 50, *Coccygomimus annulipes* (Brullé), head, anterior view; 51, *Eupelmus cyaniceps* Ashm., thorax, dorsal view; 52, *Habrocytus thyridopterigis* Howard, thorax, dorsal view; 53, *Atrometus* sp., petiole, lateral view; 54, *Gambrus* sp., petiole, lateral view; 55, *Exeristes comstockii* (Cress.), petiole, lateral view. ab_1 first abdominal segment; ab_2, second abdominal segment; ax, axilla; cx_3, metathoracic coxa; dsc, discoidella; mv, marginal vein; nv, nervellus; prp, propodeum; rv, recurrent vein, scl_2, mesoscutellum; st, stigma; sv, stigmal vein; 2nd M, second marginal cell; 2nd SM, second submarginal cell.

buoliana successfully parasitized by other parasite species attests to the great activity of *E. pini* as a cleptoparasite.

Cephalic structure of final-instar larva (Fig. 27) consists of mandibles and two broadly U-shaped sclerites bearing the mandibulary articulations. Head capsule split medially (dotted lines) down through cephalic structure dividing mouth frame into two parts joined only by the cuticle of the venter of the head. Epistoma absent; pleurostomata bear large superior mandibulary processes; hypostomal arms reduced to narrow strips extending ventrad. Hypopharyngeal bracon (Phillips, 1927) bears the inferior mandibulary articulations. Mandible (Fig. 27) with a large curved blade bearing a large denticle posteriorly. In anterior view (Fig. 28) mandible shows a distinctive curve to the superior mandibular condyle; this hooks behind the mandibulary process on the pleurostoma. "Vestigial maxillary palps" (Phillips, 1927) and three sensoria are present on either side below, or apparently on, the hypopharyngeal bracon depending upon the disposition of the skin. Antenna about twice as long as its diameter; antennal sclerites surrounded by more heavily sclerotized areas than the remainder of the head capsule; a single sensorium is present near each antennal socket. Larval skin smooth; head capsule and skin bear scattered long and short setae 0.07 to 0.15 mm. long; some shorter setae are present around the cephalic structure. Atrium of spiracle (Fig. 39) funnel-shaped with numerous annulations; apical ring of atrium patterned with fine wavy lines. There is a well-defined closing apparatus composed of three distinct spindle-shaped valves.

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Summary

Twenty species of parasites of *Rhyacionia buoliana* (Schiffermüller) have been reared in Wisconsin. Two keys have been prepared to separate the parasites. The first is designed to aid in

identifying the parasites on the basis of the host remains left in the bud after the parasite has emerged. Twelve sepcies of parasites, one Diptera and eleven Hymenoptera, are included in the key to parasite remains. The second is for the identification of the adults of the parasites of *R. buoliana* in Wisconsin. Brief notes on the biology of each species, and descriptions of the final-instar cephalic structures are also given.

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THE INSECT PARASITES OF THE LARCH CASEBEARER, *COLEOPHORA LARICELLA* HUBNER, (LEPIDOPTERA: COLEOPHORIDAE), IN WISCONSIN WITH KEYS TO THE ADULTS AND MATURE LARVAL REMAINS

*Norman F. Sloan and Harry C. Coppel**

The larch casebearer, *Coleophora laricella* Hbn., was first discovered near Northampton, Massachusetts, in 1886 (Hagen, 1886). Its spread to the Lake States Region was rapid: at Ann Arbor, Michigan in the early 1920's (Webb, 1953); in northeastern Wisconsin in 1939 (MacAloney, 1939); at Port Arthur, Ontario in 1947 (Webb, 1953). An outbreak on the western larch, *Larix occidentalis* Nutt. was discovered in 1957 in Idaho and currently infests nearly two million acres (Pechanec, 1963).

The preferred hosts of the casebearer include all species in the genus *Larix*. The eastern white pine, *Pinus strobus* L. (Peirson, 1927) and Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco (Webb, 1953) have been recorded also as hosts of the casebearer. Laboratory feeding experiments indicate that it might also survive on the western hemlock, *Tsuga heterophylla* (Rafn.) Sarg. Death of the host tree rarely occurs but has been noted after three years of consecutive defoliation (Patch, 1906). Increment loss may be considerable according to Pechanec (1963), who recorded an average reduction of 55% from 1956–62 in Idaho.

In 1961, studies were initiated on the bionomics of the larch casebearer in Wisconsin primarily to determine the structure of its parasite complex. Data were assembled both from field collections and laboratory studies of material collected during the summers of 1962–64 from three locations in Wisconsin; the University Arboretum, Dane County; near Antigo, Langlade County; and near Bloomington, Grant County.

This paper concerns the insect parasites collected from *C. laricella* in Wisconsin from 1961–1964 and one additional species collected by H. Coppel prior to the study. Keys both for the separation

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of the parasites based on the remains left in the case after the parasite has emerged, and for the separation of the adults are given. The final-instar cephalic structures, spiracles, and adults are illustrated and described. Notes on the biology of the parasites are also included.

METHODS

The material upon which the keys are based consisted of the adult parasites and the remains positively associated with them. The adults were identified by the staff of the Insect Identification and Parasite Introduction Branch of the U.S. Department of Agriculture at Beltsville, Maryland.

The key to parasite remains was based on the characters of the larval and pupal skins of the parasites. The larval skins were removed from the host cases by soaking the latter in a bleach for 2 to 3 minutes to loosen the silk. The parasite skins were softened in 10% potassium hydroxide for 30 minutes to several hours, and washed in distilled water. The washed skins were placed on a slide in a drop of glycerine and carefully spread with insect pins until the mouth parts and spiracles were exposed. The cover slips were ringed with clear fingernail polish.

Illustrations of gross characters and outlines of larval remains and adult parasites were prepared with the aid of a projection prism. An Ernst Leitz binocular compound microscope fitted with an ocular grid was used for the fine details of the larval remains. Adults were drawn with the aid of a Bausch and Lomb binocular zoom microscope fitted with 20X eyepieces and a 2X enlarger lens. Antennae and legs of the adults were removed from the body and placed on slides to allow examination in detail. The terminology used for the parts of the cephalic structures and spiracles of the final-instar larvae of Hymenoptera is similar to that employed by Finlayson (1960).

PARASITES OBTAINED

The following parasites were reared from *C. laricella* in Wisconsin.

HYMENOPTERA

BRACONIDAE: *Agathis cinctus* (Cress.), *A. pumila* (Ratz.), *Apanteles laricella* Mason, *Bracon juncicola* Ashm., *Bracon pygmaeus* Prov., *Bracon* sp.

ICHNEUMONIDAE: *Isdromas* sp., *Gelis tenellus* (Say), *Campoplex* sp. (*Phaedroctonus* group)

EULOPHIDAE: *Sympiesis* sp., *Tetrastichus coerulescens* (Ashm.), *Kratochviliana laricinellae* (Ratz.)

PTEROMALIDAE: *Capellia lividicorpus* (Grit.), *Habrocytus phycidis* Ashm.

CHALCIDIDAE: *Spilochalcis albifrons* (Walsh).

Two keys have been prepared for the separation of the above species. It is possible to separate the parasites on the basis of the remains left in the cases after the adults have emerged. Nine species of parasites are included in the key to parasite remains. The remaining six species have not been included because insufficient material was available. The second key allows identification of nine of the adult parasites of *C. laricella* in Wisconsin.

KEY TO THE COMMON IMMATURE PARASITES OF *C. LARICELLA* BASED ON PARASITE REMAINS

1 Parasite pupal skin found in the host case ---------------- 2
Parasite pupal skin not found in the host case ----------- 4

2(1) Parasite emerged from the pupated host; the hypostoma more than half the total length of the cephalic structure (Fig. 8) -------------------*Spilochalcis albifrons* (Walsh.)
Parasite emerged from the larva of the host; the hypostoma not more than half the total length of the cephalic structure -- 3

3(2) Cephalic structure much reduced (Fig. 10); spiracles with closing apparatus very short (Fig. 17) ------------------ -------------------------*Kratochoviliana laricinellae* (Ratz.)
Cephalic structure reduced with a complete epistoma and hypostoma (Fig. 12); spiracles with closing apparatus nearly equal to ½ the total length of the atrium (Fig. 18) -------- -------------------------------*Habrocytus phycidis* Ashm.

4(1) Mandibles with distinct teeth (Figs. 1, 2, 5) ------------- 5
Mandibles without teeth or with very small ones (Figs. 3, 4, 8, 9, 10, 12) --- 7

5(4) Epistoma complete (Fig. 2); mandibles each with 4 teeth (Fig. 6); hypostoma not forming a lateral, wing-like structure (Figs. 1, 5); labial and maxillary palpi as single circles; ---------------------------------*Bracon pygmaeus* Prov.
Epistoma incomplete or appearing incomplete (Figs. 1, 5); hypostoma forming a lateral, wing like structure; labial and maxillary palpi each as 3 circles enclosed within a larger circle -- 6

6(5) Antennae appearing as a single semicircle and two crossed semicircles (Fig. 5); incomplete antennal sclerite; labial sclerite joined near junction of stipital sclerite and labial sclerite --------------------------*Agathis cinctus* (Cress.)
Antennae appearing as two small circles within two slightly

larger circles; complete antennal sclerite (Fig. 1); labial sclerite in one piece ______________ *Agathis pumila* (Ratz.)

7(4) Atrium pitted on external surface; chambers tapering sharply without a closing apparatus (Fig. 19); antennae cone-shaped (Fig. 9); maxillary and labial palpi a single circle with a smaller circle inside; four pits located directly above both sets of palpi; two pits appear joined __________ __________________________________ unknown ichneumonid

Atrium not pitted on external surface; chambers, if tapered, with a closing apparatus (Figs. 20, 21); antennae flat topped; maxillary and labial palpi consisting of more than one circle within a larger circle; no pits near the palpi ______ 8

8(7) Atrium tapering with a closing apparatus (Fig. 20); lacinial sclerite present; maxillary and labial palpi consisting of two openings within the larger outer sclerite (Fig. 3); labial sclerite present ______________________ *Gelis tenellus* (Say)

Atrium not tapering but with progressively larger chambers; no closing apparatus (Fig. 21); labral sclerite absent; maxillary palpi a split circle within the outer circle while the labial palpi have two seperate openings within the outer one (Fig. 4) ___________________________________ *Campoplex* sp.

KEY TO THE ADULTS OF THE COMMON PARASITES OF *C. LARICELLA*

1 Wing venation reduced (Figs. 27, 29, 31, 32, 33); antennal segments not exceeding 12 _____________________________ 2

Wing venation well developed (Figs. 22, 25, 34, 36); antennal segments exceeding 12 _________________________________ 5

2(1) Hind femur much enlarged and toothed on inner edges; tarsus originating before the apex of the tibia (Figs. 27, 28); dark brown insects with white to cream colored markings on face and body _____________ *Spilochalcis albifrons* (Walsh.)

Hind femur not enlarged ____________________________ 3

3(2) Tarsal segments 4; antennal segments 7, the apical segment pointed and with a false ring; metallic green (Figs. 29, 30) ______________________ *Kratochviliana laricinellae* (Ratz.)

Tarsal segments 5; antennal segments more than 7 ______ 4

4(3) Antennal segments 10; stigmal vein ending almost at the end of the marginal vein (Fig. 33); dark purple-black insects __ _____________________________ *Capellia lividicorpus* (Grit.)

Antennal segments 12; stigmal vein not ending at the end of the marginal vein, much shorter (Figs. 31, 32); dark green insects; female larger than male with large pointed abdomen _____________________________ *Habrocytus phycidis* Ashm.

5(1) Forewings with a dark stigma ---------------------------- 6
Forewings without a dark stigma ------------------------ 8
6(5) Antennal segments 30; wing venation as in Fig. 25; wings not colored; thorax dark brown with yellow abdomen banded with brown ------------------------*Bracon pygmaeus* Prov.
Antennal segments 28; wing venation as in Fig. 22; wings smoky colored; body all black -------------------------- 7
7(6) Ovipositor not longer than ⅓ the length of the abdomen (Fig. 23) ------------------------*Agathis pumila* (Ratz.)
Ovipositor longer than the entire abdomen (Fig. 24) ------
----------------------------------*Agathis cinctus* (Cress.)
8(5) Antennal segments 19; banded brown insect with brown bands across the forewings (Fig. 34) --*Gelis tenellus* (Say)
Antennal segments 28; black insect without any colored bands in the forewings (Fig. 36) ------------*Campoplex* sp.

NOTES ON PARASITES BIOLOGY AND DESCRIPTIONS

Braconidae

Agathis cinctus (Cress.)

Figs. 5, 14, 24

One individual was collected in Polk County, Wisconsin, prior to the present study by H. Coppel. The parasite is a solitary, internal parasite and emerges from the larva of *C. laricella.* No cocoon is present in the host case. The adult emerges by cutting the silk threads that hold the top of the case closed; thus, no exit hole is found. The host remains consist only of the skin and head capsule which are tightly packed in the bottom of the case. The parasite's meconium is closely associated with the host skin.

The atrium of the spiracle (Fig. 14) is nearly spherical and leads into an irregularly shaped stalk about one-third its diameter. The stalk has about 10 annulations and terminates in a well-defined closing apparatus. The cephalic structure of the final instar larva (Fig. 5) is heavily sclerotized. Lateral wing-like structures are formed by the hypostomata, hypostomal spurs, and the stipital sclerites. The mandibles articulate at two points. The inferior mandibular process is an extension of the hypostoma. The base of the mandible fits into a groove formed in the wall of the hypostoma which serves as the superior mandibular process. The labial sclerite is joined near the top. The silk press is large and fills the area between the two arms of the labial sclerite. The epistoma is incomplete and appears as a thickened area of unpigmented skin. The maxillary and labial palpi are each three-segmented with one sensorium per segment. Three setae are located above the maxillary palpi whereas six setae are found within the labial sclerite frame and above the labial palpi. The antennal sclerites are incomplete. The antennae each appear as a single semicircle and two crossed semicircles.

Braconidae

Agathis pumila (Ratz.)

Figs. 1, 13, 22, 23

This is the most important parasite of *C. laricella* and was reared in large numbers each year. It is a solitary internal parasite which emerges from the larva of *C. laricella.* No cocoon is found in the host case. The adult emerges through the top of the case and does not cut an exit hole. The host remains, parasite larval skin, and the meconium are compacted at the base of the case.

The atrium of the spiracle (Fig. 13) is nearly spherical. It leads into an irregularly shaped stalk about one-third its diameter. Each ring of the stalk is off-set from the next to form a staggered appearance. There are about 27 annulations in the stalk which terminates in a well-defined closing apparatus. The cephalic structure of the final instar larva (Fig. 1) is heavily sclerotized. As in *A. cinctus,* a lateral wing-like structure is formed by the hypostomata, hypostomal spurs, and the stipital sclerites. Articulation of the mandibles is the same as with *A. cinctus.* The labial sclerite is one piece with a cross bar joining the base of the two arms as a curving bridge. The silk press is large and contained within the opening between the arms of the labial sclerite. The maxillary and labial palpi are similar to those of *A. cintus.* The same number of setae are found in *A. pumila* as in *A. cinctus* except for the labral area, but the arrangement is slightly different. *A. pumila* has additional setae in the area of the labrum. A row of three setae is located directly above the mandibles with, additionally, a single seta above the row and two more above and to the side on each half of the labral area. The antennal sclerites are complete. The antennae each consist of two small circles with a sensorium in each circle.

The two *Agathis* species are both dark colored insects, mostly black with white body setae. The antennae each have 28 segments including two basal segments. In Fig. 22 the first basal segment is not shown. There are five tarsal segments. The legs are yellow with bands of dark brown. The hind coxae are black. The wings are smoky colored with small setae on their surfaces. A row of hairs completely encircles the fore and hind wings. The stigma is large (Fig. 22) and dark brown. The second cubital and the radial cells are small.

The two *Agathis* species are distinguished from each other by their size. *Agathis cinctus* is larger. The most striking difference is in the length of the ovipositor, the *A. cinctus* ovipositor being longer than the abdomen whereas the *A. pumila* ovipositor is about one-third the length of the abdomen. The two species are separated from other Wisconsin parasites of the larch casebearer by their general dark appearance and smoky wings. Although *Isdromas* sp. and *Campoplex* sp. are dark colored and of about the same size, their wings are not smoky. *Apanteles laricellae,* a dark colored braconid, has clear wings.

Graham (1948) reported that *A. pumila* had one generation per year in Ontario. The first larval instar overwintered within the host larva. The parasite remained in the host larva until the host development was completed in May or early June. As soon as the host was tied in place for pupation the parasite larva began its development and pupated within the host during the second or third week in June. The presence of the parasite egg or larva did not affect the host larva until pupation time when it was prevented from pupating. Thus, the host larva remained in the field for an additional two weeks in June. Adult parasites emerged during late June and early July, and oviposited during July in the small needle-mining casebearer larvae. Eggs hatched in about 14 days and first instar larvae appeared in July.

Braconidae

Bracon pygmaeus Prov.

Figs. 2, 15, 25, 26

Bracon pygmaeus develops as a solitary, external parasite. It pupates within a white oval cocoon. The parasite larval skin, meconium, and host larval skin are found within the cocoon. Emergence occurs through a hole cut at one end of the cocoon and through the host case. The irregular emergence hole is near the top of the case.

Each spiracle (Fig. 15) has a single large atrium and a stalk with little taper. The closing apparatus is long and consists of two closely arranged valves. The epistoma, pleurostomata, and hypostomata are fused and form an arch over the mandibles and labial sclerite (Fig. 2). The superior and inferior mandibular processes are about equal length. The mandible has a short blade with several teeth posteriorly. The stipital sclerites are in the same plane and above the hypostomata. They are joined with the hypostomal spurs at their junction with the labial sclerite. The two arms of the labial sclerite are joined by a small sclerite which encloses the silk press at its apex. The maxillary and labial palpi are simple with a single sensorium in each. A row of four setae is located along the epistoma and an additional set of four along the upper surface of the labial sclerite. Six setae occur on the lower surface of the labial sclerite. Two additional setae are found, one on each side of the maxillary palpi. A single seta is located outside of the hypostomata and above the arm of the stipital sclerite on each side of the cephalic structure. The antennae are small, about twice as long as the width of their bases. Antennal sclerites are not present.

Bracon pygmaeus is dark colored but easily separated from *Agathis* spp. by the yellow on the abdomen. The amount of yellow is variable, from almost completely yellow to only small bands. The antennae each have 30 segments. There are five tarsal segments. The legs are yellow with brown bands. The body is covered with small white setae. There is a cresent-shaped yellow band bordering each eye. The wings are bordered with a row of long setae and have a covering of short setae on their surfaces. The stigma is large (Fig. 25) and dark brown. The radial cell is large (Fig. 25, r) and the intersticial nervure is continuous with the basal vein (Fig. 25, n).

According to Doner (1936) the ovipositing female of *B. pygmaeus* injected the host larva with a lethal substance. The parasite egg was then deposited on the external surface of the host. The adult parasite may have fed extensively on the body fluids of the host. The egg hatched in about 36 to 38 hours and the young larva began to feed immediately. It molted to the second instar during the second day of development. The second and third instar larvae molted on the third and fourth days, respectively. Larvae were mature 6–10 days from egg deposition. Within 24 hours the delicate white cocoon was spun within the case of the host. The pupal period lasted 4–5 days. There were three generations on the cherry casebearer, after which the parasite disappeared from the area for the remainder of the summer. The overwintering stage was unknown. It was thought that the parasite passed the winter in an alternate host.

Ichneumonidae
Unknown
Figs. 9, 19

Examination of the remains of cases from which *G. tenellus* adults had emerged revealed two cephalic structures of an unknown ichneumoid.

The atrium of the spiracle (Fig. 19) has many small pits on its surface. The pits are concentrated around the edge with few in the center. The stalk is segmented, tapers sharply, and has no closing apparatus. The cephalic structure of what is believed to be the final instar (Fig. 9) is heavily sclerotized, and the epistoma, pleurostomata, and hypostomal spur are fused with the stipital sclerite to form a continuous arch. The inferior mandibular processes are prominent. The labral sclerite appears to have a second arm which lies behind the mandibles. Three valcuoles occur on the labral sclerite. Both maxillary and labial palpi consist of a circle with a single sensorium in each. Four pits are located above the palpi, the exterior two of which are joined in each instance. The silk press is small. Four setae are located near the inner edge of the labial sclerite and one on each side of the cephalic structure between the mandibular process and the hypostomal spur. The antennae are cone-shaped, each with a complete antennal sclerite.

Ichneumonidae
Gelis tenellus (Say)
Figs. 3, 20, 34, 35

Gelis tenellus acts both as a primary and a secondary parasite, thus the cephalic structure is found in conjunction with other cephalic structures in the same host case. When secondary parasitism occurs *A. pumila* is the most common primary host. The parasite emerges through a small irregular hole cut in the side of the host case. A thin silk cocoon is found within the case. The remains of the last larval instar are compacted with the host remains and the meconium at the end of the case.

The atrium of the spiracle (Fig. 20) is composed of four horizontal sections and opens into a stalk with seven annulations and a closing apparatus. The spiracles appear funnel shaped. The epistoma is complete, although it appears incomplete because the dorsal portion is unsclerotized. The superior and inferior mandibular processes are well developed. The lacinial sclerite is present. The stipital sclerite does not appear to join with the hypostoma because its exterior portion is not sclerotized. The silk press is large with two ridges dividing its lower portion (Fig. 3) and two pits near its apex. The labral sclerite is well developed. The maxillary and labial palpi each have two almost equal sized sensoria. Setae are numerous within the cephalic structure. Antennae are each about two and one-half times as long as the width at their bases.

Gelis tenellus is perhaps the largest of the Wisconsin parasites of *C. laricella*. It is light orange with areas of reddish brown scattered over the body surface. Body setae are almost completely lacking. The antennae each have 19 segments. There are five tarsal segments and the setae on the legs are very fine. The wing surfaces are covered with small setae but their margins are not fringed with them. Two dark bands of color cross the forewings. The stigma is darker brown than the wing bands. No males of this species are known. There are reports of a wingless form, however, it was not found as a parasite of the larch casebearer in the study.

A detailed life history of this parasite was published by Muesebeck and Dohanian ,1927) using larvae of *Apanteles,* on which *G. tenellus* was a hyperparasite. The large egg was deposited singly within the cocoon of the host on the external surface of the larva. Host feeding was common and often all body fluids were withdrawn from the larva and no egg deposited. Several eggs may be deposited on the same host but only one larva matured. Because of their large size, only a few fully developed eggs were found in the uterus at one time. The limit for oviposition was 6 to 8 eggs in a 24 hour period. The total number of eggs deposited by one female was 76, which took from May 11 to July 1. The egg hatched in about 48 hours and the larva began to feed externally on the host. The insect had five instars. The first required two days, the next three a day each, and the fifth instar an average of seven days. The fifth instar larva fed for only one and one-half days. The average pupation period was 7.5 days. The total period from egg to adult was 22 days. The number of generations varied from 1 to 4 per year, with three most common. Hibernation was as a mature larva in the host cocoon. Some of the young from the same adult mature in 18 to 24 days, whereas, some do not reach maturity until the following spring. Females were produced parthenogenetically.

In *Hemiteles areator* (Panz.), the European species of *Gelis,* parthenogenetic reproduction resulted in males.

Ichneumonidae
Campoplex sp.
Figs. 4, 21, 36, 37

Two males and one female of *Campoplex* sp. were reared in 1964. The female was obtained by dissection from the host case. Emergence by the adult is through one small hole cut in the host case. A thick silk cocoon containing both the final larval skin and the meconium is found in the host case. The host skin is present at the base of the host case.

The atrium of the spiracle (Fig. 21) is small. The stalk contains many annulations and becomes progressively larger in diameter in a series of steps. No closing apparatus is present. The cephalic structure was illustrated from a single specimen which was slightly distorted during preparation. The epistoma, pleurostomata and hypostomata are fused to form an arch. The stipital sclerites are fused to the base of a wishbone-shaped labial sclerite. The superior mandibular processes are well developed. The inferior mandibular processes are represented by a groove in the base of the hypostomata in which the mandibles rest. The silk press is a large "U"-shaped structure which originates in the opening between the two arms of the labial sclerites and extends toward the tips of the mandibles. The maxillary palpi are egg-shaped with a divided sensorium in each. The labial palpi are rounded with two sensoria in each. Many setae are found wthin the cephalic structure (Fig. 4). The antennae are each about twice as long as the thickness of their bases and are flat-topped.

Campoplex sp. is a small black parasite with comparatively short wings in comparison to its body length (Fig. 36). There are 28 antennal segments and five tarsal segments. The legs are mostly yellow with areas of brown. The body has few short setae. The wing surfaces are covered with small brown setae but lack setae on the edges of either the fore or hind wings. They are not banded. The costal vein is broken just before the small stigmal area. The abdomen of the female (Fig. 36) is almost as wide as its thorax, whereas the male abdomen (Fig. 37) is visibly narrower than the thorax.

Eulophidae

Kratochviliana laricinellae (Ratz.)

Figs. 10, 17, 29, 30

Kratochviliana laricinellae is an internal, solitary parasite which forms a white silk cocoon. The larval skin, meconium, and host skin are present within the cocoon. A black pupal skin remains in the cocoon also. Emergence is through a hole cut in the host case. Location of the emergence hole is variable and is not an identifying character.

The spherical atrium of the spiracle (Fig. 17) is unsculptured. The stalk is nearly half as large as the atrium at the point of junction. It tapers to about one-third its original width at the closing apparatus which is short and narrower than the last segment of the stalk. The cephalic structure is much reduced (Fig. 10). The mandibles are large and appear to be the only part of the cephalic structure present, however, mandibular processes are present. The superior processes are well developed whereas the inferior processes consist of grooves in the hypostoma which serve as articulation points. A large silk press is present between the mandibles. The labial palpi each contain one sensorium. Three pits adjoin the palpi. The antennae are small, each slightly larger than the width at their bases. The antennal sclerites are large and well developed.

This brightly colored eulophid is primarily metallic green except for a metallic blue thorax. The sclerites of the thorax are bare and have many small pits. The abdomen has a single row of setae on the posterior edge of each tergite (Fig. 29). Each antenna is geniculate and composed of seven segments. The terminal segment is pointed and has a false ring. There are four tarsal segments on the white to pale yellow legs. The wing surfaces are covered with small white setae. The leading edges of the fore and hind wings are fringed with setae whereas the hind edges are bare. The male (Fig. 30) is smaller than the female and has a slightly narrower abdomen. The ovipositor of the female (Fig. 29) is not visible from above.

Detailed descriptions of the instars were made by Dowden (1941) and of the life history by Graham (1948). The egg was deposited in the body of the host larva. Host feeding by the parasite female was common. Many immature parasites died because they had insufficient food as a result of the extensive feeding on the host larva before egg deposition. Eggs hatched in about 48 hours. First instar larval development lasted two days with one day in each of the second and third instars. A last-instar larva took two days to complete its development after which it cut through the host skin and moved to the cleared area of the case. Pupation occurred in about 24 hours and about 8 to 10 days were spent as pupae before the adult emerged. Total developmental period from egg to adult took from 17 to 23 days.

Graham (1948) stated that *K. laricinellae* produced three generations per year. Hibernation took place in the host larval case within the full-grown larval stage of the host. Pupation took place in early May and the adult emerged 7 to 10 days later. It parasitized the overwintering larva of the casebearer which usually had been feeding for a week or so. The host larva died when the parasite egg hatched. The adults which produced the second generation emerged from mid-June to mid-July; the earlier ones parasitizing the larvae already parasitized by *A. pumila,* and the later ones the young needle-mining casebearers. Pupation did not take place until the end of August or the first week in September. Very little evidence was found to support Graham's theory of *A. pumila* serving as a support for populations of *K. laricinellae. Several* hundred cases were opened and the parasite remains examined. No evidence of *A. pumila* remains in the same case containing the remains of a successful emergence of *K. laricinellae* have been found. As the field samples were collected and examined throughout the spring period some evidence of this should have been found in the parasite remains if *K. laricinellae* was indeed dependent on the nonpupated casebearers containing larvae of *A. pumila.*

The adults producing the third generation emerged from mid-September to early October. This generation developed entirely within the needle-mining host larvae and the resulting adult parasites were very small. Emergence of the third generation usually coincided with the formation of the host case and the beginning of diapause. Development was rapid and the parasite larvae matured and entered diapause in about two weeks.

Pteromalidae
Capellia lividicorpus (Grit.)
Fig. 33

Capellia lividicorpus is not included in the key to the immature stages as the larval skins were inadvertently destroyed before illustrations could be made. The adult is dull purple with few body setae. The sclerites of the thorax are covered with many small pits. The antennae each have 10 segments. There are five tarsal segments on each leg. The wing surfaces are covered with small white setae and their edges are fringed with setae. The male is similar to the female, but has a small amount of yellow on the abdomen. This makes the male easy to confuse with the males of *H. phycidis* and *K. laricinellae*. The purple color of the thorax of *C. lividicorpus,* however, distinguishes it from the others.

The life cycle was investigated by Beacher (1947) using the pistol casebearer, *Coleophora malicorella* Riley, as a host. Copulation occurred shortly after the emergence of the insects. In general, a female required about one week to develop an interest in the host. After preliminary movements of the antennae over the case, the abdomen was curved downward and the tip applied to the point of the case where the ovipositor was to be inserted. The point of insertion was usually in the center of the case, the head of the female being directed toward the distal end. Thus, the thoracic region of the host larva was pierced, allowing the paralyzing agent to reach a vital part quickly. When the host larva remained quiescent for a few minutes, the true egg thrust occurred, and the ovipositor often remained inserted for over a minute. *C. lividicorpus* was an ectoparasite, and the eggs were deposited upon the integument of the larva. Several eggs were commonly deposited on a single host. The average number of eggs per female was 21, usually deposited over a ten day period.

Larval maturity was attained in approximately 11 days after eclosion, with the complete reduction of the host larva to a flattened, dried mass. Reports of ten parasite larvae reaching full growth on a single host and successfully emerging as adults were known. The mature larvae averaged 2 mm. long and 0.5 mm. wide. A fine white cocoon was constructed within the case of the host. The pupal stage usually lasted seven days. The complete life cycle averaged 20 days as follows: egg stage 36 to 48 hours; larval stage (three instars) 11 days; pupal stage seven days. At least two generations occurred annually on the pistol casebearer.

Pteromalidae

Habrocytus phycidis Ashm.

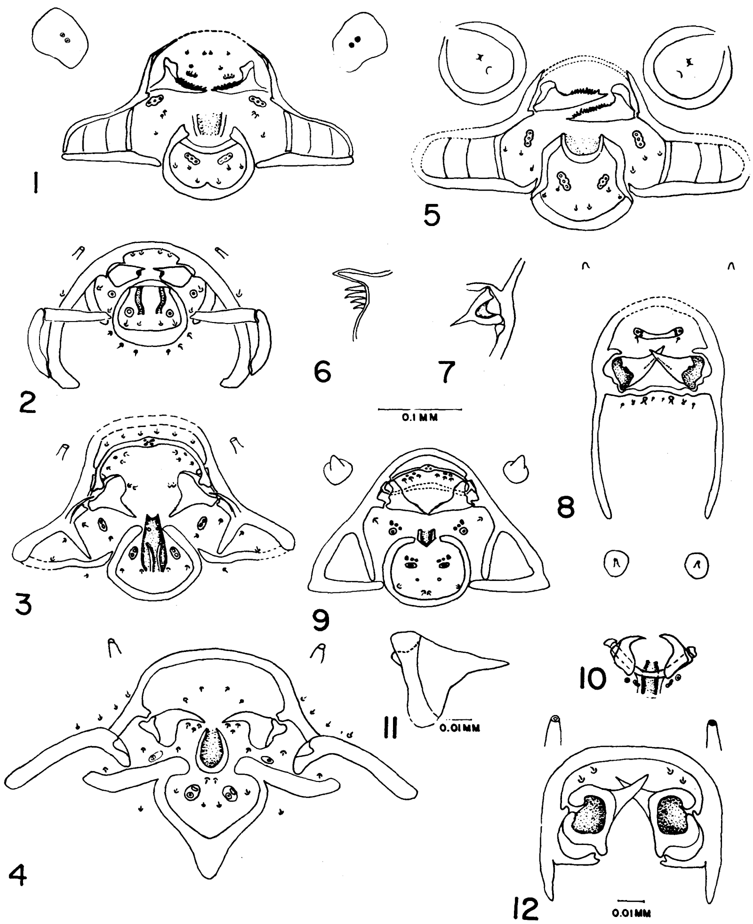
Figs. 11, 12, 18, 31, 32

This parasite was reared frequently from the different sampling areas. In all instances but one it was a solitary parasite. In that instance, two males emerged from the same case. A light brown pupal skin is found within the host case. No cocoon is apparent and the parasite appears free in the host case. The larval skin, meconium and host skin are compacted at the base of the host case. Emergence occurs through a hole cut in the side of the case.

The atrium of the spiracle (Fig. 18) is large and irregularly sculptured. The stalk is almost as wide as the atrium and has seven annulations before the large closing apparatus. The cephalic structure is reduced and very small. The epistoma, pleurostomata and hypostomata are fused into a single arch. The superior mandibular processes are reduced to ball-and-socket type pivot points (Figs. 11, 12). The inferior mandibular processes are greatly enlarged and extend for about one-third the width of the cephalic structure. The labial sclerite, labial palpi, maxillary palpi, stipital sclerites, silk press and labral sclerites are apparently lacking. Four setae occur along the epistoma. The antennae are long, about two times the width of the base. Antennal sclerites are lacking.

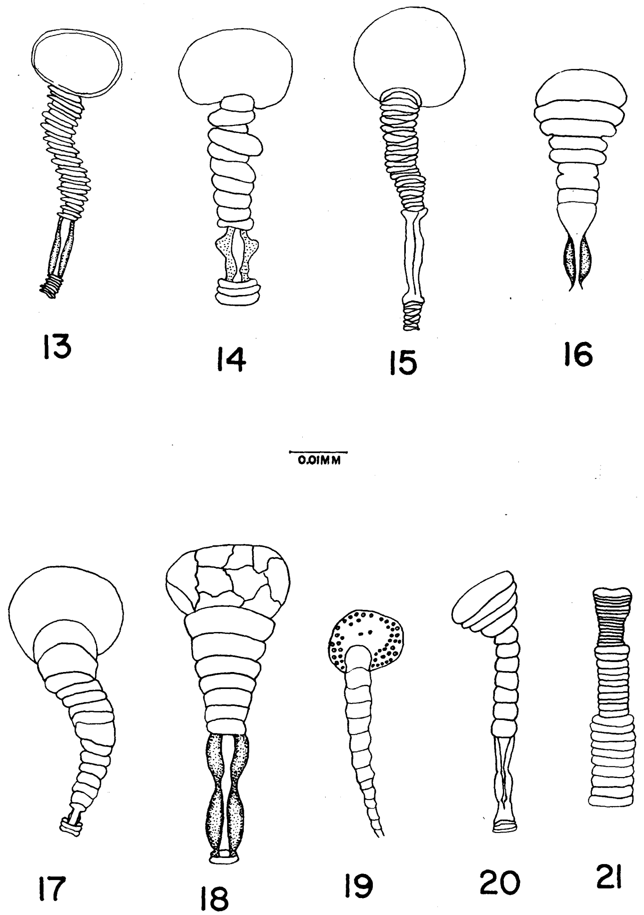
Habrocytus phycidis is a small metallic green parasite. The thorax is bare, but the sclerites are covered with many small pits. The antennae are geniculate and each is composed of 12 segments which include two very small segments between the second and fifth segments. There are five tarsal segments. The legs are light yellow-brown. The wing surfaces are covered with small white setae and both the fore and hind wing margins are fringed with setae. The abdomen of the female (Fig. 31) is pointed and dark green whereas the male (Fig. 32) has a rounded abdomen with an area of light yellow grading to dark green at the apex.

Clausen (1962) reported that the majority of species of this genus were external gregarious parasites of lepidopterous and coleopterous larvae and pupae. In all but one of the larch casebearers examined they have been solitary. Host feeding was very important in this group and detailed studies have been made of the formation of a feeding tube by the female to enable her to draw the fluids from the host. The female parasite pumped droplets of a paralyzing fluid into the body of the host. Doner (1936), found that the female of *H. phycidis* made repeated injections of the paralyzing fluid. This was done by stinging the host several times,



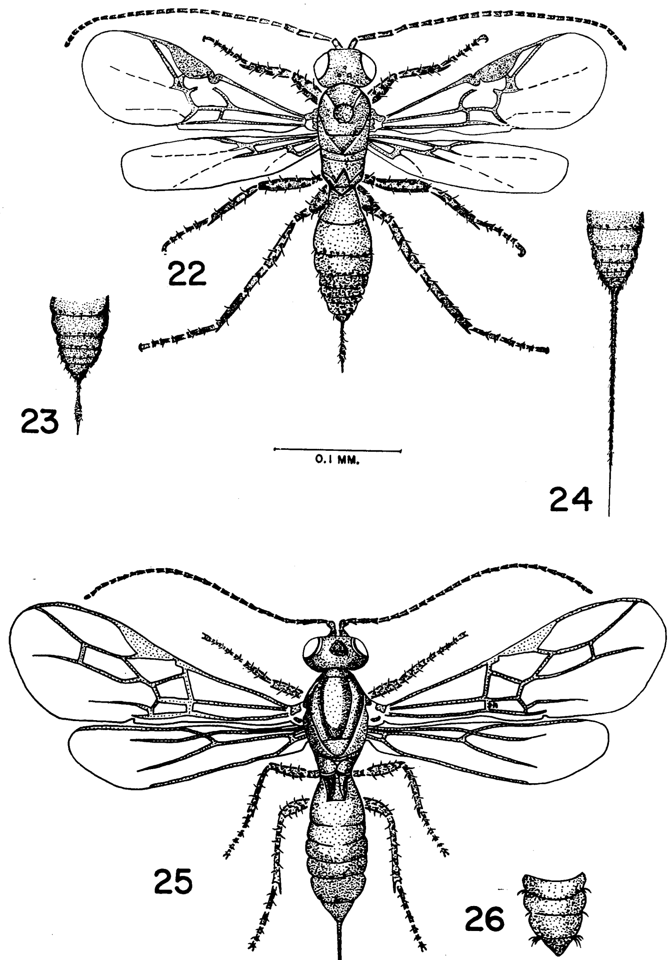
FIGURES 1–12. Cephalic structures of final-instar hymenopterous larvae. 1, *Agathis pumila* (Ratz.), cephalic structure, anterior view; 2, 6, *Bracon pygmaeus* Prov.; 2, cephalic structure, anterior view; 6, left mandible showing teeth; 3, *Gelis tenellus* (Say), cephalic structure, anterior view; 4, *Campoplex* sp., cephalic structure, anterior view; 5, *Agathis cinctus* (Cress.), cephalic structure, anterior view; 7, 8, *Spilochalcis albifrons* (Walsh); 7, left mandible showing points of articulation; 8, cephalic structure, anterior view; 9, unknown ichneumonid, cephalic structure, anterior view; 10, *Kratochviliana laricinellae* (Ratz.), cephalic structure, anterior view; 11, 12, *Habrocytus phycidis* Ashm.; 11, right mandible; 12, cephalic structure, anterior view.

leaving it, and later returning to re-sting it. The parasite usually then left for a second time and returned shortly to oviposit in the completely paralyzed larva. The number of eggs per female ranged from 38 to 59 and these were deposited usually over an 8 to 10 day period.



FIGURES 13–21. Spiracles of final-instar hymenopterous larvae: 13, *Agathis pumila* (Ratz.); 14, *Agathis cinctus* (Cress.); 15, *Bracon pygmaeus* Prov.; 16, *Spilochalcis albifrons* (Walsh); 17, *Kratochviliana laricinellae* (Ratz.): 18, *Habrocytus phycidis* Ashm.; 19, unknown ichneumonid; 20, *Gelis tenellus* (Say); 21, *Campoplex* sp.

Clausen (1962) outlined the life history of the group as being short, averaging three weeks from egg to adult. The incubation of the egg required from less than one to three days, the larval period 4 to 10 days and the pupal period 4 to 14 days. The number of generations per year was dependent on the availability of the host stages, and most species produced generation after generation as long as these were available. Hibernation of the majority of species was in the mature larval stages within the host cell, cocoon, or



FIGURES 22–26. Adult hymenopterous parasites of *C. laricella*: 22, 23, *Agathis pumila* (Ratz.); 22, female; 23, tip of abdomen showing length of ovipositor; 24, *Agathis cinctus* (Cress.), tip of abdomen showing length of ovipositor; 25, 26, *Bracon pygmaeus* Prov.; 25, female; 26, tip of abdomen of male.

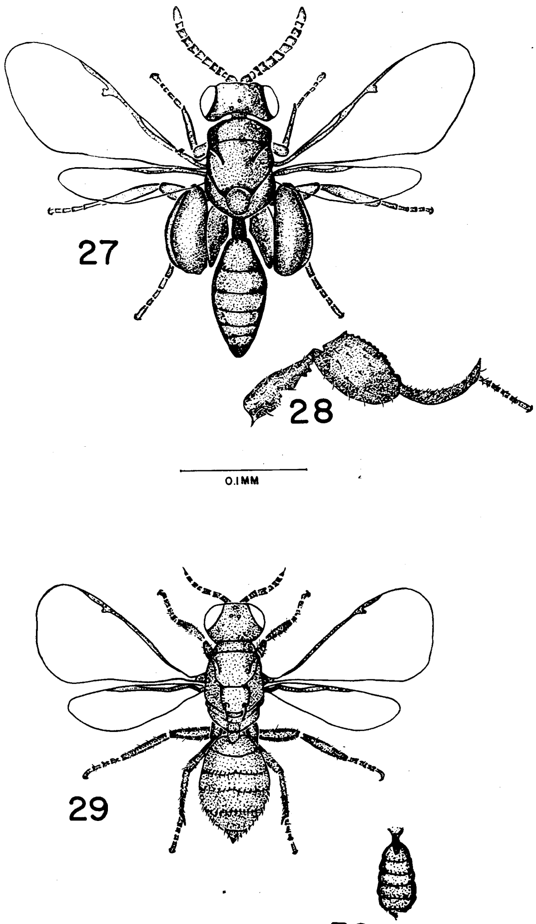
puparium. No descriptive studies were available on the immature stages of *H. phycidis*.

Chalcididae

Spilochalcis albifrons (Walsh)

Figs. 7, 8, 16, 27, 28

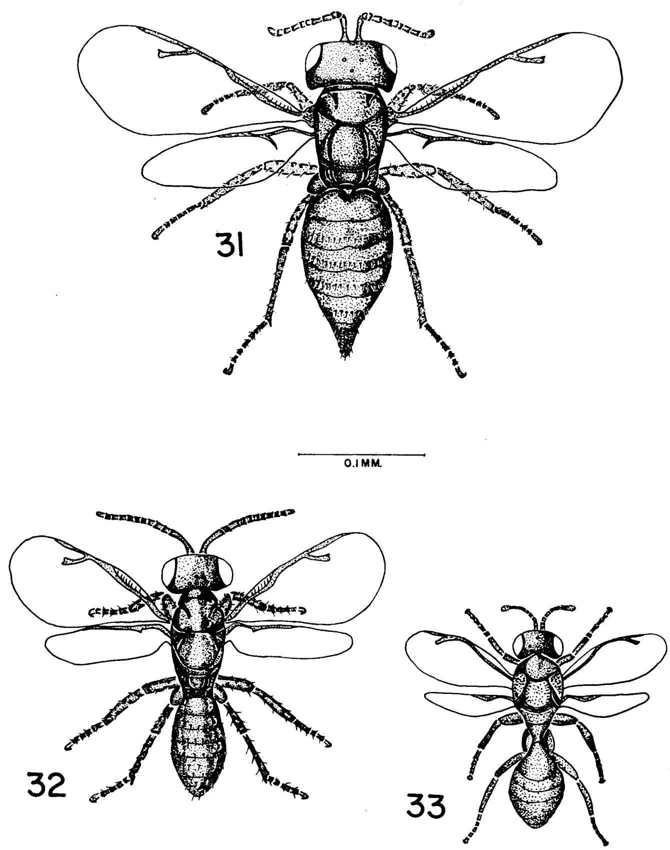
Spilochalcis albifrons is the only parasite of the complex which always emerges through the host pupal skin. The parasite pupal



FIGURES 27–30. Adult hymenopterous parasites of *C. laricella*: 27, 28, *Spilochalcis albifrons* (Walsh); 27, male; 28, hind femur showing enlargement and teeth; 29, 30, *Kratochviliana laricinellae* (Ratz.); 29, female; 30, abdomen of male.

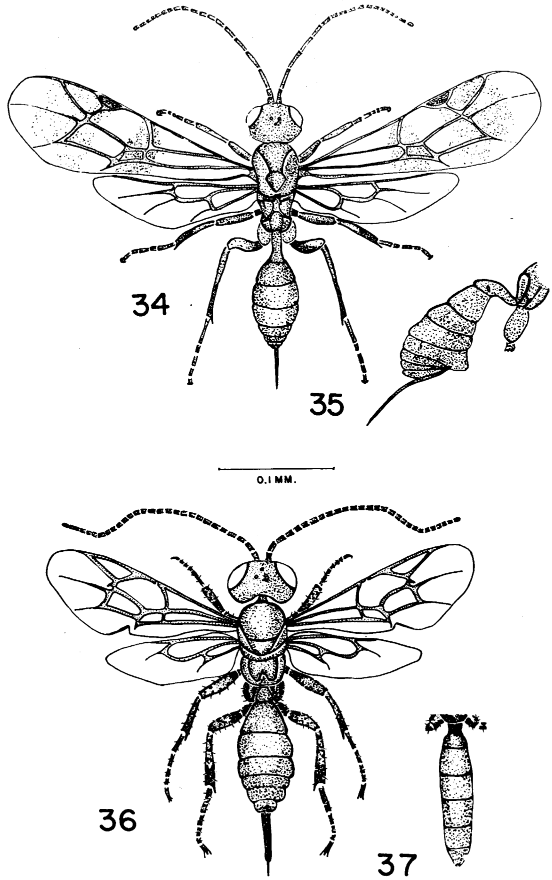
skin is dark brown and occurs next to the host pupal skin in the host case. The parasite is solitary. A thick silk cocoon is present. The larval skin is usually found tangled in the silk of the cocoon. The host meconium and skin are packed at the base of the case, and the parasite meconium within the cocoon.

The atrium of the spiracle (Fig. 16) is slightly smaller than the first annulation of the stalk. Seven annulations are present, and the fifth has a false segmented appearance. The last annulation is



FIGURES 31–33. Adult hymenopterous parasites of *C. laricella*: 31, 32, *Habrocytus phycidis* Ashm.; 31, female; 32, male; 33, *Capellia lividicorpus* (Gir.), female.

funnel-shaped and the closing apparatus joins the stalk of the funnel. The cephalic structure is reduced. The epistoma is incomplete in appearance but may be complete with the dorsal portion unsclerotized. The pleurostomata and hypostomata are fused to form two side pieces. The hypostomata are long, nearly more than half the total length of the cephalic structure. The labral sclerite has a group of vacuoles at each end. The superior mandibular processes are well developed. The inferior mandibular processes are joined and extend completely across the cephalic structure (Figs. 7, 8). The labial palpi appear as projecting knobs. Two sensoria are present in the area adjoining the labial palpi. Maxillary palpi could not be located.



FIGURES 34–37. Adult hymenopterous parasites of *C. laricella*: 34, 35, *Gelis tenellus* (Say); 34, female; 35, lateral view of abdomen of female; 36, 37, *Campoplex* sp.; 36, female; 37, abdomen of male.

This chalcid is readily separated from the remaining Wisconsin parasites by the presence of the much enlarged femora (Figs. 27, 28). The adult is black with areas of white or cream on various parts of the body particularly in the facial region. The antennae are geniculate and each is composed of 12 segments (Fig. 27, basal segment not shown). There are five tarsal segments. The tibia and tarsal segments are cream colored and the remaining portions of the legs are dark. The body is covered with fine setae.

Clausen (1962) reported that all known species were solitary and developed internally. Arthur (1938) described the mating behavior of *Spilochalcis side* (Walk.) a closely related species. Mating took place soon after the female emerged and was preceeded by a courtship. This included waving the antennae up and down and swaying the body by the male. Wing stroking by the male also occurred. Eggs were deposited 1 to 4 per host and hatched in 40 to 48 hours. One first instar larva usually killed the rest of the parasites present. Three larval instars were reported by Arthur. The larval period lasted 6 to 10 days, with emergence of the adults 20 to 25 days after the eggs were deposited. Clausen (1962) stated that, for the group, the usual number of larval instars was five rather than the three of Arthur's, these varying from the hymenopteri-form first instar larva to an oval larva in the fifth instar.

Summary

Some fifteen species of parasites of *Coleophora laricella* Hbn. have been reared in Wisconsin. Two keys have been prepared to aid in separation both of adult parasites and the parasite remains left in the host case. Nine species of parasites are included in each of the keys. Brief notes on the biology of each species, and illustrations and descriptions of the final-instar cephalic structures are also included.

Acknowledgements

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THE BEAVER IN EARLY WISCONSIN

*A. W. Schorger**

Wisconsin was noted among the French for the quantity and quality of its beaver. Perrot (1864:57), who came first to the Northwest in 1665, stated that as one went north to the Wisconsin River, the winters became long and cold. Here the beaver was best and the hunting season lasted longest. A memorandum of 1786 from the British traders (1892) at Montreal states that the Chippewa country south of Lake Superior was scarcely to be surpassed or equalled for its fine furs. Johnston (1960) was at Fond du Lac (Superior) in 1792 and thought that the region produced the best assortment of furs of any place on the continent. Beaver of the highest quality, however, came from north of Lake Superior according to Aigremont (1902).

The upper Misissippi district in the season 1734–35 produced 100,000 good beaver skins, worth 178,000 livres, and this in spite of the Indian troubles (Hocquart, 1906). Champigny (1902) expressed the opinion that Le Seur's request to develop mines on the upper Mississippi concealed an intention to mine for beaver. The number of Indian hunters frequenting Lake Pepin about 1766 was 2000 and each brought to trade 100 pounds of beaver (Carver, 1781:337). This is approximately 160,000 pelts. In 1774 about 130 canoes from Mackinac came to Prairie du Chien and departed with 1500 packs of various furs (P. Pond, 1908).

Green Bay (La Baye, Baye des Puants) was long the beaver emporium in the state. La Salle (1902), peaked at ecclesiastical competition, wrote that the Jesuits at the mouth of the Fox River held the key to the beaver country. There "a lay brother that they have, who is a blacksmith, with two companions converts more iron into beaver-skins than the Fathers convert savages into Christians."

In 1739 Green Bay produced only 110 packs of beaver, though ordinarily 300 to 400 packs (Innis, 1927:151). A few years later this post provided 500 to 600 packs of mixed furs and was farmed for 9000 francs. The post was worth 312,000 livres to Rigaud and Marin over a period of three years (1754–56) ; and in the time of the Senior Marin it netted a profit of more than 150,000 livres an-

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nually (Bougainville, 1908:183, 192). Todd and McTavish (1895), merchants of Montreal, estimated in 1794 that Green Bay, including the upper Mississippi and the south shore of Lake Superior. provided 300 packs; and Milwaukee 120 packs.

A government factory, or trading post, was established at Green Bay in 1810. Joseph P. Varnum, Indian agent at Mackinac, recommended the Bay on account of the valuable beaver pelts produced in the area (Peake, 1954:20). This is a far cry from reality at that time. During a period of four years the returns in beaver to the factory were: 1816, none; 1817, 13 pounds; 1818, none; and 1819, 2 pounds (Anon., 1834). The factories were never able to compete successfully with the private traders.

Fur Trade Annals

The arrival of Jean Nicolet at Green Bay in 1634 formed the first visit of a white man to Wisconsin. As a result of intertribal wars, no traders appeared in the state for nearly a score of years afterwards. The beaver trade then continued with few important interruptions. These were usually caused by Indian wars which were a plague to the French since they interfered with the hunting of beaver.

1654. Radisson and Grosseilliers are the first recorded traders. Defeat of the Iroquois in 1653 permitted Radisson to accompany the Ottawa to the St. Lawrence with a cargo of furs.

1656. Radisson and a companion returned to Wisconsin.

1660. Radisson and Grosseilliers built a trading post at Chequamegon Bay. Antoine Trottier with a party arrived at the bay. Return was delayed for three years by Indian wars. Insufficient furs were collected to meet expenses.

1668. Perrot came to Green Bay.

1669. The mission of St. Francis Xavier was established at Green Bay by the Jesuits who were active in the fur trade.

1673. Marquette and Joliet "discovered" the Mississippi though they were not the first to do so.

1679. The trader Duluth obtained a peace pact between the Indians gathered at Fond du Lac (Superior).

1678–80. La Salle had men at Green Bay to collect furs.

1685. Perrot left his command at Green Bay in autumn and built a temporary wintering post at Trempealeau. The following spring he built Fort St. Antoine in Pepin County.

1687. The mission house at Green Bay was burned by hostile Indians. Perrot lost his furs valued at $40,000.

1693. Le Seur built a post on the southwestern shore of Madeline Island.

1694. A post was established by Le Seur on the Mississippi, below the mouth of the St. Croix, on Pelee, now Prairie Island.

1689–1701. By royal decree there were few traders in the West. This was due in part to a surplus of beaver and in part to the influence of the Jesuits.

1706. Boisseau was operating at Green Bay without a license.

1716. Louvingy attacked the Fox village on Little Lake Butte des Morts. The truce agreement stipulated that the cost of the war would be paid for by the Fox in beaver.
1718. The French built a new military post on Madeline Island.
1727. A military and trading post was built on the west shore of Lake Pepin.
1731. Beauharnois sent Villiers to rebuild the fort at Green Bay. Linctot constructed a fort at Mount Trempealeau on the site of Perrot's old wintering post. It was maintained for five years.
1740. The Chippewa drive the Sioux from Lac du Flambeau and Lac Court Oreilles.
1759. Wolfe defeated Montcalm at Quebec.
1760. Montreal surrendered.
1761. Lieut. James Gorrell with seventeen men and two traders occupied the delapitated French fort at Green Bay.
1763. Following the massacre at Mackinac, the English army permanently abandoned Green Bay.
1765. The trader Alexander Henry arrived at Chequamegon Bay.
1779. The Northwest fur company was organized.
1784. The Mackinac Company was formed about this time.
1808. The American Fur Company was organized by John Jacob Astor.
1811. Astor formed, under the American Fur Company, the Southwest Company which absorbed the Mackinac Company.
1834. Astor retired from the American Fur Company which was then headed by Ramsay Crooks.
1848. The American Fur Company virtually ceased operation.

UTILIZATION

The beaver formed one of the important foods of the Indians and was captured throughout the year. It was roasted entire and the French had to persuade them to discontinue this practise as the pelt was destroyed. Perrot (1864:99) relates that the Ottawa returned some prisoners to the Sioux in northwestern Wisconsin. They did not bring back many beaver pelts since the Sioux were accustomed to roast the whole beaver for eating.

Originally the pelt was of little value in the eyes of the Indians. At Chequamegon Bay they could not understand why the French would come so great a distance to obtain their well-worn robes (La Potherie, 1753:86). While Marquette (1903) was at Chicago in 1674, the Illinois were so eager for French tobacco that they threw beaver skins at his feet in order to obtain a few pieces of it. A chief at Green Bay gave Perrot (La Potherie, 1753, II:127) ten beaver robes for some theriac.*

The flesh of the beaver was eaten quite extensively by whites especially on trading expeditions. To some the flavor was unpleasant. Edibility resulted from long boiling or preferably roasting. Lahontan (1703, I:142) thought the flesh delicious in autumn and winter but it had to be roasted to taste well. The roasted fat tail was eaten eagerly by trappers. Thompson (1962:152, 209) wrote

*A mixture of many drugs used as an antidote to poison.

tersely: "His meat is agreeable to most although fat and oily; the tail is a delicacy." Among the provisions for his trip down the St. Louis River in Minnesota were four beaver tails. Hunger is a sauce blind to discrimination. Du Creux (1951) in 1664 thought it a moot question whether the beaver was a land or water animal. Rationalization permitted the French to eat beaver on meatless days. The faculty of medicine in Paris declared from its aquatic habits that the beaver was a fish, so the faculty of theology decided that it could be eaten on lean days (Charlevoix, 1744:142). The kidneys of the beaver were collected at a few posts. Perrault (1909–10:555) brought out a keg of them, from his post on the Red Cedar River, weighing 45 pounds. In 1754 there were shipped to France 1040 pounds of kidneys valued at three livres a pound (Innis, 1927:153).

Special glands in the beaver secrete a yellowish, unctous substance called castoreum. Its uses in medicine as given by Charlevoix (1744:145) represents the quackery of the age. In relatively recent times it was used as a fixative in perfumes. Its most valuable use was as a lure in trapping beaver. The amount collected was not large. The inventory of October 15, 1824, of all the returns assembled at Mackinac by the American Fur Company shows 83 pounds of castoreum. During the ten-year period, 1837–46, the total collection at La Pointe was 128.5 pounds with an annual variation of 4.75 to 26.75 pounds. On August 20, 1837, 11.5 ounces of castoreum were sold by the American Fur Company at Mackinac for $5.50. William Brewster, Detroit, was informed by the Company in March, 1839, that a price of $4.00 a pound was expected.

Though garments of beaver fur were worn quite extensively, particularly in Russia, the greatest use of the fur was in the manufacture of hats. Only the hairs of the undercoat (wool) were employed. The nature of the scales on beaver hairs gives them a high felting quality by interlocking. At first the hat was made entirely of beaver hair. According to Cadillac (1883) a satisfactory hat could be made by using one-third dry beaver wool and two-thirds of fat or semi-fat wool. These terms will be explained subsequently. The French for a long period enjoyed a monopoly in hat manufacture. In 1752 the wool sold in France at 18 shillings a pound and in England at 32 shillings. Beaver pelts were worth 6 shillings a pound in France and 11 shillings in England. One English manufacturer used 10 to 12 ounces of the wool in a hat for export and 7 to 8 ounces in one for domestic wear (Hume, 1803). In France it was estimated that 10 pounds of pelt would produce 33 ounces of wool which would make three and one-half hats, since at most 9 ounces of wool were used in a hat (Cadillac, 1883).

Hats were eventually cheapened by using a foundation of rabbit and other common fur hairs, and limiting beaver wool to the nap or surface (Lawson, 1943). About 1830 the silk hat came into fashion and the use of beaver declined rapidly. In January, 1836, the London agent of the American Fur Company wrote that the abundance of nutria had lowered the price of beaver; and in August of the same year that silk hats were in almost universal use (Nute, 1944:nos. 1168, 1865).

HUNTING

Several methods for taking beaver were employed. The only trap used by the Indians prior to the arrival of Europeans was the deadfall which was baited with a branch of aspen or other suitable wood. This mechanism was used from the Atlantic Ocean to the Mississippi River (Le Clercq, 1691; Carver, 1781:185). The deadfall was of little use in winter, the season when the fur was most valuable, since at that time the beaver seldom appeared on land. Then the beaver had to be driven from its house. The early writers frequently garbled the procedure or omitted essential details. Having found the exit from the house, by cutting a hole in the ice, a net was placed in front of it. A hole was then cut into the house to drive out the beaver which was caught in the net, drawn to the surface, and dispatched (Hennepin, 1903:518). Before iron axes and spuds were made available by Europeans, the opening of a frozen beaver house was a laborious procedure for the Indian with his primitive tools.

The beaver was taken in nets in other ways. According to Le Jeune (1897.1:299) a hole was cut in the ice near the house into which a baited net was placed. On attempting to eat the bark of the wood, the beaver became entangled in the net, rose to the surface of the water and was killed with a club. This method entailed a long, patient, and often fruitless vigil on the part of the Indian. Also a hole was made in the house to drive the beaver into the adjacent pond. The dam was then broken down and a net placed in the gap to catch the beaver as it sought deep water when the pond drained (Perrot, 1864:52). Carver (1781:185) states that when a house was broken into the beaver sought the deepest water in the pond. Here a net had been set in which the beaver became entangled.

The use of nets was original with the Indians who made the twine of various bast fibers. In northwestern Wisconsin, about 1662, the Sioux stretched beaver nets with attached bells in a rice marsh where the Hurons were hidden. When the latter attempted to reach dry land, the Soiux were warned and captured them

(Perrot, 1864:89). Traders carried twine for making nets. Duluth (1902) gave an Ottawa some twine with the reminder that to keep the Indians from dying of cold and hunger the French supplied them with guns, axes, and twine.

Another method of capture was to cut a hole in the ice and drive stakes to form a ring within which fresh aspen was placed. One of the stakes was withdrawn to permit entrance of the beaver. When the beaver entered the enclosure the stake was inserted in the gap, forcing the beaver to rise eventually to the surface where it was killed with a club or a spear. Grant (1860) mentions that a board closed the entrance after a beaver entered. The method was practical only in February and March by which time the beaver had tired of his stale food.

Some beavers lived in bank burrows in lieu of houses. There were also escape burrows around the ponds if the banks permitted. The Chippewa name for a burrow was *o-wazhé*, corrupted to "wash." Before the steel trap came into use most of the beavers were taken from washes. Henry (1921:127–28) wrote of his hunting experiences with the Indians: "Breaking up the house, however, is only a preparatory step. During this operation the family make their escape to one or more of their washes. These are to be discovered by striking the ice along the bank, and where the holes are a hollow sound is returned. After discovering and searching many of these in vain we often found the whole family together in the same wash. . . . From the washes they must be taken out with the hands; and in doing this the hunter sometimes receives severe wounds from their teeth."

The presence of a beaver in a wash could sometimes be detected by the motion of the water at the entrance or by the muddy appearance of the water after the beaver had entered, following exodus from the house. The burrow rose from its under water entrance to a dry chamber near the surface of the ground in which was a small opening for the admission of air. In order to secure the beaver the entrance to the burrow was closed with stakes and the burrow opened at the chamber. If the beaver remained above water it was killed with a club; and if submerged, it was withdrawn with a crooked stick or by hand (Le Jeune, 1897.1:301; Morgan, 1868:238). The Indians of western Manitoba had a peculiar breed of dogs with an extremely keen sense of smell. They were used to detect the thinnest places in the beaver houses and the air openings of the burrows (Thompson, 1962:153). The Chippewa along Lake Superior also used dogs for detecting inhabited washes (Grant, 1860).

Many beavers were taken with spears. Le Jeune (1897) was requested by the Indians to furnish them with cord which was to be attached to spears with barbed iron points. The Indian held the cord until the diving beaver became so exhausted that it could be drawn in. The father of W. W. Cooke (1940:294) speared beaver in Buffalo County. He would follow a stream with his dog which was so highly trained that he would come to a point at the air opening of an occupied wash. Cooke would go to the edge of the stream and locate the exit. On a signal the heavy eighty-pound dog would rear and come down on the ground at the air hole. The earth was usually so thin that it caved in. The beaver would break for the stream and was speared easily.

Beavers were sometimes shot. At dusk when they came out to feed or work on their dams, the hunter allowed his canoe to drift silently down stream (Henry, 1921:125). The hazard lay in securing a beaver which had been killed since it sank quickly to the bottom. The trade goods shipped to Milwaukee in 1821 for James Kinzie (1888) contained 112 pounds of beaver and duck shot invoiced at $22.40. As long as a demand existed for beaver for making hats, the value of the skin was not decreased by the perforations produced by shot and spear. After the hair was removed, the "leather," or skin proper, was made into glue.

The most effective way of taking beaver was with the steel trap which was in general use by 1750 (Schorger, 1951:178). Pierre Grignon who traded at Green Bay from 1763–95 always kept a blacksmith to make traps (Grignon, 1857). All that was necessary to catch a beaver was to place in the water a trap beside which projected a stick having castoreum on the end. The discoverer of this efficient lure remains unknown. Strangely the Indians learned its use from the whites. Many aromatic substances were used as a substitute for castoreum and were frequently mixed with it. In Trempealeau County the Indians sometimes used castoreum but camhpor would also serve (Bunnell, 1897:197). Cinnamon, cloves, and oil of juniper were used in the Lake Superior region. The government factories, of which there was one at Prairie du Chien and one at Green Bay, carried in stock for this purpose cinnamon, nutmeg, cloves, ginger, allspice, and mace (Peake, 1954:60).

The beaver dams were sometimes opened and a trap set in the channel. Regarding the efficiency of this method in Dunn County, Cartwright (1875:240) wrote: "There Mr. Putnam tried the old but fatal plan of cutting down the dam to catch the beavers. He did let them out; but he caught only two from the four or five dams which he cut into."

The steel trap became indispensable and competition in the nineteenth century between traders caused them to loan rather than sell traps to the Indian. If the trap was not returned he was charged five dollars for it on the books. Newhouse (1874) summed up the importance of the trap by stating that trapping for furs took place in advance of civilization. The trap preceded the axe and the plow and caused the bear and beaver to give way to settlement. In his opinion it would not be inappropriate, accordingly, for Wisconsin to have a steel trap in her coat of arms.

Grades of Pelts

The Indians captured beavers at all seasons. Those taken in summer for food might or might not be skinned. The poorest pelts were taken at this season. The quality improved through fall, winter, and spring. The pelts were not fully prime until spring, the best being obtained between the first of February and the first of April, depending on latitude and altitude. In order to keep the goodwill of the Indians, it was necessary for the trader to buy all the skins presented, and this forced the establishment of several grades (La Potherie, 1753, I:269).

There is some inconsistency as to the grades among the early writers. Lahontan (1703, II:70) defines hazily five grades: (1). Winter beaver, called Muscovite, valued at 4 livres and 10 sous per pound. (2). Fat beaver, the long hairs of which have fallen out while being worn by the natives and valued at 5 livres. (3). Soft beaver, that is beaver taken in autumn, worth 3 livres and 10 sous. (4). Dry or ordinary beaver, 2 livres. (5). Summer beaver valued at 3 livres.

Six grades are given by La Potherie (1753, I:267–69). The first is fat winter beaver *(gras d'hiver)* with a fine thick undercoat and long guard hairs. Six or seven skins were sewed together to make a robe. The sweat from the Indian's body and the bear's grease from his soiled hands turned the undercoat yellow. Handfulls of the grease were taken to eat, some of which fell on the guard hairs and gradually reached the undercoat. The chief source of grease was probably the bear oil which the Indians applied liberally to their bodies especially in winter.

The second grade was the half-fat winter beaver *(demi-gras)*. Due to pressing needs the natives sold these robes to the French when they were only half-fatted. It was necessary, however, that they be as supple as the fat robes. The third grade was the summer fat. The robes had large guard hairs but a thin undercoat. The fourth grade was the soft beaver *(veule)*. The robes were of fine quality but since they had been worn very little, the undercoat was only slightly greased. The pelts were well prepared and the price was the same as for the fat winter beaver. The fifth grade was the dry winter beaver *(sec)*. The skins were not used for robes on account of the holes made by shot or spear. The skin was very thick and badly prepared. The sixth grade was the Muscovite for which grade the beavers were caught in traps. This was a fine fur with long guard hairs. There was a large commerce with Russia in this grade. The Russians combed out the undercoat, leaving only the long guard hairs. The wool was sold to hatters.

Two kinds of pelts are mentioned by Charlevoix (1923:146), the green *(vert)* and the dry *(sec)*. The green pelt was one which had been worn by the Indians, hence was equivalent to the fat pelt. The leather side was scraped, then rubbed with bone marrow to make the pelt supple before the robe was made. He states that the robe was worn with the hair side next to the body and was never removed day or night; also that the long guard hairs soon fell out. This is doubtful. If the guard hairs fell out, the ampulla, or base of the hair, must have been cut by too severe scraping in removing the flesh and fat adhering to the skin. In this case the hairs of the undercoat would fall out also.

The values in trade of *gras, demi-gras, sec (autrement bardeau),** *veule,* and Muscovite pelts were argued by Cadillac (1883.1). He thought that the commerce in fat beaver should cease. Properly, *veule* was only a dry beaver which had been scraped, cleaned, and sewed into a robe. The leather was white, light in weight, and thinned to the point where the hair could still be held fast. In the half-fat the leather is greased inside and out, is more worn, dusty, and matted than the *veule* and smells of the Indian. It is dirty but not as much so as the *gras*.

Eight grades are given by Dobbs (1744:25) whose information came from French sources. They follow:

"The first is the fat Winter Beaver, kill'd in Winter, which is worth 5s. 6d. per Pound.

"The second is the fat Summer Beaver killed in Summer, and is worth 3s. 6d.

"The third the dry Winter Beaver and fourth the Bordeau, is much the same, and are worth 3s. 6d.

"The fifth the dry Summer Beaver is worth very little, about 1s. 6d. per pound.

"The sixth is the Coat Beaver, which is worn till it is half greased and is worth 4s. 6d. per Pound.

"The 7th the *Muscovite* dry beaver, of a fine skin, covered over with a silky Hair; . . . This is worth 4s. 6d. per Pound.

"The eighth is the Mittain Beaver, cut out for that Purpose to make Mittains, to preserve them from the cold and are greased by being used, and are worth 1s. 9d. per Pound."

His grades are poorly defined and he confused *bardeaux* with Bordeaux. The English used only coat (fat) and parchment (dry) beaver in their data on exports in the early part of the eighteenth century (Dobbs, 1744:199).

*I have been unable to find the meaning of *bardeau* as applied to the beaver pelt.

Most of the beaver pelts produced were dry. For example in 1723, Canada exported 649 packs of dry beaver, 330 of fat, 2 of soft, and 20 of Muscovite (Innis, 1727:150). These grades fell into disuse in the latter part of the eighteenth century in Wisconsin. The pelts were then graded as No. 1 and No. 2. I have not discovered the difference. Porlier (1911) shipped: "No. 1. 100 Beaver weighing 108 lb.; No. 2. 57 Beaver weighing 78 lb." Both parcels are stated to have been of the best quality. The No. 2 beavers were the heavier, hence the largest; so that the difference in grades does not appear to have been based on size.

Weight of Packs and Pelts

Beaver pelts were compressed into packs for economy of space and ease of handling. Poor grades of bear skins were commonly used as covers. Four methods of compression were used (Russell, 1948). At small and remote posts a pole was employed. One end was fastened to the ground and pressure was applied by the weight of a man on the other end of the pole. The wedge press consisted of a frame of four posts driven into the ground, and provided with cross pieces beneath which were placed the furs covered with slabs of wood. Pressure was obtained by driving wedges between the slabs. Large trading posts having easy shipping facilities, such as Mackinac, used a heavy metal screw press. This press was superseded by the simple and efficient jack.

The weight of a pack of furs is usually given as 90 to 100 pounds. Chittenden (1904) states that a pack weighed 100 pounds and contained 80 beaver pelts, which would be 1.25 pounds per pelt. Larpenteur (1933) gives 100 pounds for a pack containing 60 average pelts, or 1.66 pounds a pelt. A weight of 100 pounds is also mentioned by Henry (1921:197). The packs of beaver taken along the Minnesota River in 1822 weighed 100 pounds and contained 80 skins; again 1.25 pounds a pelt (Neill, 1852). Harmon (1922) in 1801 had his furs in packs weighing 90 pounds each. According to Morgan (1868:228) an average pelt from the Upper Peninsula of Michigan weighed 1.5 to 1.75 pounds.

Extensive data on the packs of beaver collected by the Northwest Company at the Fond du Lac post in 1804–05 are given by Pike (1895). Four packs of mixed large and small pelts averaged 91.5 pounds in weight and contained on the average 69.5 skins weighing 1.32 pounds each. He lists the weights of 115 packs. If the highly abnormal weights of 72 and 127 pounds for two packs are rejected, the average weight of a pack is 91.5 pounds.

The following data were compiled from 133 invoices of the American Fur Company and its agents of beaver taken in the upper Great Lakes region, principally in Wisconsin. A total of 25,630 pelts weighed 29,545 pounds, or 1.15 pounds each. All lots weighing less than a pound per pelt were rejected as young or "cubs." Their average weight was 0.88 pound. The heaviest lot consisted of 416 pelts having an average weight of 1.4 pounds, shipped by Jacques Porlier in August, 1821. Two apparently especially selected skins weighed two pounds each. It may be accepted that the average pack of Wisconsin beaver pelts weighed 91.5 pounds and contained 80 pelts of 1.15 pounds each.

Large beaver, weighing 80 to 110 pounds, have been caught in the state (Schorger, 1953; Jackson, 1961:193).

Prices

Originally the unit of value at the trading posts was a beaver pelt or *plus,* pronounced plew. Not only were trade goods priced in beaver pelts but furs other than beaver as well. In the Fond du Lac region in 1820, a large prime beaver pelt was worth two otter skins, and three of marten or mink (Doty, 1876:205). The cost of goods at the posts varied considerably but was regulated largely by the distance that the supplies must be transported. Examples of the rate of exchange are given in Table 1.

English blankets for the Indian trade varied in size and weight and were classified as 2, 2½, 3, 3½, and 4 point (Elliott, 1900). The points were woven into the blanket. A black strip four inches long represented one point, and a strip two inches long one-half of a point. A 2½ point blanket was six feet and three inches long, five feet and two inches wide, and weighed seven and one-half pounds (Peake, 1954:56). A 3 point Northwest or Mackinac blan-

Table 1. Rate of Exchange of Full Beaver Pelts For Goods

Year	Place	Blanket Kind	Blanket No. Pelts	Gun No. Pelts	Reference
1689	Albany	White or Red	1	2	Anon. (1855)
1689	Montreal	White or Red	2	5	Anon. (1855)
1776	Fort des Prairies, Saskatchewan	White	8	20	Henry (1921:303)
		Stroud	10	—	Henry (1921:303)
1804	Lac du Flambeau, Wisconsin	2½ Point	3	10*	Malhiot (1910:221, 222)
1820	Fond du Lac, Wisconsin	2½ Point	2	5	Doty (1876:205)

*Inventory value.

ket was six and one-half feet long, five and one-half feet wide, and weighed eight and one-half pounds. A 3 point American blanket, e.g., was inferior in size, weight, and quality.

In 1820, according to Doty *(l.c.)* a plus (or pound) was estimated at $2.00 and a large prime beaver skin was worth two plus. His data have been adjusted to full skins in the above table. Turner (1889, 1891) was informed by Andrew J. Vieau that a plus was a pound of pelt worth $1.00 in his day. Vieau's trading experience was in the period 1834–50 and was confined to Milwaukee and a few places north of this city, an area where the beaver was close to extinction. The values given by Malhiot *(l.c.)* for his post at Lac du Flambeau in 1804–05 are somewhat perplexing. He carried a gun at ten plus and a 2 point blanket at two plus in his inventory. The blanket was traded at three plus. His plus must have been a large skin weighing two pounds for in his return for December 23 he lists 30 beaver skins, evidently small, at 16.5 plus. Traders at Green Bay in 1810 charged $10.00 for a 2½ point blanket (Peake, 1954:20).

It is difficult to follow the early prices in currency of beaver since it is frequently impossible to determine if the price was based on the whole skin or the pound. The hat manufacturers were interested only in the weight of skins, so that selling beaver by the pound became an early custom. A good example of confusion is to be found in the tables in Innis (1927:153, 154). In 1754 a skin was priced at four francs, and the following year the price is four francs per pound. In the Canadian trade the average beaver skin was considered to weigh one and one-half pounds. Where weight is not stated I have assumed (Table 2) that the price is per pound. In Table 3 all prices are per pound.

TABLE 2. PRICE OF BEAVER PER POUND

YEAR	PLACE	CANADIAN CURRENCY	DOLLARS	REFERENCES
1635	Albany		1.50[1]	Morgan (1868:243)
1681	Montreal	4 livres, 10 sols[2]	.75	Du Chesneau (1855)
1681	Albany	8 livres	1.33	Du Chesneau (1855)
1699	Montreal	3 livres 7 sols 6 den.	.56	Cadillac (1883:148)
1738	Montreal	55 sols	.46	Salone (1906)
1744	Montreal	4 livres[3]	.67	Salone (1906)
1754	Quebec	4 livres	.67	Innis (1927:154)
1799	Montreal	12 shillings[4]	2.88	Morison (1910)

[1]A skin sold for $2.25 making $1.50 per pound.

[2]Canadian livre, or shilling after the conquest of Canada, was worth 16.6 cts. There were 20 sols to the livre and 12 deniers to the sol. One English shilling = 1s. 4d. Canadian.

[3]Increase in price attributed to war with the English.

[4]Sterling.

The prices in Table 3 have been taken from the voluminous papers of Wisconsin fur traders in the Wisconsin Historical Society library and from those of the American Fur Company.

There was a financial crisis in England and the United States in 1837 and the American Fur Company did not know what to do with its beaver. About this time the Northern Outfit of the Company at La Pointe issued "beaver money" (Fig. 1) with which the trappers were paid (Nute, 1928). The certificate was payable in merchandise only. Under normal conditions two profits were obtainable, one from the merchandise, the other from the furs.

TABLE 3. PRICE PER POUND PAID TO WISCONSIN TRADERS

YEAR	DOLLARS	TRADERS
1811	3.00*	Pierre Grignon
1813	2.50*	Pierre Grignon
1814	3.34*	Jacob Franks
1815	3.50	P. and A. Grignon
1816	3.50	Franks and Co.
1820	4.00	Lawe and Grignon
1820	3.50	Porlier and Rouse
1821	4.00	Lawe and Grignon
1824	3.00	Suggested buying price Stuart to Abbott Aug. 18
1825	4.38	Lake Superior beaver } Prices paid by Am. Fur. Co.
1825	3.75	Upper Miss. beaver } Crooks to Astor July 29
1827	4.00	La Bulle (Wausau) Post
1840	4.00	Dec. 19. Suggested buying price Crooks to Juneau
1844	3.00	Dec. 25. H. L. Dousman to A. Bailly
1845	2.25	July 23. Dousman's offer for Ermatinger's beaver

*Prices in livres changed to dollars.

FIGURE 1. Beaver Money used at La Pointe, Madeline Island.

The Wisconsin traders in the first half of the nineteenth century rarely made a profit, many continuing to sink deeper into debt. The main reason why the Company continued to advance credits was that most of the traders had acquired land which had grown in value and could be put up for security. In 1844 Solomon Juneau (Nute, 1955: no. 14,187) at Milwaukee was bankrupt with $20,000 of debts. John Lawe (Nute, 1944: no. 7,883), with forty-two years of experience in the Indian trade, could lament that no one ever heard of a rise in price of furs. Accustomed to dealing only in furs and with no other means of support, the traders accepted with resignation a fate improverishing and inescapable. The Company was not free from the line of least resistance. Time and again it was determined to close an unprofitable post, yet the trader was continued in employment for years afterward.

Decrease of the Beaver

Few species of mammals can withstand continuous and indiscriminate trapping. There is precious little evidence that the Indian practised conservation in spite of Lahontan's (1703, II:161) statement that after breaking down a dam the Indians spared a dozen females and half a dozen males for reproduction. It would be an unusual pond that even had an initial population of eighteen beavers. Indians were directly responsible for exhaustion of the beaver as nearly all the pelts were taken by them.

Only a few Indian tribes were of importance in taking beaver in Wisconsin. The Chippewa hunted the south shore of Lake Superior and bartered their furs at Fond du Lac and La Pointe. In 1757 the Menominee, Sauk, Fox, Winnebago, Mascoutin, Kickapoo, Prairie Sioux and Lake Sioux came to Green Bay to trade (Bougainville, 1908:183). It is sometimes stated that the Sioux occupied lands west of the Mississippi and were not residents of Wisconsin. In the early days, the Sioux held the country immediately east of the Mississippi and never relinquished in spirit their rights to this borderland, especially the privilege of hunting. In the census of 1821, the number of Sioux men, women, and children residing east of the Mississippi is given as 1,182 (Cass, 1911). As late as 1850 Grignon (1914) traded with the Sioux for the furs which they had obtained up the Trempealeau River.

Beaver were so scarce in the Mackinac region by 1700 that the Indians went 200 leagues to hunt them. Between October and May a good hunter could capture 50 to 60 beavers, more or less (Cadillac, 1883). This means that he would average only one beaver in four days. Morgan (1868:243) wrote that an Indian family of four effective persons would take 75 to 150 beavers in a season on the south shore of Lake Superior in well-stocked beaver territory, and that 50 to 100 were not uncommon. This statement might have applied to the Upper Peninsula of Michigan, but doubtfully to Wisconsin. The winter of 1870–71, Cartwright (1875:272) and a companion caught 73 beavers in Marquette County, Michigan.

By 1793, according to Dickson (1923; Doyle, 1923), very few beavers were taken east of the Mississippi or on the streams which flowed into it. The land of the Menominee on Green Bay was almost exhausted of game. These Indians accordingly spent the winter in part on the upper Wisconsin, but chiefly on the upper Mississippi where they captured large numbers of beaver. They excelled all the other Indians in art. The Winnebago, Sauk, and Fox hunted chiefly deer, raccoon, and bear. Furs at Fond du Lac (Superior), which was once a highly productive region, had dwindled to a trifle by 1807 (Monk, 1923). This year, at Prairie du Chien, Dubuque (1910) outfitted a party of eight men to trap beaver on the Missouri. The Fond du Lac Indians hunted south to Pine Lake, Polk County, and in 1820 had but few beavers in their territory (Doty, 1876:201). Brunson (1843) traveled overland from Prairie du Chien to La Pointe. The only sign of beaver found was between the headwaters of the Black and Chippewa rivers.

The statement of Lanman (1847) that the beaver was extinct south of Lake Superior is not true. In the 1880's it was supposed to be close to extinction in the state (Strong, 1883; Paquette, 1892). It was sufficiently uncommon at that period that the trapping of one, or the presence of its dams, was certain to receive publicity. In 1912 it was still to be found in most of the northern counties (Cory, 1912). The estimate of Seton (1929) that in 1925 only 100 beavers remained in Wisconsin is much too low since 2,208 beavers were trapped in the season 1933–34. The recovery of the beaver under protection has been remarkable as 14,232 were trapped in 1958, and 9,806 in 1962. These figures were not approached at any time during the nineteenth century.

I have tabulated the copious data on the shipment of beaver from Wisconsin in the nineteenth century to be found in the fur papers in the Wisconsin Historical Society without being able to find consecutive quantitative data for any one post extending over a period as short as ten years. Henry (1921:196) obtained 150 packs at Chequamegon Bay in the spring of 1766. The return in 1832 at adjacent La Pointe, under Lyman F. Warren, was down to 250 pelts. These came from the seven posts on the St. Croix, Lac Court Oreilles, Lac Chetec, Chippewa River, and Lac Vassale* (Allen, 1834). The shipment of beaver from Green Bay declined from 535 pounds in 1813 to 198 pounds in 1836, but in neither case is possi-

*Corruption of Vaseux or Mud Lake, Town of Oakland, Burnett County.

ble to know the extent of the area from which the furs were collected. The last shipment of beaver from Milwaukee which I found was 21.5 pounds in 1822.

If the returns from a post were poor, the trader had an excuse whether valid or not. There was too much snow or none, high water, severe competition from rival traders, and the Indians were starving or ill. In March, 1835, Solomon Juneau wrote from Milwaukee that the Indians were so discouraged by the arrival of so many settlers north of Chicago that they refused to hunt. Then on Nov. 23, 1836, Ramsay Crooks wrote that the progress of civilization will break up all of the American Fur Company's trade south of the Fox and Wisconsin Rivers, worth $25,000 annually.

DISTRIBUTION OF THE BEAVER

The statement (McLeod, 1946; Lapham, 1946) that formerly the beaver occurred on all the waters of the state is undoubtedly correct. As demonstrated below it has been possible to show the early presence of the beaver in nearly all of Wisconsin's counties. I am indebted to Walter J. Zelinske and George J. Knudsen of the Wisconsin Conservation Department for information on the present and recent status of the beaver in certain counties. The recent presence of the beaver is good presumptive evidence that it occurred in primitive times. Numerous streams and lakes bear the name Beaver from the former presence of this animal (Fig. 2).

ADAMS.—Beavers were numerous in the early days of settlement (Cole and Smythe, 1919). In the fall of 1843 Kingston (1879) and a companion descended the Wisconsin River from Grand (Wisconsin) Rapids. Fresh sign of beaver was noted on the east bank below the mouth of Yellow River, hence in the town of Quincy.

Beaver Pond is in the eastern part of the town of Jackson.

ASHLAND.—Lapham (1858) listed the beaver among the mammals inhabiting the vicinity of Ashland. In 1878 Joe Harper of Butternut caught an old beaver which had lost a front paw (Ashland, 1878). According to McManus (1920) the headwaters of the Potato River formed "a vast region of beaver dams." Some beaver were to be found in 1920.

Beaver Lake, town of Morse, two and on-half miles SE of Mellen; a second Beaver Lake, one mile SW of the city of Clam Lake; a third Beaver Lake, western part of the town of Marengo; Beaverdam Lake, seven miles S of Marengo; Beaver Creek rises two miles W of Butternut and flows S into Butternut Creek.

BARRON.—Surprisingly to some inhabitants, several beavers were caught in the county in 1881 by J. M. Parkhurst of Prairie

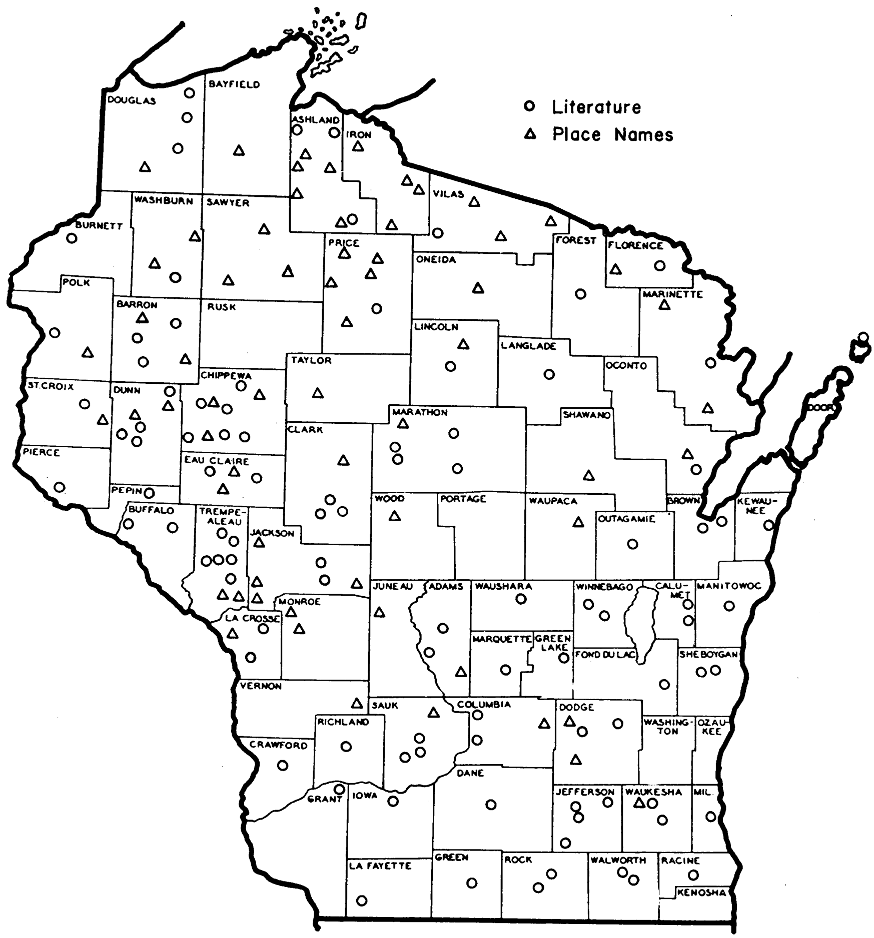

FIGURE 2. Early Distribution of the Beaver in Wisconsin.

Farm (Barron, 1881). The following year a few beavers were still being captured near Rice Lake and their old dams were common (Butler, 1882). An old and crippled beaver was caught in Hay River by Mr. Harris of Barron in 1892 (Barron, 1892).

Beaverdam Lake, edge of Cumberland; Beaver Creek, town of Dovre, flows NW into Tenmile Lake.

BAYFIELD.—In 1885 a colony of beavers was building a dam on a stream a few miles from Bayfield (Bayfield, 1885). Nineteen beavers were taken in March, 1921, by W. T. Gray, mostly in this county (Jackson, 1961:193), a good indication that the beaver was fairly common.

Beaver Lake, seven and one-half miles N of Drummond.

BROWN.—When Nicolet (1898) visited the Winnebagos at Green Bay in 1634 at least six score beavers were served at one feast. This is probably an exaggeration like his four to five thousand curious male visitors, but it indicates that the beaver was common in the region. Perrot (1864:279) was in the Great Lakes region from 1665–70. At the Potawatomi village on the eastern shore of Green Bay near Point Sable, the Indians gave him five beaver robes to dispel the ill-will which they had created in him. They did not wish to hunt beavers as they were few, preferring to seek other game to satisfy the needs of the body. Lahontan (1703, I:139) was at Green Bay in 1689 when he was served a roasted beaver tail. He saw in the Indian village ten or twelve tame beavers which came and went at will.

BUFFALO.—W. W. Cooke (1940:295) came with his parents in 1856 to a homestead five miles from Gilmanton. Beavers were in all the streams and two dams flooded part of the farm. His father took them by spearing. They were pleased if $1.50 was received for a pelt. In the fall of 1860 two trappers returned to Viroqua with 69 beaver pelts obtained on Beef River (Slough) in a period of six weeks (Viroqua, 1860).

BURNETT.—The winter of 1803–04 Curot (1911) collected three packs of beaver at his trading post where the Yellow River leaves Yellow Lake.

CALUMET.—Old beaver sign has been found in the towns of Charlestown and Brillion. At present there is a colony in the town of New Holstein *(In litt.,* Warden K. L. Reichenbach).

CHIPPEWA.—The fall of 1858 Cartwright (1875:241) and two companions caught beavers on Mud, Elk, and O'Neil creeks. Trappers in the fall of 1886 were taking four to five beavers nightly at various places on Duncan Creek eight miles above Chippewa Falls. The animals were also quite numerous on this creek near Bloomer (Chippewa Falls, 1886). Several beavers were taken on the same stream a year later by J. L. Stevens. A substantial dam had been built within a mile of Bloomer (Chetek, 1887). A fine beaver caught on Paint Creek, which flows into Lake Wissota, was exhibited in Chippewa Falls (Chippewa Falls, 1888). At this time a number of beavers was taken by a Minnesota hunter in the woods north of Chippewa Falls (Shullsburg, 1888). On October 25, 1891, Frank Hunter on Duncan Creek trapped a beaver weighing 68 pounds (Chippewa Falls, 1891).

Beaver Lake, ten miles NE of Bloomer; Beaver Creek, town of Wheaton, flows E into the Chippewa River near Chippewa Falls; another Beaver Creek, a small stream flows N and enters Fisher River eight miles NE of Cornell.

CLARK.—Manly (1927) trapped on the upper Black River the winter of 1843–44. He stated that the beavers living in the banks could not be secured until the ice went out in the spring. At this period the beaver was abundant (French, 1875.1). In 1874 a beaver minus one leg was killed on the Black River above Neillsville (Neillsville, 1874). A beaver dam was discovered in 1886 on O'Neill Creek a short distance east of Neillsville (Milwaukee, 1886). Two beavers were killed "near the mound" west of the Black River in the fall of 1889 (Neillsville, 1889).

There is a town of Beaver.

COLUMBIA.—E. F. Lewis settled in 1849 on Section 16, Town 13N, Range 7E on Beaver Creek, so-called because beavers had built a dam across it (Lewis, 1920). The stream is now called Big Slough. A beaver dam at Dorward's Glen, town of Caledonia, was still visible in 1896. Dorward (1901) saw it first about 1864.

Beaver Creek rises nine miles N by E of Columbus and flows into Beaver Dam Lake.

CRAWFORD.—During the 1959 season, 195 beavers were trapped in the county (Bersing, 1959).

DANE.—In 1836, according to Tenney (1877), the beaver had not yet been exterminated in the town of Madison. At present it is fairly common in the western part of the county.

DODGE.—Beaver Dam Lake and the city of Beaver Dam owe their names to the beaver. Prior to construction of the dam, the lake was a large marsh (Snyder, 1902). W. H. Murkley stopped at Beaver Dam in the spring of 1849 and reported that he saw beavers working on a dam (Beaver Dam, 1924). In 1843 Lapham (1925) visited Solomon Juneau's trading post on the Rock River, which according to the surveyor's description was near Mayville. Beavers were present until about 15 years previously.

Beaver Dam Lake is in the NW part of the county. The portion of Beaver Creek draining this lake flows S into the Crawfish River, town of Shields. On the map of Cram (1839) Beaver Creek bears the Algonquian name of the beaver, Ahmic.

DOOR.—As late as September 14, 1905, a beaver was shot at Washington Harbor, Washington Island (Sturgeon Bay, 1905).

DOUGLAS.—At intervals the Brule was a famous stream for beavers. In 1680 their dams were numerous (Duluth, 1886). Henry (1921:188) spent the winter of 1765–66 at Chequamegon Bay where he advanced goods worth 3000 plus to the Indians who went to Fond du Lac to hunt. When they paid their credits in the spring he obtained 150 packs of beaver weighing 100 pounds each. Even if it is assumed that on the average a pelt weighed as much as one and one-half pounds, he obtained 10,000 skins!

The water was so low at the headwaters of the Brule in 1767 that Carver (1781:81) had to close several old beaver dams, broken down by hunters, to raise the water sufficiently to float his canoe. In 1840, at the proper season, the Chippewa went to the Brule for "the beaver and otter that exist along its whole course. There are indications of its once having been abundantly stocked with these animals; but the trappers have made such havoc among them of late years, that the stock has become very much reduced" (Cram, 1841). Writing of the Brule in recent years, McManus (1920:136) stated that it had many ponds formed by beaver dams.

Beaver Creek, flowing S, enters the St. Croix about nine miles W of Gordon.

DUNN.—Perrault (1909–10:547, 555) built a post on the lower Red Cedar River and during the winter of 1788–89 traded for 14 packs of beaver of 90 pounds each. From his rough map his post could not have been much farther up the river than Menomonie. On one occasion he camped down the river at the *petit rocher,* near the post, where a deer pursued by wolves jumped from a cliff and broke its legs on the ice of the river. His rock corresponds with the Pinnacle midway between Downsville and Menomonie. Furthermore this is the only elevation sufficiently close to the river for the tragedy to have occurred.

The winter of 1857–58 Cartwright (1875:240) and a companion trapped beaver on Pine Creek, town of Sand Creek. The fall of 1858 he and two companions caught beavers on Gilbert and Wilson creeks. Writing of the "Big Woods" a "Pioneer" (1884) stated: "A notable feature to the eye of the observer, along the small streams, is the great number of old beaver dams, showing that at one time these animals must have been very numerous here." A few still lingered. The Big Woods comprised the present towns of Eau Galle, Weston, Lucas, Stanton, Sherman, Sheridan, and parts of others.

Big Beaver Creek flows SE into Hay River four miles NW of Wheeler; Little Beaver Creek flows into Big Beaver; Beaver Creek, rising in the town of Auburn, Chippewa County, flows W into the Red Cedar three miles S of Sand Creek. The Beaver River on Perrault's map *(l.c.)* appears to be the present Hay River.

EAU CLAIRE.—The fall of 1866 Charles Martin trapped several beavers in the town of Bridge Creek (Bartlett, 1929). The Slayton brothers of Augusta took four beavers during their hunt the winter of 1867–68 (Dodgeville, 1868). On January 22, 1877, a beaver was killed on the upper Eau Claire River (Eau Claire, 1877). Three large beavers were trapped in 1883 by Herman Heckern on Seven Mile Creek about seven miles east of Eau Claire. They were then quite rare; however fifteen years previously they were plentiful (Eau Claire, 1883). In the fall of 1886 a party of hunters captured 40 beavers on Muskrat Creek, town of Wilson (Delevan, 1886).

Beaver Creek enters the Eau Claire River from the E seven miles E of Altoona; another Beaver Creek flows N into Otter Creek at Brackett.

FLORENCE.—A black beaver was caught by Paul Miller on Pine River, town of Commonwealth (Florence, 1886).

Beaver Pond, town of Long Lake.

FOND DU LAC.—Beavers had not been seen for many years in the town of Osceola until the fall of 1872 when four were killed by W. Tomkins (Fond du Lac, 1872).

FOREST.—The county produced 296 beaver pelts in 1959. Insofar as known, the beaver was never exterminated.

GRANT.—At Muscoda, the fall and winter of 1845–46, Robert and William McCloud bought beaver and other furs, fur-bearing animals being numerous (Butterfield and Ogle, 1884). There is now a considerable population of beaver in the county. The take of beaver in 1959 was 202.

GREEN.—According to Jackson (1961) there were remains of beaver dams and ponds as late as 1900.

GREEN LAKE.—When Perrot (La Potherie, II:109) came to the Indian village at the site of modern Berlin there was a mixed population of Mascoutin, Miami, and Kickapoo. He gave the women knives for skinning beaver and cutting meat. The Miami told him that they had no beaver pelts because up to that time they were accustomed to roasting the entire animal. As late as 1847 the Indians were busily engaged in trapping beavers and muskrats (Acme, 1890).

IOWA.—Fifteen beaver were trapped in 1959. Most of the beaver occur along the Wisconsin River and the streams flowing into it.

IRON.—Beaver Pond, town of Gurney, two miles SW of Saxon; Beaver Lake, six miles N of Mercer; a second Beaver Lake, six miles NE of Mercer; Beaver Creek, town of Sherman, flows N into west arm of the Flambeau Flowage.

JACKSON.—The creeks flowing into Black River had beaver dams at short intervals in 1841 (French, 1875). In January, 1887, Royal McGregor caught a beaver on Robinson Creek, town of Manchester (Black River Falls, 1887). The take in 1959 was 390.

Beaver Creek, town of Northfield, flows S into Pigeon Creek at York; a second Beaver Creek rises in the town of Bear Bluff and flows E; South Beaver Creek, rises in the town of North Bend, flows W.

JEFFERSON.—Hawkins (1940) thought that the beaver was exterminated prior to settlement. He mentions that several well preserved dams could still be seen near Milford. On one of the dams was growing an elm tree estimated to be 100 years old. The father of E. D. Coe (1908) settled on the west bank of Rock River, town of Watertown, seven miles from the city of Watertown, in 1839. The following winter about thirty Winnebago families camped near his home. Beaver was among the furs taken by them. During the archeological excavations at Carcajou Point, Lake Koshkonong, there were found split incisors of beaver which had been used for chisels (Hall, 1962). Thirty remains of the beaver at the Aztalan site on the Crawfish River were identified by Parmalee (1960).

JUNEAU.—Beaver Creek rises in the town of Kingston and flows S into the Lemonwier. The county furnished 398 pelts in 1959.

KENOSHA.—There were no beaver in the county in 1956.

KEWAUNEE.—There are no resident beaver at present. Warden Philip Hein has seen an occasional beaver in years past. He furnished a photograph of a beaver traveling along the Lake Michigan beach in May, 1950.

LA CROSSE.—The Sioux called the Black River Chabadebah or Beaver River (La Salle, 1902). The former presence of the beaver in Lewis Valley, town of Farmington, is mentioned by Sisson (1955). In 1881 a man living a few miles from La Crosse brought to town the pelts of seven beavers which he had trapped (La Crosse, 1881).

LAFAYETTE.—In April, 1894, W. H. Calvert shot a beaver on a small stream on his farm near Benton. Its length from tip to tip was three feet and nine inches. None other had been seen for many years (Dodgeville, 1894).

LANGLADE.—Beaver was formerly one of the principal furs taken in the county (Dessureau, 1922). It furnished 205 skins in 1959.

LINCOLN.—It was stated by Hoy (1882) that a few beavers persisted in this and adjacent counties. The take in 1959 was 268.

Beaver Lake, town of Skanawan, three miles SE of Tomahawk.

MANITOWOC.—Beavers, though rare, were present in the county in 1956.

MARATHON.—Having seen sign of beaver on the Eau Pleine River east of Colby, William Wilde set his traps, but secured only part of the foot of a beaver (Colby, 1886). The following year a beaver weighing about 70 pounds was trapped by J. W. Denney (Colby, 1887). In the fall of 1889 beavers had a new dam two miles up Little Rib River, town of Stettin. Several had been trapped. The editor (Wausau, 1889) stated that a few years previously the streams in the region were well-stocked with this animal which was now becoming scarce. He entered a plea for protection. Two years later two beavers were trapped on Little Rib (Wausau, 1891). In the early days, Michael De Jarden, a Chippewa, assisted his father in trapping beaver and other fur-bearers near Mosinee (Ladu, 1907).

Beaver Creek, town of Bern, flows S to join Black Creek two miles NW of Athens.

MARINETTE.—Stanislaus Chapeau (1831, 1835) wrote in 1831 from his post on the Menominee River that a rival trader had secured most of the beaver. In June, 1835, he informed John Lawe that he had 150 pounds of beaver.

Beaver Branch, town of Dunbar, flows S into KC Creek two miles NW of Dunbar; Beaver Creek, Town of Beaver, flowing E, enters the Peshtigo seven miles S of Crivitz.

MARQUETTE.—In 1680 Hennepin (1903:306) descended the Fox River from Portage and before reaching the lakes on this river broke down several beaver dams in order to get the canoes through. From Portage to Buffalo Lake the Fox is broadly margined by marsh, a condition rendering the construction of dams improbable. The dams were probably found between Buffalo Lake and Puckaway Lake. Beaver are still present.

MILWAUKEE.—Lapham (1855) mentions an old beaver dam at Milwaukee. It is shown on his Plate III on a streamlet which enters the Milwaukee River three and one-half miles north of its mouth.

MONROE.—One hundred beavers were captured in 1959.

West and East Beaver Creeks rise in the NW corner to form Beaver Creek which flows S into the La Crosse River at Sparta.

OCONTO.—A beaver weighing 48.5 pounds was caught in the fall of 1884 on the Pensaukee River, near Abrams, by George Lince (Oconto, 1884). A year later a black beaver, "a rare variety," was captured near C. B. Alford's logging camp (Oconto, 1885).

Beaver Lake, three miles N of Oconto Falls.

ONEIDA.—The county produced 280 beavers in 1959.

Beaver Lake, town of Cassian, about eight miles NE of Harshaw.

OUTAGAMIE.—There were few beaver colonies in 1956.

OZAUKEE.—According to Warden Albert W. Wilke, there has not been a beaver in the county during the past 75 years.

PEPIN.—Two beaver were trapped by W. B. Dyer on the Eau Galle, west of Durand, in October, 1885. A colony was reported to exist on this stream in the town of Waubeek (Durand, 1885). One was also trapped on the Eau Galle by Dyer in 1887 when they were considered quite scarce (Durand, 1887). Three years later a trapper came into Durand with the pelts of three beaver trapped on the Eau Galle. A fourth beaver was shot but lost (Durand, 1890).

PIERCE.—In 1659 Radisson returned to Montreal with a "great store" of beaver pelts obtained while living with the Indians on Prairie (Pelee, Bald) Island, at the northern end of Lake Pepin (Adams, 1961). The number of beaver pelts taken in 1959 was 108.

POLK.—Branches gnawed by beaver, along with the bones of extinct bison, were found in Mountain Meadow, Interstate Park, town of Osceola (Pond, 1937).

The North and South branches of Beaver Brook rise near the village of Turtle Lake and form Beaver Brook which enters the Apple River at Amery.

PORTAGE.—Beaver are present, 40 having been taken in 1959.

PRICE.—In 1897 Capt. Wiken had two colonies of beavers at his lake; and a large colony was at work on the Jump River one and one-half miles north of Prentice (Prentice, 1897).

Beaver Creek, a small stream in the town of Catawba, flows SW into the North Fork of Jump River three miles SE of Catawaba; a second Beaver Creek, rising in Ashland County, flows S and enters Butternut Creek three miles SW of Butternut; a third stream of this name, town of Flambeau, flows into Price Lake seven miles W of Lugerville; Beaver Lake, three and one-half miles SE of Fifield; and Beaverdam Lake, five and one-half miles E of Fifield.

RACINE.—West (1903) stated that the remains of beaver dams were still quite common.

RICHLAND.—During the 1959 season, 50 beavers were trapped.

ROCK.—At one time there were beaver dams in the town of Harmony (Janesville, 1869). Remains of beaver dams and ponds were still visible in 1900 (Jackson, 1961).

RUSK.—This is one of the best beaver counties. The harvest in 1959 was 348 beavers.

ST. CROIX.—The dams built of alders and the canals dug by the beavers on Sand Creek, town of Emerald, were described by John E. Glover (Hudson, 1874). The present population is low.

Beaver Creek, town of Springfield, flows NE into Tiffany Creek at Downing.

SAUK.—Canfield (1890) came to Sauk County with a government surveying party in 1842. He wrote: "I have seen from five to ten dams, within a space of half a mile, upon some small spring branch, and have often noticed where they have dammed large streams. It would seem as though the whole country had once been alive with them." When the first settlers arrived in the town of Westfield there was a beaver dam, about 200 feet in length, one and one-half miles east of Loganville (Baraboo, 1921). Cole (1922) stated incorrectly that the beaver was exterminated about 1820; however, an occasional old dam existed. A beaver weighing 50 pounds was taken along the south branch of Honey Creek, Town of Franklin, by Edward Tabor in 1859 (Baraboo, 1859). W. A. Canfield had a section from a tree 27 inches in circumference supposedly cut by the same beaver. Parmalee (1960) identified 19 remains of beaver from the Durst rockshelter, section 12, town of Honey Creek.

Beaver Creek, a small stream, enters Dell Creek 5 miles SW of Delton.

SAWYER.—This county produced 706 beavers in 1959.

Beaver Creek, town of Weigor, flows into Little Weigor Creek 2 miles N of Weigor; a second Beaver Creek, town of Winter, flows SW, entering Thornapple River 8 miles SW of Draper; Beaver Lake, town of Round Lake, 6 miles S of Teal Lake.

SHAWANO.—Beaver Creek, town of Belle Plaine, flows SW into the Embarrass River five miles N of Embarrass.

SHEBOYGAN.—The original government survey recorded beaver dams in the towns of Plymouth and Sheboygan Falls. Charles D. Cole bought beaver and other furs from the Indians at Sheboygan (Buchen, 1944). At one time there was a large beaver dam on the farm of W. Kuhlmey, town of Plymouth (Plymouth, 1901). There were no beaver among the fur animals caught by the Indians about 1870 (Gerend, 1920).

TAYLOR.—A Mr. Hinman exhibited chips from a birch tree felled by beavers near the headwaters of Black River (Kilbourn, 1869). In the fall of 1876 a trapper caught eight beavers in the county (Plover, 1877). The take in 1959 was 451 beavers.

Beaver Creek, town of Ford, flows into Johns Creek four miles SW of Perkinstown.

TREMPEALEAU.—Beaver Creek was so named by James Reed and Willard Bunnell on account of the numerous beavers on the stream. A Menominee Indian is reported to have taken 50 beavers during a hunt on Trempealeau River. In September, 1843, W. Smothers caught a few beaver on Pigeon Creek, and T. A. Holmes some on Elk Creek (Bunnell, 1897:238). James Reed was famous as a beaver trapper. He came to Trempealeau in 1840 and died on the Little Tamarack in 1873. Much of his trapping was done on the Trempealeau River and its tributaries. Pierce (1915) relates that in 1863 Reed stopped at his home with his pony on which was a large pack of beaver pelts and traps. In January, 1859, Reed came into Osseo with 25 beaver pelts (Madison, 1859).

The spring of 1850 Antoine Grignon (1914) traded with the Sioux Indians who had trapped on the Trempealeau River and had collected a fine lot of beaver and other furs. Beavers were still quite plentiful on Beaver Creek in 1862. Cut trees, chiefly ash, were to be found throughout the length of the stream (Galesville, 1862).

A beaver was killed by Andrew Benson in the mill pond at Whitehall in November, 1878 (Whitehall, 1878). In the spring of the following year Albert Spaulding caught a large beaver in the Trempealeau River at Independence (Arcadia, 1879). Two beavers, weighing 52 and 62.5 pounds respectively, were caught by A. Lawrence in the spring of 1887. He trapped nine during the season (Merrillan, 1887). Though formerly so numerous in Beaver Valley, it was considered to be extinct in 1917 (Curtiss–Wedge, 1917).

Beaver Creek flows SE to join the Black River three miles south of Galesville. Both Beaver Creek and its South Fork rise in Jackson County.

VERNON.—Beaver Creek, town of Greenwood, flows N into the South Branch of the Baraboo two miles S of Hillsboro.

VILAS.—At his trading post at Lac du Flambeau, Malhiot (1910) obtained about 100 beaver pelts the winter of 1804–05. The Lac Vieux Desert region was "tolerably well provided" with beaver in 1840 (Cram, 1841).

Amik (Beaver) Lake, seven miles W by S of the village of Lac du Flambeau; Beaver Lake, town of St. Germain, four miles NE of Big St. Germain Lake; a second Beaver Lake, town of Boulder Junction, seven miles N by E of the village of Boulder Junction; and Beaver Creek, town of Phelps.

WALWORTH.—The beaver occurred formerly in the town of Sugar Creek and their dams were to be seen at the lakes in the town of Troy (Western Hist. Co., 1882). Their works were still discernible in 1900 (Jackson, 1961). Lapham (1852) was informed by solomon Juneau that the last beaver killed in southern Wisconsin was on Sugar Creek in 1819.

WASHBURN.—In the vicinity of Long Lake old beaver dams existed on dry land showing where streams had disappeared (McManus, 1919).

Beaver Lake, town of Bass Lake, four miles SE of Stansberry; Beaver Brook, town of Beaver Brook, flows NW into the Yellow River at Spooner.

WASHINGTON.—Warden R. J. Lake has written that about 1929 beavers were planted in Moon Lake, town of Fond du Lac County: "The animals multiplied, moved to Manitowoc County, the Sheboygan Marsh, built dams on all branches of the Milwaukee River. They moved into Washington County and built dams at the outlet of Smith Lake and Little Dricken in the town of Barton, blocked off the drainage ditch in the Rockfield Swamp in the town of Germantown as well as Cedar Creek in the Jackson Marsh." The beavers were eventually trapped out because of damage to property. None remained in 1956.

WAUKESHA.—Unonius (1950) came to Pine Lake in 1841. The beaver was still present, but "was beginning to migrate from his small but carefully constructed house." The beaver had disappeared at Waukesha, but his works were still to be seen when Silas Chapman (1890) arrived in 1841.

Beaver Lake, two miles N of Hartland.

WAUPACA.—Beaver Creek, town of Bear Creek, a small stream, flows W into Little Wolf River eleven miles SW of Clintonville.

WAUSHARA.—William H. Boose of Wild Rose, has written to me that remains of old dams can still be seen in the vicinity of this town, and that he had personally trapped eight beaver in the county. George J. Knudsen *(in litt.)* found the beaver rare in 1956.

WINNEBAGO.—In 1670 stags, bears and beaver were abundant in the country embracing the junction of the Wolf and Fox rivers (Allouez, 1899.1). At the Menominee Indian payment at Lake Poygan in 1847, the Indians had for trade many furs, including beaver (Watertown, 1847). According to Overton (1932) beavers were once abundant and their dams were still visible. Many beaver teeth had been found.

WOOD.—While digging a trench, J. Lavigne found a hand-made beaver trap twenty inches in length under six feet of sand (Grand Rapids, 1885). A total of 363 beavers was taken in 1959.

Beaver Creek flows S and enters Yellow River five miles S of Marshfield.

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ARISTOTLE-GENERAL SEMANTICIST? OR KORZRBSKI-ARISTOTELIAN?

*Kenneth D. Frandsen**

Since scholasticism corrupted the brilliance of classical scholarship, the ancients have been suspect and many have agreed that the early contributions should be seen but not heard. Attractively displayed in the academic market place, the products of this attitude are the offspring of what Alfred Korzybski called the "great scientific revolution."[1] One of these products is labeled General Semantics, and Korzybski's insistence on a clean break with what he called "Aristotelian Semantic Clutches"[2] is exemplary of the strongest form of that kind of revolutionism. But Korzybski's formulation of a non-Aristotelian system seems clearly an echo of Hamlet's reply to Polonius signaling a confusion of subject matter and cause for dispute. Whether there is sufficient *cause* for a new system and what is its *matter* are two esentially separate questions.

When recast and directed to the general semanticist, the questions are (1) What is Korzybski's rationale or justification for the term, "non-Aristotelian?" and (2) What does he offer that cannot be found in Aristotle? The answer to the first of these two questions can be found in Korzybski's introduction to the second edition of *Science and Sanity*. Consider that rationale briefly, observing its generally semantic and semantically general implications.

Asserting that the two-valued Aristotelian system could not deal adequately with the electro-collodial, sub-microscopic levels of the functioning of our nervous system, on which sanity depends, Korzybski concluded that the formulation of an infinite-valued, non-Aristotelian system was an imperative necessity.[3] Thus Korzybski announces his two fundamental premises: (1) The Aristotelian system *is* two-valued, and (2) Sanity or insanity can be, in the language of one branch of contemporary psychological theory, "reduced" to physiological explanations.[4] He observes that "applied"

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[1]Alfred Korzybski, *Science and Sanity*, 3rd. ed. (Lakeville, Connecticut: The International Non-Aristotelian Library Publishing Co., 1948), p. 86.

[2]*Ibid.*, p. 94.

[3]*Ibid.*, p. xxx ff.

[4]For an explanation of "Reductionism" in contemporary psychological theory, see George Mandler and William Kessen, *The Language of Psychology* (New York: John Wiley, 1962), pp. 260–268.

Aristotelianism promotes artificial and, therefore, harmful splits such as "mind" and "body" or "space" and "time."[5] Finally, he notes the similarity between the primary goals of the Aristotelian and non-Aristotelian systems—the formulation of a general method for science and for life. The presumed difference between the two systems rests with the departure from "two-valued" orientations to "general, infinite-valued, process orientations." The specific proposal accompanying this departure is the use of extensional devices —indexes, dates, quotation marks, hyphens, and etc.

In short, Korzybski's argument appears to be: (1) Modern science has demonstrated that we live in a much more complex world than was conceived of by our ancestors; (2) Because our (Aristotelian) language behavior and symbolic processes are not appropriate to the complexity of our world, our nervous systems are adversely affected, resulting in insanity; (3) When our nervous systems are affected in this manner, our language behavior and symbolic processes become even more inappropriate to our complex world; and (4) If we change our language and thought patterns—pretraining the children and retraining the disturbed—we can both prevent and cure certain mental disorders by correcting the improper activity of our nervous systems.[6] Admittedly, this is a simplified version of a multi-faceted theory of psycho-physio-logical therapy, but it will provide a convenient and comprehensible notion of Korzybski's reasons for proposing to formulate a non-Aristotelian system.

Reserving for the moment Korzybski's obvious alliance with the "reductionists" regarding physiological explanations of behavioral phenomena and recalling his premises concerning the characteristics of the Aristotelian system, consider the second question: What is there in Korzybski's system that renders it *non*-Aristotelian? To answer this, we should first determine what Korzybski means by the term, "System." His use of the word, system, carries at least two implications. It is a term for a set of "this-is-the-way-things-are-and-you-can't-prove-they're-not" statements, such as the negative premise concerning the non-identity of words and things and the assertions about what exists "inside our skins," and it is a term for a set of prescribed, symbolic antidotes for our apparent, linguistic maladies—extensional devices, consciousness of abstracting, etc.

System, as used by Korzybski, refers to a collection of observations and hypotheses about living, thinking, knowing, and talking. To be a non-Aristotelian system, then, it must go beyond or add

[5]Korzybski, pp. xxiii–xxxv.

[6]*Ibid.*, pp. xxix; 469–536 et passim.

something new and original to Aristotle's collection of observations and hypotheses about living, thinking, knowing, and talking.

On the surface, it might appear that a simple comparison of the two sets of observations and hypotheses would provide a useful answer to the question. Such an approach, however, provides only an incomplete understanding of the relationships between the two systems. A comparison of this sort would be vitiated by the fact that the documents which constitute the so-called "Aristotelian Corpus" are fragmentary, somewhat disorganized, often repetitious, sometimes internally inconsistent lecture notes which probably spent their first three hundred years in the worm infested, mouldy cellars of Asia Minor and Rome. Furthermore, the responsibility for integrating these documents into what was thought to be a unified and consistent body of doctrine, a "system," rests not with Aristotle himself but with the Greek, Syriac, Arabic, Jewish, and Latin–Christian phases of the whole "scholastic enterprise."[7]

Korzybski's itemized list of fifty-two "orientations," appearing in the introduction to the second edition of *Science and Sanity,* provides such a comparison.[8] Presented in tabular form, the two sets of observations and hypotheses are labeled "Aristotelian" and "New General Semantic Non-Aristotelian," and dated 350 B.C. and 1941, respectively. In view of the origin of the so-called Aristotelian system, this use of the extensional device known as dating is false-to-facts. The point is that Aristotelian system 1941 is *not* Aristotelian system 350 B.C. and either system could be called non-Aristotelian when compared with the other.

Rather than examine Korzybski's General Semantics to discover what makes it non-Aristotelian, it seems more appropriate to reexamine Aristotle's orientations to discover what they *are* and not what "scholasticism" has made them. In the course of one reexamination of this type, Randall clearly identifies in the fabric of Aristotelian thinking two central strands that place Aristotle squarely on the side of the general semanticists and in direct opposition to his scholastic editors. The first is his persistent concern for precise talking;[9] the second, his thoroughgoing philosophy of process which prompts Randall to call him the outstanding *functionalist* in the Western tradition.[10]

For Aristotle, what can be said about things is vastly different from the things themselves. This is the same principle that Korzybski illustrates in the map-territory analogy. Aristotle's treat-

[7]John Herman Randall, Jr., *Aristotle* (New York: Columbia University Press, 1960), pp. 22–31.

[8]Korzybski, pp. xxv–xxvii.

[9]Randall, pp. 34–58.

[10]*Ibid.,* pp. 65–67.

ment of entities *(ousiai)* as objects of rational discourse in Books Zeta[11] and Gamma[12] of the *Metaphysics* is consistent with the general semanticists' distaste for "identification behavior." But *ousiai* are also entities in process. It is this "process orientation" concerning the things we talk about that indicates Aristotle's point of view.

The Aristotelian process orientation is closely linked with functionalism, or the "organism-as-a-whole" orientation that permeates the works on biology. Chapter five of Book One in the work, *On the Parts of Animals,*[13] and the entire trèatise, *On Life,* are particularly representative of this point of view. It is clear from these works that, for Aristotle, "Living organisms and their parts are to be understood in terms of how they act and operate *as a whole.*"[14] This facet of the Aristotelian system is far removed from the elementalism reflected in the scholastic interpretations.

Obviously, there are clear parallels between the central strands of Aristotelian and General Semantic thinking. Because of these parallels, the use of the term, "non-Aristotelian," is not only meaningless but unnecessary. The abuse of the Aristotelian system and the heralding of a non-Aristotelian system might be defended on the basis of the superficial distinction between Aristotle's operational behaviorism and Korzybski's physiological reductionism. However, the significant fact is that Korzybski's system is probably more Aristotelian than the system or systems he criticized. Korzybski attacked the "Platonic left-overs" as manifested through scholasticism and not the mature nor the whole Aristotle. Aristotle provides a system that, as Jaeger so conclusively demonstrates, "remains provisional and open in every direction."[15] Korzybski's contribution consists of concrete suggestions for talking-living which are neither "anti" nor "non" Aristotelian but flow naturally from the results of Aristotelian inquiry.

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[11]Ch. 3. 1029a 27, 28.

[12]Ch. 4: 1006b 6–10.

[13]See *De Partibus Animalium* I, Ch. 5: 645b 15–20.

[14]Randall, p. 235 (italics mine.)

[15]Werner Jaeger, *Aristotle: Fundamentals of the History of His Development,* trans. Richard Robinson, 2nd ed. (London: Oxford University Press, 1948), p. 374. Cf. Martin Gardner, "General Semantics" in *Fads and Fallacies in the Name of Science* (New York: George P. Putnam & Sons, 1952).

TWO RARE INCUNABULA IN MILWAUKEE

*Alan D. Corré**

Alverno College in Milwaukee owns two rare incunabula which apparently have not previously been noticed outside the walls of the College, since they are not included in Stillwell's 1940 census of American incunabula.

The first is an edition of the works of Horace with a commentary: *Christophori Landini Florentini in qu. Horatii Flacci libros omnes ad illvstrissimvm Gvidonem Feltrivm magni Federici dvcis filivm interpretiones.* It was printed in 1486 at Venice by Bernadinus, and contains 178 numbered leaves.

The text is printed 20 lines to 110 mm., and the commentary 20 lines to 80 mm. There are 57 lines to a page. The work is bound in boards with clasps. The bottoms of the first and last few pages are worm-eaten.

The colophon reads: Imp̄ssū Uenetiis p māgistrū Bernadinu de tridino ex mōteferrato Anno salutis. M.cccc.lxxxvi || a b c d e f g h i k l m n o p q r s t u x y. Vna q q lra de andictis p qternum unum se extendit dempta y. que qnternū signat.

The book is inscribed at the beginning: Rev. A. Michels, St. Joseph–Convent, Greenfield Park Milwaukee Wisc. South Seid (sic) Office.

I am informed that Father Michels was chaplain to the School Sisters of St. Francis in Milwaukee, who operate Alverno College. He apparently used to purchase books on his trips to Europe, and on his death they were added to the College library.

The last page bears a very faint Latin inscription in ink, including the date 1507 in medieval numerals.

Pieces of a parchment manuscript, apparently liturgical in nature, were used in the binding of the book. Only parts are visible, but phrases such as *Deus qui dedisti legem moysi in sumitate montis synai et in eadem loco paratos. .* are clearly readable. The blue and red inks used are not faded.

On the basis of the above details, we may identify this text with no. 8884 in Ludwig Hain's *Repertorium Bibliographicum* and H386 in Stillwell's 1940 census. According to Stillwell, only Harvard,

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Princeton and the Library of Congress, among libraries in the U.S. possess copies, and as of 1940 there were five more copies in private hands.

The other incunabulum, scarcely less rare, is the 1493 edition of Augustine's *Epistolae,* printed at Basel by Johannes Amerbach: *Liber Epistolarum beati Augustini episcopi hipponensis ecclesiae.* The pages are not numbered. The book consists of 4 blank pages / 394 leaves / 32 leaves of an *annotatio* / 4 blank pages.

The text is printed 20 lines to 85 mm. There are 52 lines to a page. The work is bound in boards (some leather remains) with clasps.

The colophon, which occurs before the *annotatio,* reads: Diui Aurelij Augustini Hipponēsis epi: Liber eplar: uigilanti accuratissimoq stu- || dio emēdatar & impressar: Argumētorū quoq nouor praenotatiōe succincte & di- || lucide expositar: atq opa magestri Iohānis de Amerbach civis Basilien. pfectar: An- || no dni &c. xciij. Foelicita explicit.

The work was apparently closely studied as there are frequent Latin marginal notes in ink.

The title page is inscribed: Bibliotheca conventis S. Lucij Frum Minorum. . prope Heckingam. There are some other faint provenance notes.

This volume may be idenfified with Hain 1969 and Stillwell A 1127. These copies have been reported to the Bibliographical society, and will be listed in the forthcoming new census of incunabula in the U.S.

ICE-WEDGE CASTS OF WISCONSIN

*Robert F. Black**

INTRODUCTION

Ice-wedge casts are the fillings of sand or other material that replace former ice wedges. Ice wedges grow only in perennially frozen ground subjected to marked seasonal temperature changes and where atmospheric humidity is high enough to transfer moisture from the air and snow cover to open contraction cracks in the ground (Leffingwell, 1919; Black, 1952b, 1954 and 1963; Lachenbruch, 1962; Black and Berg, 1963 and 1964). Thus, true ice-wedge casts are diagnostic of permafrost and of cold humid climates. Many ice-wedge casts are easily confused with sand wedges (Péwé, 1959) which grow in cold arid climates or with casts of composite wedges (Black and Berg, 1964) that commonly represent humidities intermediate between those which produce sand wedges and ice wedges. Seasonal frost wedges (Black, 1952b) and solution phenomena (Yehle, 1954) are also easily confused with true ice-wedge casts, but obviously connote markedly different climates and ground conditions.

No criteria are known to distinguish true ice-wedge casts from all other features with 100 percent reliability. Nonetheless, comparison of detailed features of a group of wedge-shaped casts in polygonal pattern with those of sand-wedge or ice-wedge polygons in polar areas permits their correlation. Once seasonal frost and solution phenomena have been eliminated as possible origins, distinction between former sand wedges and ice wedges is based on the fabric of the fillings left behind. As sand wedges grow in increments annually of no more than a few millimeters in width, the criss-crossing bands or layers of sand oriented vertically are generally still retained. In contrast as ice wedges melt or sublimate away, material adjacent and overlying them is dropped into the void vacated. Such filling commonly goes mostly or completely across the width of the wedges and stratification tends to develop horizontally on top of the ice. As lowering of the ice surface con-

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tinues, continued slumping and infilling leave a jumbled heterogeneous deposit of the adjacent walls and overlying material that has distinctive fabric. However, when the overlying material is well-sorted sand, as in dunes, the filling has little fabric and is easily confused with normal sand wedges. Most of the casts of Wisconsin are of such type, but large inclusions of the walls and overlying material in many casts attest to former large voids. Most casts are, hence, believed to be true ice-wedge casts.

Since the fall of 1956, the writer has examined 20 localities containing ice-wedge casts and 2 other known localities are recorded here for completeness (fig. 1) (table 1). All are in

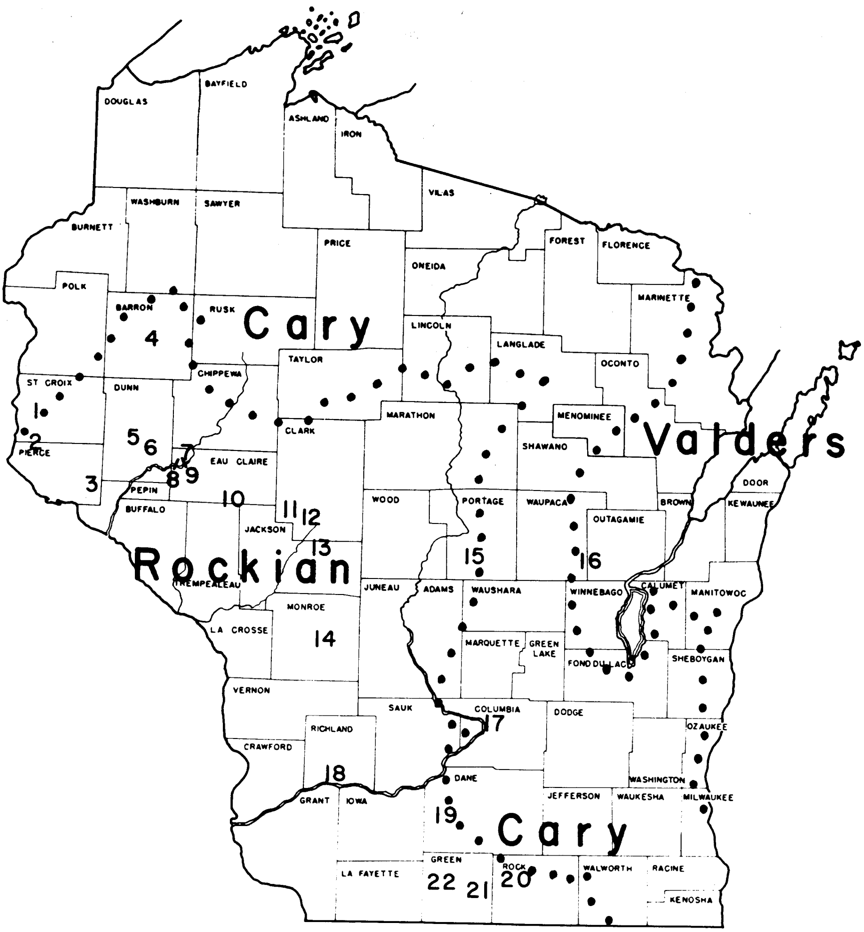

FIGURE 1. Index map of Wisconsin, showing localities with ice-wedge casts by numbers and generalized distribution of late-Wisconsinan drifts.

TABLE 1: LOCALITIES WITH ICE-WEDGE CASTS

1. St. Croix County, New Richmond quadrangle, SE ¼, SE ¼, sec. 4, T29N, R18W; excavation for military construction in till and kame.
2. St. Croix County, River Falls quadrangle, SW ¼, SW ¼, sec. 36, T28N, R19W; borrow pit in kame.
3. Pierce County, Arkansas quadrangle, NE ¼, NE ¼, sec. 30, T26N, R15W; road cut in till.
4. Barron County, Barron quadrangle, SW ¼, NE ¼, sec. 4, T33N, R12W; borrow pit in Cambrian sandstone.
5. Dunn County, Menomonie quadrangle, NE ¼, SW¼, sec. 15, T28N, R13W; road cut in lacustrine sediments.
6. Dunn County, Menomonie quadrangle, NW ¼, NW ¼, sec. 12, T27N, R12W; road cut in Cambrian sandstone.
7. Chippewa and Eau Claire Counties, Elk Mound quadrangle, SE¼, SW¼, sec. 36, T28N, R10W and NE ¼, NW ¼, sec. 1, T27N, R10W; road cut in kame and till.
8. Eau Claire County, Elk Mound quadrangle, SE¼, SE ¼, sec. 17, T27N, R10W; road cut in Cambrian sandstone.
9. Eau Claire County, Elk Mound quadrangle, SW ¼, SE ¼, sec. 16, T27N, R10W; road cut in till.
10. Eau Claire County, Osseo quadrangle, NE ¼, SW ¼, sec. 24, T25N, R7W; borrow pit in outwash.
11. Clark County, Fairchild quadrangle, NE ¼, NE ¼, sec. 4, T24N, R4W; road cut in kame.
12. Clark County, Fairchild quadrangle, NW ¼, NE ¼, sec. 10, T24N, R4W; borrow pit in kame.
13. Jackson County, Hatfield quadrangle, NE ¼, NW ¼, sec. 12, T22N, R3W; borrow pit in outwash.
14. Monroe County, Tomah quadrangle, NE ¼, NW ¼, sec. 7, T17N, R1W; borrow pit in chert rubble and Cambrian sandstone.
15. Portage County, Amherst quadrangle, SW ¼, SE ¼, sec. 7, T22N, R9E; borrow pit in till.
16. Outagamie County, New London quadrangle, SW ¼, SW ¼, sec. 31, T22N, R15E; road cut in till.
17. Columbia County, Portage quadrangle, NE ¼, NE ¼, sec. 33, T13N, R9E, borrow pit in till.
18. Richland County, Muscoda quadrangle, NW ¼, SE ¼, sec. 33, T9N, R1W; borrow pit in outwash.
19. Dane County, Cross Plains quadrangle, SW ¼, SE ¼, sec. 28, T7N, R7E; road cut in loess and Ordovician dolomite.
20. Rock County, Evansville quadrangle, SE ¼, NW ¼, sec. 18, T4N, R10E; borrow pit in kame.
21. Green County, Brodhead quadrangle, NW ¼, NW ¼, sec. 32, T3N, R9E; borrow pit in kame.
22. Green County, Monroe quadrangle, NW ¼, NW ¼, sec. 15, T3N, R7E; road cut in Ordovician shale and sandstone.

Paleozoic bedrock or in glacial drift dating from the Rockian advance of about 29,000 to 32,000 years ago to that of Cary age, perhaps 12,500–16,000 years ago. As of 1965, all but two localities (16 and 17) were confined to the area of pre-Cary drift of southwest Wisconsin—the northern and eastern counties were singularly free of such features. Brief mention of one locality, the first discovered (fig. 1, locality 2), was published early in this investigation (Black, 1957); information on it and 15 other localities was summarized in a report to the VIth International Congress on the Quaternary in Warsaw, Poland, 1961 (Black 1964). As that report is not widely available in Wisconsin and few details were included, those sites are again reviewed here with the newer ones.

This paper attempts to summarize the available information on the ice wedge casts of the state, and on the time and conditions of their formation. Hopefully, this information will spur others into looking more closely at exposures of unconsolidated materials and of bedrock for such features.

Just why such casts were not recognized earlier is not known. Former times of increased frost action and mass movements in the "Driftless area" of southwest Wisconsin have been recognized for decades, although the first review of periglacial or cold-climate phenomena did not appear until fairly recently (Smith, 1949). Smith discussed the products of frost weathering, solifluction, and frost heave which produced block streams, block fields, rubble zones, and talus. Up to that time no casts of ice wedges were recognized in the state. None of the features reviewed by Smith is diagnostic of permafrost conditions, yet permafrost features were recognized to the south in Illinois (Sharp, 1942; Horberg, 1949). There it is thought that sporadic permafrost existed briefly in a relatively narrow zone marginal to the Wisconsinan-age glaciers as evidenced by involutions and ice-wedge casts (Frye and Willman, 1958).

It is now clear that permafrost has existed in Wisconsin, and buried glacial ice survived perhaps 18,000 years in southern Wisconsin and even longer in northern Wisconsin—from the Rockian advance of about 29,000 to 32,000 years ago to Two Creeks time (11,000–12,500 years ago) in southern Wisconsin and until post-Valders time (perhaps 9,000 years ago) in northern Wisconsin (Black, 1964). The available casts indicate ice wedges that required only a fraction of that time to grow, and details of the events and climate of that long interval still remain shrouded in mystery.

Ice-Wedge Casts

Ice-wedge casts are most abundant in west-central Wisconsin and are rarer in south-central Wisconsin. Most casts are in stratified deposits of sand and gravel and in sandy till; none is in truly fine-grained silts normally considered most susceptible to "frost action". The casts are in sandy gravel kames (localities 1, 2, 7, 11, 12, 20 and 21) (fig. 1), in gravelly sand outwash (localities 10, 13, and 18), in sandy till (localities 1, 3, 7, 9, 15, 16, and 17), in rhythmically banded lake clay-silt-sand (locality 5), and in thin bedded rock (localities 4, 6, 8, 14, and 22 in sandstone and 19 in dolomite). More than 200 casts are known; 45 were mapped at one time in locality 2, and additional casts were exposed there as excavation proceeded. Casts were best displayed or were most numerous in localities 2, 4, 7, 10, 13, 14, 15, 16, 17, and 21.

With the exception of localities 19 and 22, all casts are composed of clean, yellowish well-sorted glacial sand in marked contrast in color and texture to the host material; at localities 19 and 22 the filling is loess and colluvium or till. The coarser sand fractions are generally well-rounded to sub-rounded grains of quartz with 10–40 percent of igneous and metamorphic rock and mineral fragments. The finer fractions are generally angular to subrounded grains of quartz with appreciable other minerals as well —typical glacial suites. Frosting of intermediate-sized quartz grains is common. In most instances wind seems responsible for transporting the sand considerable distance to its present resting place.

Most casts are 0.5–2.0 m high in vertical exposures and 0.2–2.0 m wide (normal to the strike of the wedge). The largest casts are 2–3 m wide; the highest 3–3.7 m. In all but localities 5, 6, and 22 the casts occur in groups where a wide range of sizes is observed. The strike of the casts is such that in localities 1, 2, 4, 7, 10, 13, 15, 16, 17, and 21 primary polygons 5–20 m in diameter in plan are outlined by wedges 0.4–2.0 m wide and 1.0–2.5 m high. Secondary polygons 2–5 m in diameter also were seen at localities 2, 7, and 15, outlined by casts of wedges 0.1–0.4 m wide and 0.3–2.0 m high. Excavations at localities 2, 15 and 16 demonstrated that true polygons in plan actually exist. The tops of all wedges (except possibly some of those of locality 16) are truncated by mass movements, and it is not known how large they might have been. No large amounts of the sand typical of the fillings were observed in any of the nearby colluvium, but comparison of casts in locality 16 with others suggests that one-quarter to one-half the original height and width have been removed.

Individual locations where ice-wedge casts have been found are outlined below. All widths cited are maximum measured normal to strike of wedges, not oblique widths showing in many excavations. Heights are true vertical measurements regardless of inclination of casts. Thus, they represent the depth of penetration and not the length of material penetrated. Isolated casts and typical examples of wedges in groups were excavated or augered into the walls to demonstrate their horizontal continuity. Colors are those of the Munsell Soil Color Chart, taken dry unless otherwise indicated. The National Research Council Grade Scale (1947) is used for textural classifications in the sand range. Those sizes in millimeters are:

Gravel	>	2.0	–
Very coarse sand		2.0	– 1.0
Coarse sand		1.0	– 0.5
Medium sand		0.5	– 0.25
Fine sand		0.25	– 0.125
Very fine sand		0.125	– 0.0625
Silt and clay	<	0.0625	–

Descriptions are more complete for the smaller numbered localities than for the higher numbered to avoid undue repetition. Differences are emphasized. Generally detailed descriptions of individual wedges and of samples of fillings are not attempted. At many sites casts are in host materials with stratification that is cut and upturned adjacent to the casts as from pressure effects within the former wedges. Only the striking examples are cited.

LOCALITY DESCRIPTIONS

Locality 1, St. Croix County

Thomas E. Berg discovered casts of six ice wedges in an artificial excavation about seven miles south-southwest of New Richmond. The writer examined them on August 13, 1958. The smallest cast was 10 cm wide and the largest 50 cm; the shortest was 50 cm high and the tallest 130 cm. Outlines of the cross sections of the wedges are shown in figure 2. The tops of all were cut off by mass movement of the surface soil and by plowing on a slope of 7° to the south. The casts were spaced regularly around the periphery of a semi-circular pit, at intervals of 2.3 to 2.9 m. The reddish yellow (5YR–7/6 to 7.5YR–6/6) well-sorted fine- to medium-grained sand stood out in marked contrast to the light reddish brown (5YR–6/4) poorly-sorted till and kame sand and gravel (5YR–5/4 and 6/4 to 5/6). See figure 3 for textural analyses of the wedge fillings (A, B, and C represent casts 1, 3, and 6 respectively) and host materials (D represents till or sandy col-

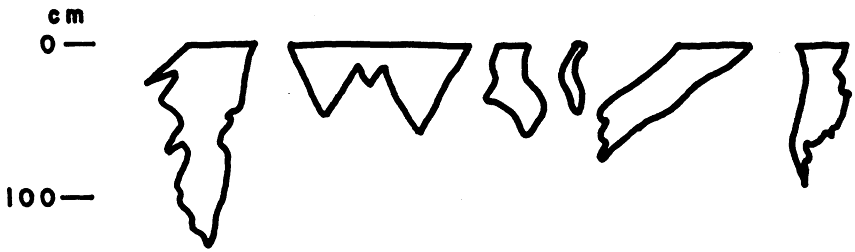

FIGURE 2. Cross sections of ice-wedge casts, Locality 1, St. Croix County.

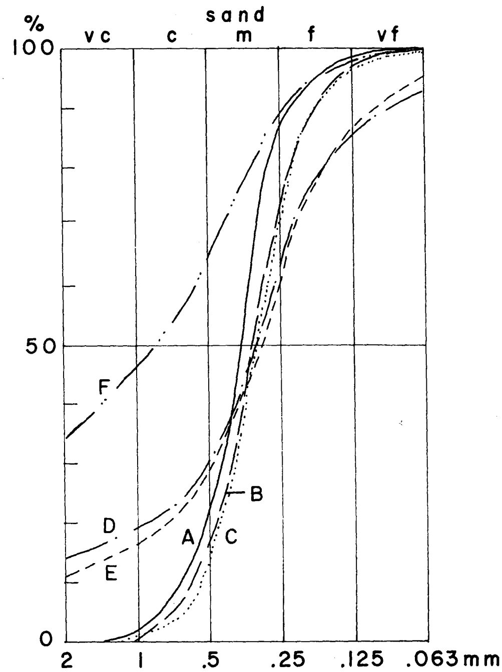

FIGURE 3. Size-grade analyses of some samples from Locality 1, St. Croix County.

luvium and E and F represent sand and gravel in the kame). The general section consists of:

1 m reddish brown gravelly sand and sandy till or colluvium,
65 cm gravel with pebbles up to 10 cm in diameter,
30 cm reddish brown sand from very fine- to coarse-grained,
30 cm gravel to bottom of excavation.

Stratification of the kame was upturned along the casts. Occasional blocks of dolomite and boulders of igneous rocks as large as 1 m in diameter are found on the surface and through the kame. A concentration of 2–3 percent of magnetite and 5–10 percent of igneous minerals other than quartz characterizes the silt and very-fine sand sizes of the wedge fillings and kame sand. Greater rounding and high quartz content characterize the median sizes in contrast to the greater angularity of the quartz in the silt and very fine sand sizes and the high igneous content in both the smaller and larger sizes.

The well-sorted and markedly frosted sand in the casts suggests emplecement by wind action. No suggestion of a source other than the local till and kame sand which it resembles in composition and degree of alteration was seen. As the deposit is on top of the highest hill for many kilometers in all directions, no source can be imagined for lacustrine sand other than that in a lake contained entirely by decaying ice.

Inclusions of till and clumps of coarse sand 2 to 3 cm across and irregular borders of the casts indicate slumping of the sides into a fairly large void—larger than the contraction cracks characteristic of sand-wedge formation. No trace of cracks outside the casts was seen. The implication is that these were ice wedges that were replaced by eolian sand.

Locality 2, St. Croix County

On February 6, 1957, the writer discovered numerous ice-wedge casts in a borrow pit at the junction of county roads M and MM, at River Falls. This locality contained the best-developed network of ice-wedge casts and has been the best exposed of any seen in the state. Figure 4 is a sketch in plan showing strike and width of the casts seen in 1957, and figure 5 shows typical cross sections of the casts. Fillings consist of clean, yellowish red or reddish yellow (5YR–5/6 or 6/6 to 6/8) medium-grained sand in

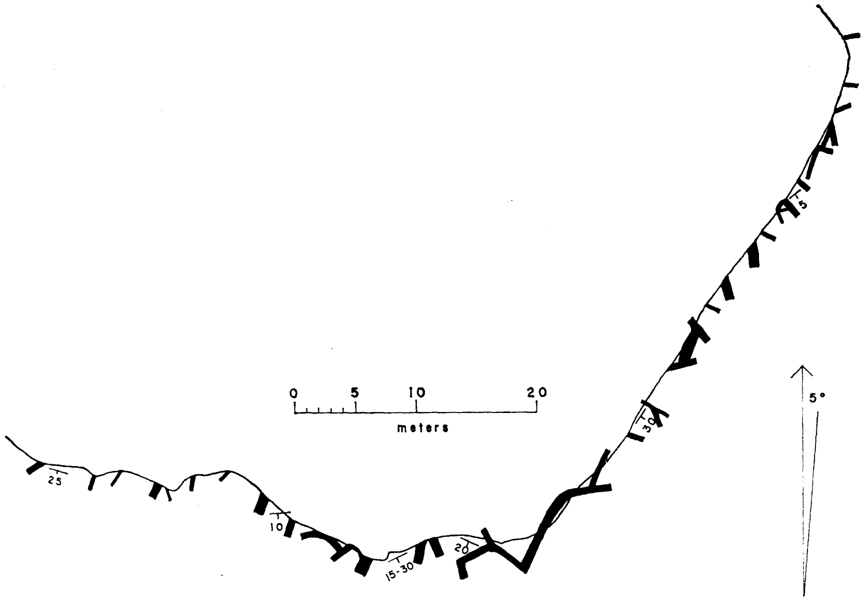

FIGURE 4. Plan view of ice-wedge casts along edge of borrow pit, Locality 2, St. Croix County, showing strike and width of the casts and strike and dip of the stratification.

marked contrast in color (figs. 6 and 7) and in texture (fig. 8) to enclosing reddish brown (5YR–4/4 to 3/4) poorly-sorted, dirty, gravelly sand kame deposits.

On June 28, 1957, when the pit was mapped (fig. 4), the south and east sides of the pit, about 100 m long, revealed 45 ice wedge casts. Wedges in primary polygons 5–10 m in diameter (fig. 4) were 0.4–1.2 m wide and 1.0–2.0 m high; wedges in secondary polygons 2–4 m in diameter were 0.1–0.4 m wide and 0.3–1.7 m high. Upturned bedding from pressure effects during growth of ice in the wedges was plainly visible adjacent to many casts. Colluvium was slumped into the top of several casts. The tops of all casts have been truncated by mass movement and deflation or by current action in a short-lived lake; a prominent stone layer crosses their tops. Loess up to 50 cm thick now covers the stone layer in which ventifacts are common. The borrow pit was worked sporadically after June, 1957, and the original group of casts was removed. Numerous additional casts have been exposed from time to time in plan and in section during stripping and as borrow from the excavation was removed. They showed features similar to the ones described, but slump of side walls and of large masses of overlying material into former large voids was particularly clear.

Size-grade analyses of 13 samples (not in fig. 8) of sand from the casts are shown in Table 2 as averages of individual sizes and

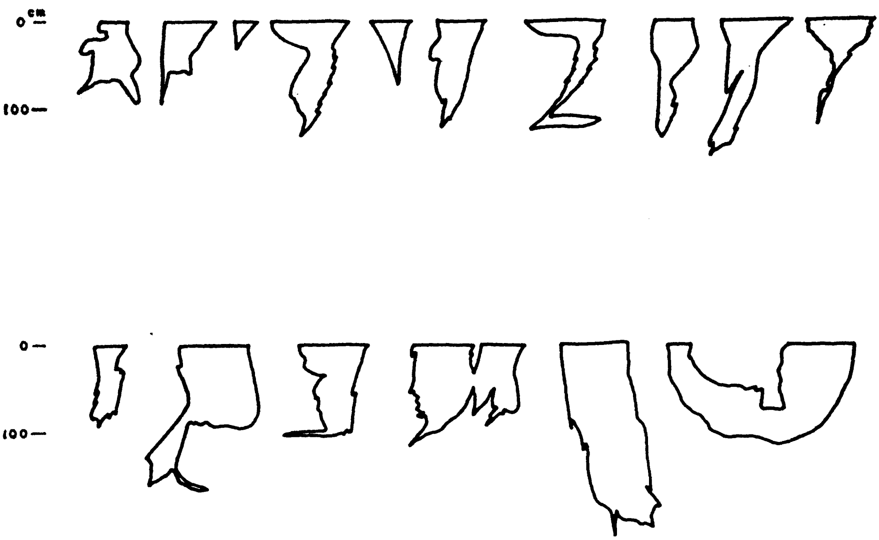

FIGURE 5. Cross sections of some typical ice-wedge casts, Locality 2, St. Croix County.

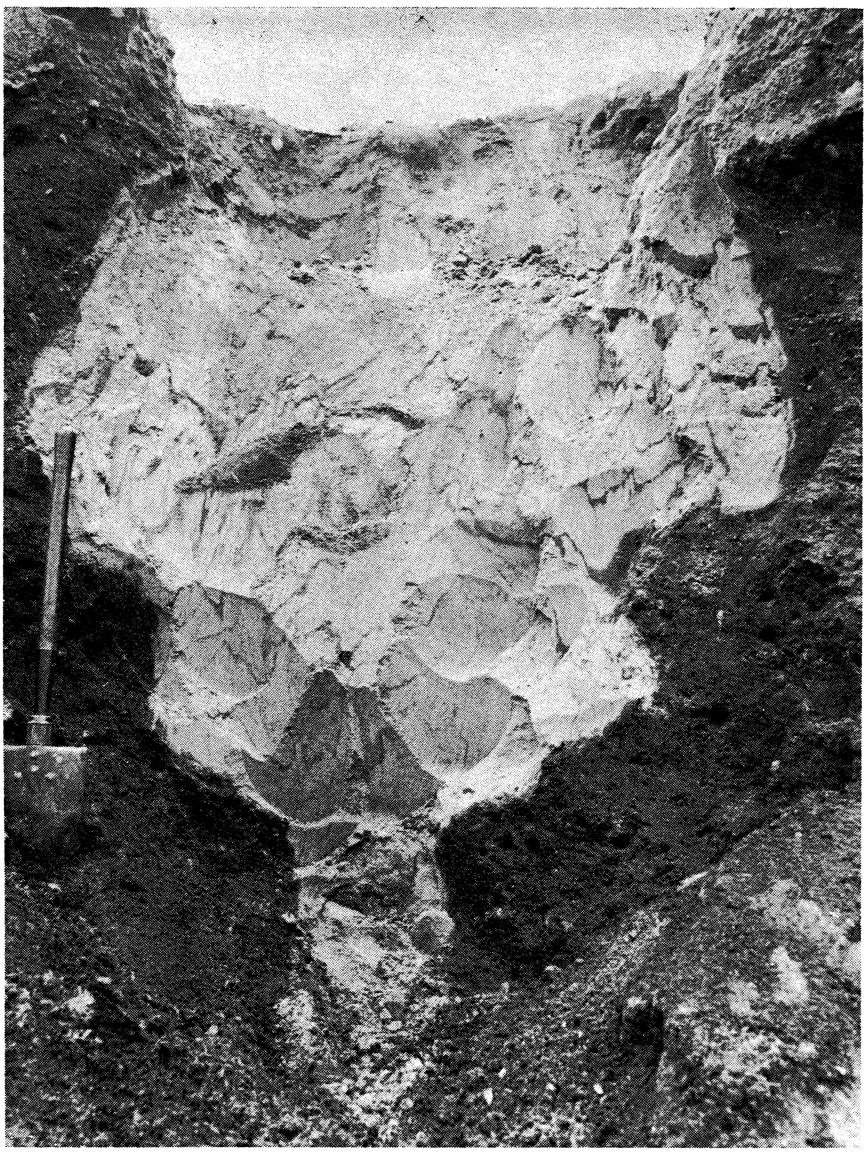

FIGURE 6. Typical large ice-wedge cast, Locality 2, St. Croix County. Shovel is 28 inches long.

as a range of individual sizes. Moreover, the small-size fractions of two samples of the host material are also shown. These data indicate the well-sorted nature of the sand filling which has a median size in the medium-sand range, and which on the

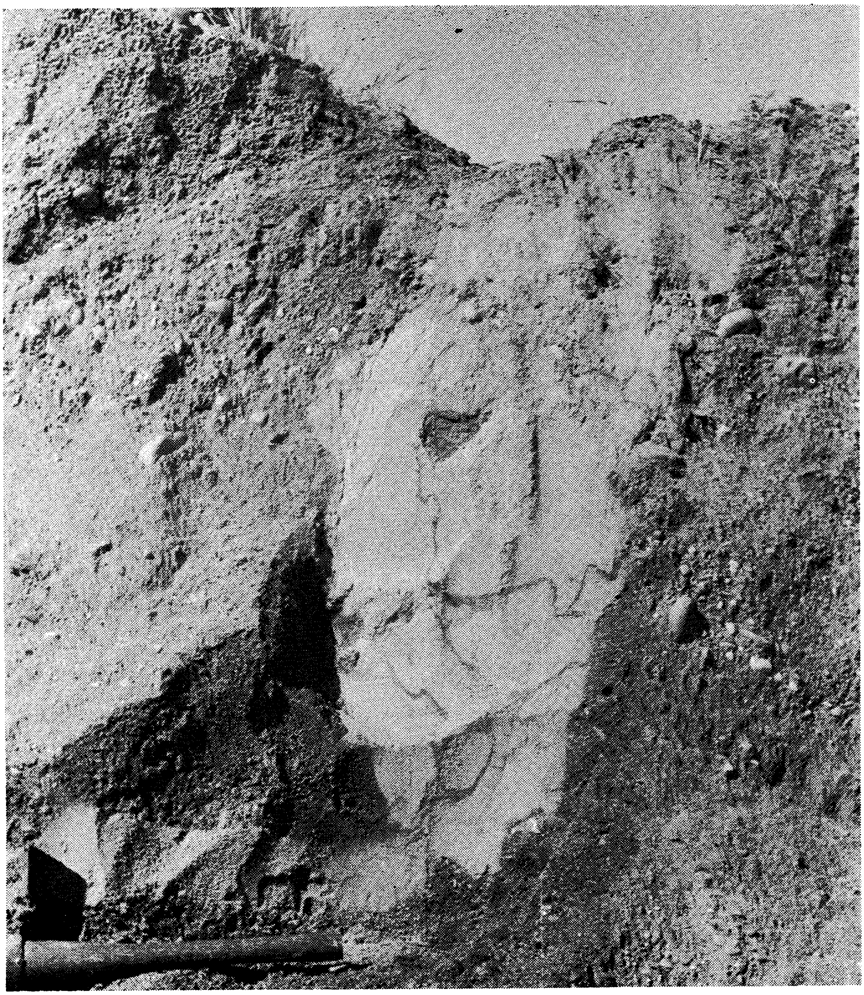

FIGURE 7. Ice-wedge cast with horizontal extension of the base, Locality 2, St. Croix County. Pick handle is 15 inches long.

average is symmetrically distributed around the median. In contrast the same size fractions of the host material are markedly skewed to the coarser sizes.

Binocular microscope examination of individual fractions of the samples from the casts shows that rounding of individual grains is greater in the medium-sand size and decreases toward fine and coarse fractions; more angular grains and more angularity of subround grains are noted at the extremes. Quartz dominates all sizes, on the average, but in some samples igneous rock fragments,

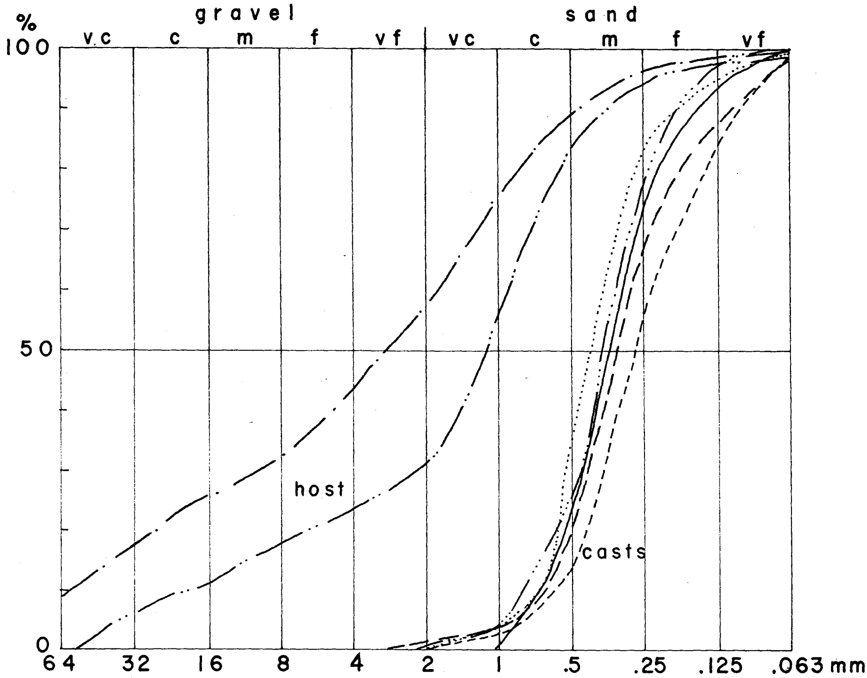

FIGURE 8. Size-grade analyses of some samples from Locality 2, St. Croix County.

quartzite, and siliceous metamorphic rock fragments make up all or most of the very fine gravel size. Various heavy minerals constitute an estimated 5–15 percent of the silt and clay and are 2–8 percent of the very fine sand. In contrast the same sizes from the host material contain less than 1–2 percent of heavy minerals.

TABLE 2

Sizes mm		Average of 13 Samples from Casts Percent	Range of Individual Samples from Casts Percent	Sand Portion of Host Percent	
2–4	v f gr.	0.8	0– 4.3	33.8	14.6
1–2	v c sand.	2.1	0.1– 5.7	29.5	31.8
.5–1	c sand.	20.4	9.5–32.8	20.4	34.6
.25–.5	m sand.	50.3	38.6–60.5	11.2	12.9
.125–.25	f sand.	20.6	10.8–29.9	2.4	3.0
.0625–.125	v f sand.	4.3	1.0–13.5	1.4	1.5
<.0625	silt and clay.	1.0	0.2– 4.3	1.4	1.7
		99.5		100.1	100.1

Rounding of grains in the host material is similar per size fraction to that in the casts. Igneous rock fragments in the coarser sizes make up an estimated 5–10 percent of the total. Iron and clay skins are common in the host material; iron staining in irregular bands or layers and some development of clay skins are present in the casts. All material is oxidized; dolomite fragments are rare in the coarser gravel and blocks of the host and absent in the fines.

The fine- to coarse-grained quartz sand is very similar in size, degree of rounding and frosting to the sand making up the St. Peter formation of Ordovician age which underlies the kame and crops out to the west of the kame. However, the igneous and metamorphic rock fragments and heavy mineral suite of the casts are markedly different from constituents in the St. Peter. The St. Peter formation has less iron and clay skins in this locality and is generally very pale brown (10YR–7/3).

In the casts of some wedges distribution curves of samples from the lower part of the cast, when compared with curves from samples from the upper part of the same cast, show a variation in skewness that is not explained. In most such pairs of samples, the lower samples are skewed to the coarser fraction whereas the upper samples are skewed to the finer fraction. This was not universally true and insufficient samples are available to pursue the matter further.

Whether destruction of the wedges took place beneath a shallow lake, as was postulated earlier (Black, 1957), and fillings came from the lacustrine sediments are still difficult to prove. The existence of the former lake seems clearly established from beach features and other deposits 10–15 feet above the level of the casts. However, similarity of the fillings with those of other localities believed to be due to wind work leaves one in doubt. Moreover, strong wind action is indicated by ventifacts in the stone layer which has slumped into some casts. The timing of wind work versus water work is also yet to be established.

Locality 3, Pierce County

On May 20, 1958, Aleksis Dreimanis (personal communication) saw three wedge-shape casts of sand in buff till near the break of the slope overlooking Plum Creek, one mile southeast of Waverly. He interpreted them as ice-wedge casts. The writer has not seen them, and details are lacking.

Locality 4, Barron County

On May 17, 1964, the writer examined four casts of former ice wedges cutting sandstone bedrock in a borrow pit 1.7 miles south of Barron, on Highway 25. This locality was recognized by John Foss, State College, River Falls. One cast was 3.1 m high and 60 cm wide; another was 1.4 m high and 85 cm wide (fig. 9). The other two were smaller. Curvature of the walls of the pit and the strike of the casts suggest that the larger pair initially joined as one wedge as also did the smaller pair. In the tallest cast 1.2 m of the lower part was filled largely with broken fragments of sandstone from the walls of the cast; the upper 1.9 m was filled with well-sorted reddish brown (5YR–5/4) sand of which 94 percent in the sample is fine- to coarse-grained; median size is 0.36 mm.

FIGURE 9. Ice-wedge cast penetrating Cambrian sandstone, Locality 4, Barron County. Folded shovel is 21 inches long.

Silt and clay make up only 2.1 percent. Occasional pebbles up to 1 cm are scattered throughout the cast. Although frosted quartz predominates, many varieties of igneous and metamorphic rocks and minerals are present in a typically glacial suite. Iron oxide and clay coatings are weakly developed, and mafic minerals are little weathered. Fillings of the other wedges are essentially identical, except that the upper part of the fillings consists of gravelly-sandy till or colluvium that has slumped *en masse* into the upper 30–40 cm. The till exposed in the pit contains boulders to 2 m of ventifacted Duluth gabbro; Lake Superior sandstone, red felsite, granite and many other rocks are present. Quartz grains of the size filling the wedges are not frosted but otherwise similar. Quartz in local Cambrian sandstone is finer grained, unfrosted, and more angular than the sand in the casts, and because of paucity of other minerals and rocks cannot have provided a significant source of the filling. The sandstone is white (10YR–8/2) and various shades of yellow and brown. Presumably wind played a significant role in frosting quartz grains, in sorting of sizes, and in emplacing them in the casts.

Locality 5, Dunn County

On March 28, 1959, the writer saw one coarse-sand cast of a supposed ice wedge in rhythmically banded, lacustrine clay-silt-sand exposed in a road bank of Interstate Highway 94, 2 miles north-northwest of Menomonie. The cast was 15 cm wide and 2.3 m high. The coarse-grained sand filling contained a typical glacial suite of minerals and was distinctly coarser than the enclosing lacustrine sediments. As the ground was still frozen at the time of visit, the cast could only be traced into the bank about 20 cm. The cast bisected the top of a small erosional knoll carved out of the lake sediments by streams established immediately after the draining of the lake. The well-bedded lake sediments were upturned adjacent to the cast.

Locality 6, Dunn County

On March 28, 1959, 6 miles east-southeast of Menomonie, the writer saw one fine- to medium-grained glacial sand cast 1.9 m wide and exposed vertically 1.3 m; the base was buried beneath frozen talus in Cambrian sandstone. The glacial sand is distinctly different in its mineral suite from that of the essentially quartz sandstone. No such glacial sand was seen in the vicinity. The cast was at the apex of a hill, but because of the frozen ground could not be traced horizontally.

Locality 7, Chippewa and Eau Claire Counties

Two miles west of Eau Claire, on the County Line Road, 0.4 mile east of Co. T, Thomas E. Berg recognized ice-wedge casts which the writer mapped and described on July 18, 1959. Outlines of 17 casts are shown in figure 10. The largest was 220 cm high and 110 cm wide; the tops of all casts were cut off at the base of a pronounced stone line which is multiple and inclined 10–12 degrees on the flanks of the knoll. The surface is covered with 40-80 cm of loess.

The casts of clean reddish yellow (commonly 5YR–6/6) well-sorted sand are in marked contrast with the gravelly sand kame and till (commonly yellowish red, 5YR–4/6 to 4/8). Sand in the casts has a median size of 0.2 to 0.3 mm whereas that of the host is 0.6 to 0.8 mm. Typical sorting is shown in figure 11. The coarser sand fraction of the casts has many frosted round to sub-round grains of quartz, but only rarely were similar grains seen in the host. Most grains in the host are commonly sub-rounded to angular. A large variety of rocks and minerals, typical of glacial suites, is present in both host and casts. The very fine sand size of the casts commonly has several percent of heavy minerals. Iron oxide and clay skins are much more abundant in the host than in the casts, but weathering of mafic minerals and rocks is highly variable from fragment to fragment.

Extended trends of wedges show they form primary polygons 5–8 m across and some secondary polygons 3–4 m across. Stratification in the kame is commonly upturned along the sides of the casts.

In August, 1965, numerous ice-wedge casts were seen about two miles northeastward, in the banks of the north-trending road in the center of Section 30, Township 28 North, Range 9 West. These have not been studied in detail but appeared very similar to the other casts at locality 7 just described.

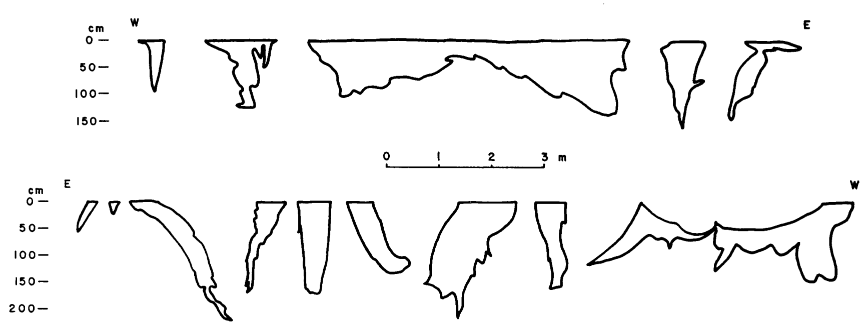

FIGURE 10. Cross sections of some ice-wedge casts, Locality 7, Chippewa and Eau Claire Counties.

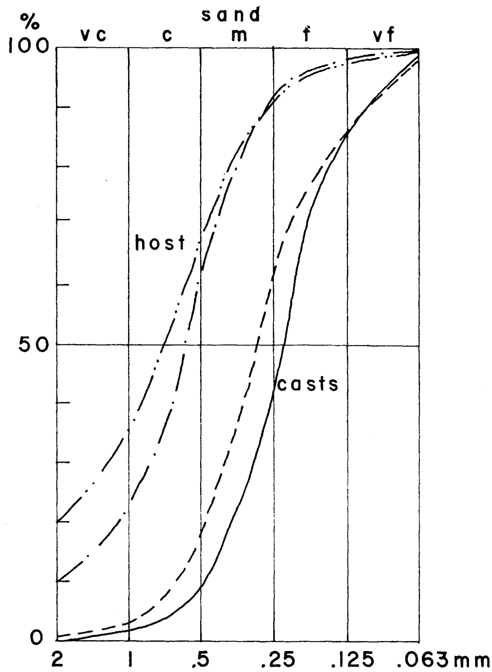

FIGURE 11. Size-grade analyses of some samples from Locality 7, Chippewa and Eau Claire Counties.

Locality 8, Eau Claire County

On March 28, 1959, the writer saw several ice wedge casts filling V-shaped notches in the Cambrian sandstone that outcrops at the apex of a rounded hill 5 miles west of Eau Claire on County Road E. The bedding of the sandstone was upturned in places along the casts from expansive forces in the wedges. Wedges 15–60 cm wide were as much as 200 cm high. Fillings consist of very fine- to coarse-grained, light brown (7.5 YR–6/4) sand similar to that in other casts in Eau Claire County, but more clay skins are seen. The textural distribution of a typical sample is:

	Percent
Fine gravel	1.6
Very coarse sand	1.6
Coarse sand	18.1
Medium sand	42.3
Fine sand	19.9
Very fine sand	13.0
Silt and clay	3.8

The gravel is sub-rounded fragments of the local sandstone; the sand fractions contained abundant (up to 10 percent) igneous rocks and minerals of a typical glacial suite, showing little or no weathering. Quartz in the larger sized fractions is sub-rounded to rounded, but angular in the smaller sized fractions. No frosted grains were seen but they may have been obscured by clay skins.

In contrast the local sandstone is pale yellow (5YR–7/3) with angular to sub-rounded quartz of very fine to fine sand. Glauconite locally makes up a few percent of the total. Because of the difference in size of grains and of lithology, the sandstone can provide only a small part of the total filling. No till was seen in the cracks or on the bedrock on the hill. The upper few decimeters of the sandstone are locally much crumpled and contorted, supposedly from frost action and gravity movements.

Locality 9, Eau Claire County

On March 28, 1959, the writer observed 14 well-defined casts of ice wedges preserved in reddish-brown sandy till on dolomitic sandstone of Cambrian age, 4 miles west of Eau Claire, on County Road E. Widths ranged generally from 20 to 65 cm and heights from 1.8 to 2.2 m. Casts were speced commonly 3–4 m along the road. As the ground was frozen, no excavations were attempted beyond a few centimeters. Samples of the filling showed them to be well-sorted glacial sand similar to other localities in the county. A typical reddish-yellow (7.5YR–6/6) sample shows:

	Percent
Very coarse sand	0.9
Coarse sand	9.6
Medium sand	45.8
Fine sand	26.6
Very fine sand	15.9
Silt	1.2

Clay is absent. Igneous rock and mineral fragments make up 30–40 percent of the coarser fractions which are sub-rounded to rounded grains; the finer fractions are angular to sub-rounded grains. Frosting was not observed.

Again because of texture and lithology the local bedrock can have supplied only a small part of the filling. Slump and slope wash obscure details of the wedges, but pressure effects along the sides of the casts were seen especially where the till grades into bedded kame sands and gravels. The tops of all casts were at a marked stone line, and loess overlying was markedly different from sand in the casts.

Locality 10, Eau Claire County

On August 27, 1959, the writer found several ice-wedge casts of typical well-sorted yellowish glacial sand in a borrow pit in gravelly sandy outwash 5 miles southwest of Augusta. The largest cast was 130 cm wide and 105 cm high. Upturned strata were obvious adjacent to the sides of the casts. Spacing was irregular but for three casts which were uniformly 3 m apart. These have not been studied in detail.

Locality 11, Clark County

On July 17, 1959, the writer noticed several small ice-wedge casts in dirty sand and gravel in small crevasse fills and kames on Cambrian sandstone on Highway 10, 2.5 miles east of Highway 12. The typical yellowish well-sorted sand fills were generally about 30 cm wide and only 60–70 cm high. They were poorly displayed, and have not been studied in detail.

Locality 12, Clark County

Clarence Milfred, on November 30, 1964, informed the writer that he had seen several ice-wedge casts in a borrow pit of poorly-sorted drift 5 miles east-southeast of Fairchild. Wedge-shaped fillings of yellowish sand in the reddish brown drift seem typical, but the writer has not seen them.

Locality 13, Jackson County

On August 27, 1958, the writer saw three ice-wedge casts in relatively clean gravelly sand outwash, in a borrow pit 2 miles southeast of Hatfield. One wedge (fig. 12) was 45 cm wide and 1.5 m high; the other two were 15 cm wide and 1 m high. Their trends and spacing around the periphery of the pit suggest a polygon whose diameter is 15–30 m. Upturned strata along the flanks of the casts were common. Frost-stirred rubble lies on top of the casts and host and has slumped into the upper part of the casts. Fillings (10YR–7/3, very pale brown) are in marked contrast in color to the host (5YR–5/6, yellowish red), but texture and lithology differ only in details. A sample of the typically uniform sandy facies of the host contains 85 percent medium and coarse sand whereas the cast in figure 12 contains 75 percent in the same size range. The cast differs mainly in having almost no gravel and over 17 percent fine sand whereas the host has distinct gravel layers and less than 6 percent fine sand. Both are low in very fine sand, silt, and clay. Lithologically the coarser fractions of the host are dominated by igneous and metamorphic rocks and mineral fragments, but the same fractions of the cast are mostly well rounded to sub-rounded quartz and only 3–5 percent are typically glacial suites. Frosted grains are common in the cast but not the

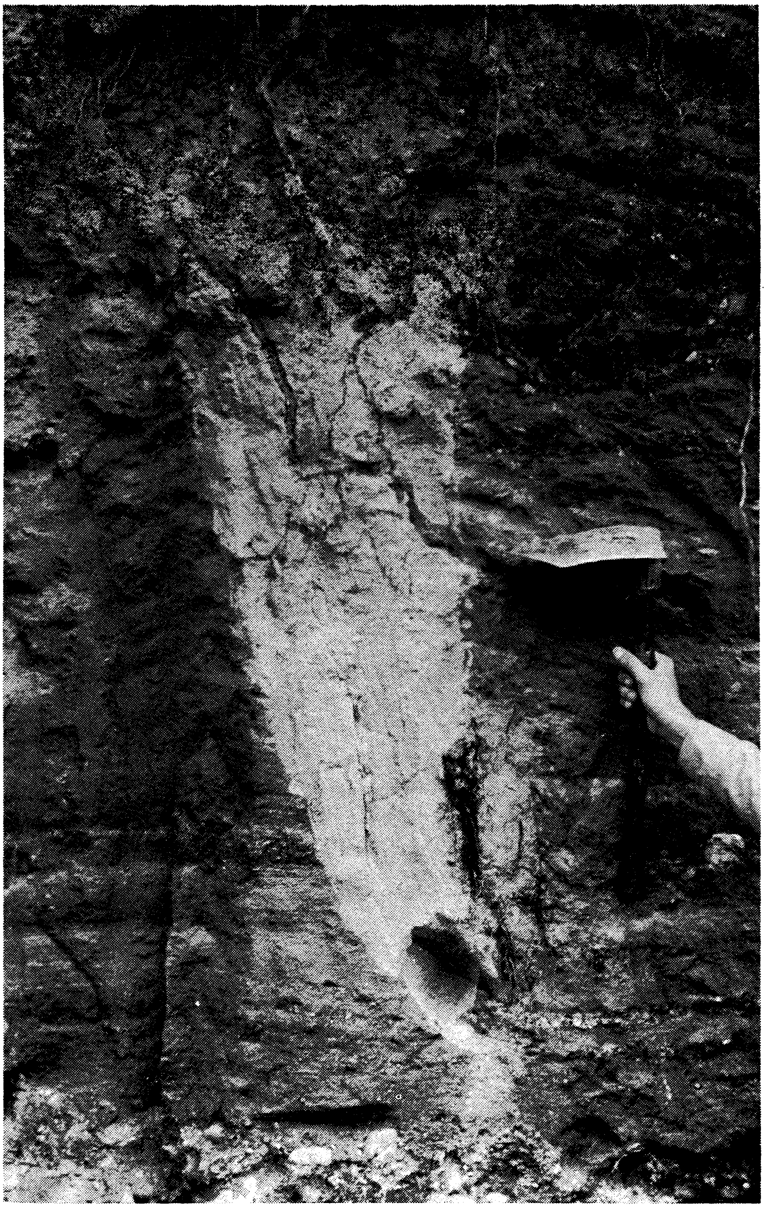

FIGURE 12. Large ice-wedge cast in outwash, Locality 13, Jackson County. Folded shovel is 21 inches long.

host. The color difference is attributed largely to iron oxides and very minor clay skins on the surface of the larger grains in the host.

Although tree roots are utilizing the casts, they have played no role in making them. Excavation shows that the casts are distinctly linear, not circular features such as are produced by solution. Ground water effects subsequent to filling of the wedges, has left iron oxide zones traceable across both cast and host. However, stratification of the host does not carry through the cast.

Locality 14, Monroe County

Ronald H. Akers discovered numerous ice wedge casts in a borrow pit 2 miles west of Tomah and later studied the lithology of the sand and rubble host on the Cambrian sandstone into which the casts penetrated (Akers, 1964, p. 104–108). The writer examined them on July 5, 1963, and sketched the cross sectional outlines of the more exposed ones shown in figure 13. More than 30 casts are present along the walls of the borrow pit. The widest casts are 1.2–1.6 m; the highest 2–3 m. Widths decrease abruptly in the bedrock. The yellow to reddish yellow (10YR–7/6 to 7.5YR–7/6) well-sorted sand in the casts differs markedly in color and texture from the coarser yellowish red (5YR–5/8) sand in lenses in the overlying rubble. Sand in lenses in the rubble is typically medium to coarse, well-rounded quartz with some very coarse sand and gravel of chert and sandstone fragments; less very fine and fine sand and silt and clay are present. However, the casts are mostly fine to medium sand with about 10 percent each of coarse and very fine sand. Very coarse sand or gravel are rare. The larger grains are well-rounded and frosted quartz; the smaller are angular quartz. Fresh green glauconite makes up 1–5 percent of the smaller sizes of the casts but is absent or only a trace in the host sand. The local Cambrian sandstone is very similar to the finer fractions of the sand in the casts, including the glauconite, and presumably was the source. The host sand and rubble contain plagioclase, potash feldspar, and calcium-magnesium carbonate (Akers, 1964, table 16) and seem to have supplied relatively little of the filling for the casts.

Locality 15, Portage County

On May 31, 1958, more than 25 ice wedge casts were observed in a borrow pit in the Arnott moraine, 9 miles southeast of Stevens Point. The casts are as much as 1.8 m wide and 2.6 m high. They have been examined at different times during sporadic working of the pit, and cross sectional outlines of some were sketched (fig. 14). The reddish yellow to yellowish red (5YR–6/6 to 5/6) sand

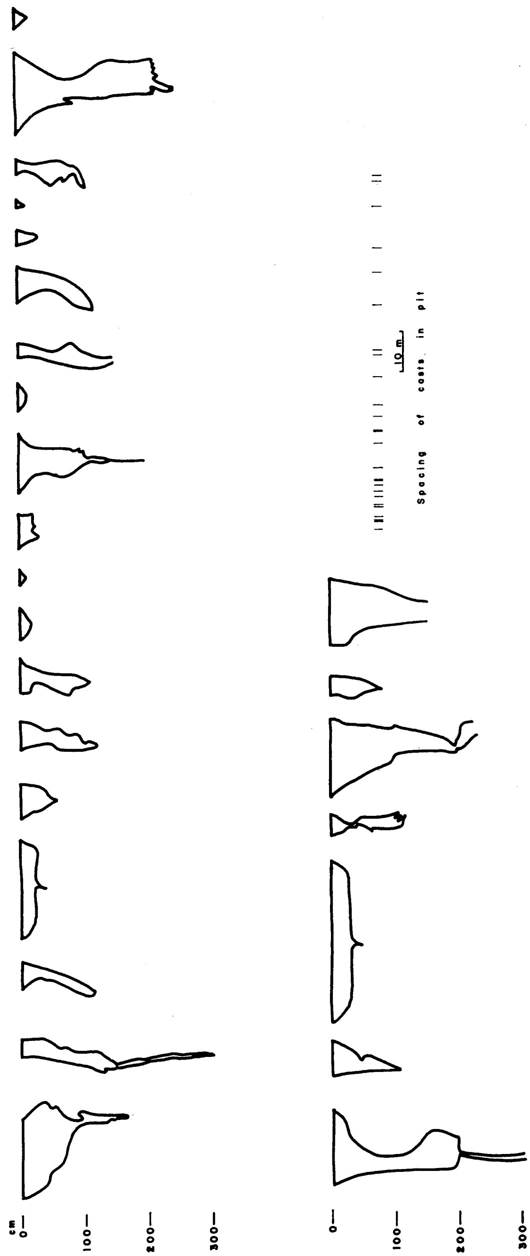

FIGURE 13. Cross sections of some ice-wedge casts, Locality 14, Monroe County.

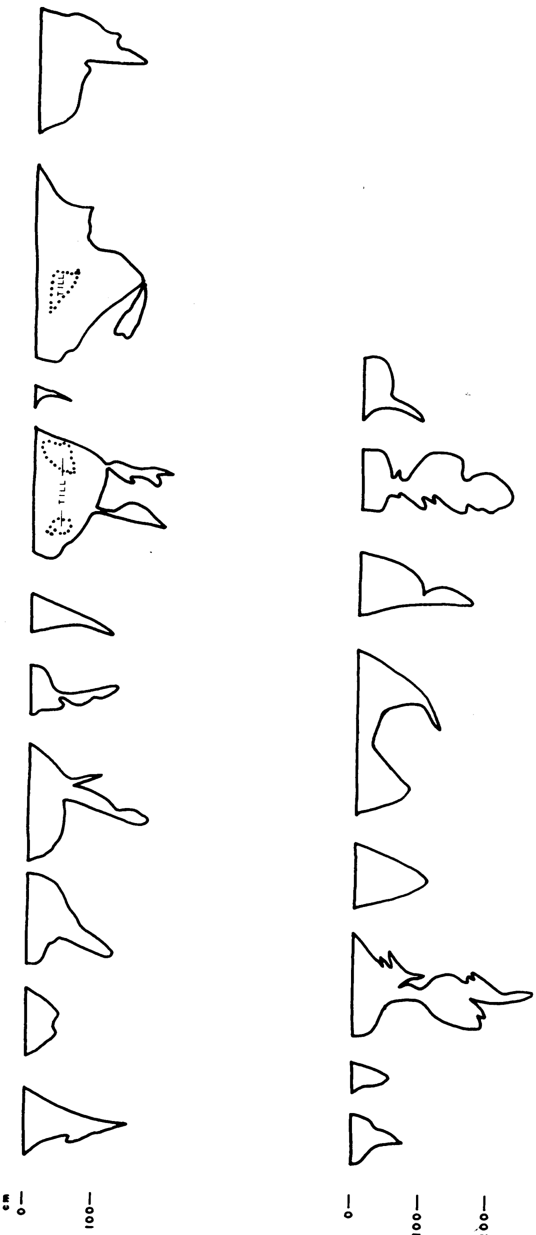

FIGURE 14. Cross sections of some ice-wedge casts, Locality 15, Portage County.

in the casts differs from the red to light reddish brown (2.5YR–4/6 to 5YR–6/4) sandy till of the host mostly in texture. Representative size analyses of four samples of the casts and two of the host are shown in figure 15. Gravel larger than 10 mm in diameter and numerous boulders of granite 1–2 m in diameter in the till are excluded from the curves. In the casts generally 80 to 90 percent of the sand is fine to medium; the curves are skewed toward the coarse fraction. Granules of angular disaggregated granite are common in the casts. Very little silt and practically no clay occur in either casts or host. The sand of the casts contains a typical glacial suite of rocks and minerals, but glauconite is common in the very fine fraction. Quartz is only 10–20 percent of the very coarse fraction; most grains are igneous rocks of wide variety. Quartz dominates the smaller fractions.

This pit contains pockets of sand in wedge-like form at depths that suggest roots of truncated casts. Their color, texture, and lithology are indistinguishable from those of the surface casts. Several are at a slight discontinuity in the till shown by a color change from red above to light reddish brown below and by slight

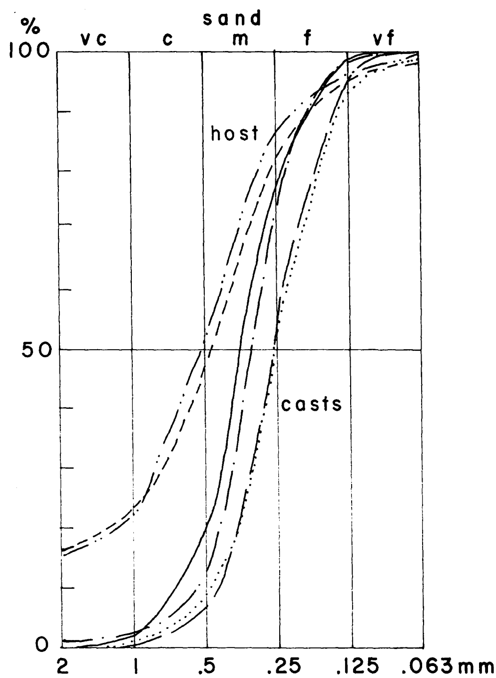

FIGURE 15. Size-grade analyses of some samples from Locality 15, Portage County.

differences in pebble counts. Textures (fig. 15) in the till and in the casts above and below are identical. However, it seems clear that the upper casts do not penetrate that discontinuity nor do they join or cut the lower casts. Too little information is in hand to pursue the problem of two generation of wedges; it remains a possibility for which much additional work needs to be done.

In 1958 one wedge cut in half a disaggregated granite boulder at a depth of 1.6 m. The width of the cast decreased abruptly from many decimeters in the till above to only a few centimeters within the boulder. It has since been removed.

The near surface wedges have all been truncated. Ventifacted stones are common.

Locality 16, Outagamie County

On November 7, 1964, Fred Madison showed the writer the tallest ice-wedge casts seen in the state, at the junction of County D and TT, 4 miles south of New London. Two wedges were 3.1–3.7 m high and 1.0–1.1 m wide. They were traceable from the face of the roadcut across the stripped upland for 5–10 m, and with a third wedge indicated a polygon of about 10 m diameter. Slump features on the sides and patches of reddish brown sandy till with flow structures crossed at least half the width of the two wedges, but the lowermost tip of one showed vertical foliation and separated crack fillings typical of an original sand wedge. The fillings of well-sorted very fine to fine sand were reddish yellow (7.5YR–6/6) to strong brown (7.5YR–5/6 to 5/8) in contrast to the reddish brown (2.5YR–5/4) till. Samples of the lower and upper part of the tallest cast and a third from the lower part of the adjacent wedge contain 61–67 percent fine, 19–27 percent very fine, and only 9–11 percent medium sand. Coarse and very coarse sand and gravel constitute together 1–4 percent. In contrast overlying sand several decimeters thick of eolian or lacustrine origin that seems to have slumped into the upper part of the wedges is slightly different. One composite sample contains 54 percent fine, 9 percent very fine, and 35 percent medium sand. The very coarse sand and gravel scattered throughout the casts is absent in the overlying sand and only 0.3 percent coarse sand is present. In all samples only 1–3 percent silt and virtually no clay are present. Typical glacial suites of rocks and minerals are present in all, but igneous rocks are less abundant, more rounded, and fresher and cleaner in the overlying sand than in the casts where they are typically very angular and corroded. It seems clear that the immediately overlying sand is distinctly coarser, more mature, and has not supplied as much of the filling as was thought on brief field examination. Appreciable glauconite in the finer sizes suggests a Cambrian sandstone source rather than the till host.

Numerous other casts are present in the vicinity of the junction of County D and TT and for 0.75 mile northward on County D, particularly on the west or Waupaca County side of the highway. All are smaller; some are 1.8–2.4 m high and 20 to 60 cm wide. Those to the north are truncated at a depth of 1–1.2 m. Several joined in polygonal network as seen in plan on the sloping road bank. They were not examined in detail nor sampled.

Locality 17, Columbia County

On June 13, 1961, the writer saw four ice wedge casts in the top of a drumlin 1 mile north of Portage. They appeared in the walls of a borrow pit in the apex of the rather sharp oval hill of reddish-brown sandy till. By April, 1962, the pit had been enlarged considerably but the same wedges could be identified and another new one showed up. The extensions of the four casts were smaller than those originally seen. One was 1.8 m high and 1.1 m wide; another was 1.5 m high and 70 cm wide (fig. 16); the other two were somewhat smaller. Spacing between three wedges in the southwest part of the pit was 3 m, but other walls 15 m long of the borrow pit showed no casts. Slump features and till masses extending diagonally across much of the width of two casts distinctly showed large linear voids existed that were not just oriented downhill. Mixed loess and colluvium 30–90 cm thick covered the top of the casts which are well-sorted reddish yellow (5YR–6/6) very fine to medium sand. The till host is light reddish brown (5YR–6/4), sandy, and with igneous boulders up to 1.5 m in diameter. Only a few percent of the sand in the casts is typical glacial suite of igneous rocks and minerals. That and the relatively high proportion of glauconite in the finer sizes suggest a Cambrian sandstone source.

Locality 18, Richland County

On October 4, 1964, two small casts of supposed ice wedges were seen in a gravel pit about 0.75 mile south of Eagle Corners. One was about 30 cm wide and 50 cm high; the other only 10 cm wide and 40 cm high. Both are filled with very clean reddish yellow, very fine to medium sand and are in brown silty-clayey sediments showing marked cryoturbations (?) nearby. The casts were dug out enough to demonstrate their linearity, but no detailed study has been done.

Locality 19, Dane County

One mile southwest of Pine Bluff, several wedge-shaped fillings of loess and colluvium in dolomite of Ordovician age appear along

FIGURE 16. Ice-wedge cast, Locality 17, Columbia County. Exposed handle of shovel is 20 inches long.

the county road. These are typical and are cited as just one example of many such features that are to be found in thin-bedded rock in the state. Very locally pressure effects may be seen along the sides of the casts which generally are 30–100 cm wide and 60–120 cm high. Casts are spaced at fairly regular intervals of 3–4 m along the road. In many instances they seem to form polygonal patterns in plan. These particular casts have not been excavated more than a few decimeters and their origin is in doubt. It is thought likely that contraction cracking from cold and dissication would permit preferential solution and soil tonguing to operate. Subsequent wetting and drying of the filling then could produce the local pressure effects without the necessity of calling for ice wedge formation.

Similar wedge were reported earlier (Black, 1964, loc. 16) in Green County, but are not described here because of their dubious origin.

Locality 20, Rock County

Several casts of reddish yellow, clean, well-sorted, fine-medium sand are seen in the banks of a borrow pit in a dirty sandy gravel kame which rises 15–20 m above the surrounding lowland 3 miles northwest of Evansville. A stone line truncates the tops of each of the casts which are poorly preserved in the slumping bank. Several wedges have been discerned 30–60 cm wide and 40–100 cm high. Only two have been excavated as much as 2 m into the bank to establish their linearity. Slumping of the gravel into the wedges has left them very irregular. No detail work on them has been done, but they seem to be typical ice-wedge casts.

Locality 21, Green County

On April 14, 1962, the writer noted the truncated casts of four former ice wedges in a gravel pit in a kame about 2 miles southwest of Albany. Two casts on the east flank are especially striking although small; one is 40 cm wide and 115 cm high, and the other is 35 cm wide and 125 cm high (fig. 17). The well-sorted sand casts are reddish yellow with strong brown, iron-cemented streaks (7.5YR–6/6 to 5/6). The former was dug out along the surface for a distance of about 4 m and continued uninterrupted. Samples of the upper and lower parts respectively of the latter cast are 59 and 64 percent medium, 30 and 19 percent fine, and 8 and 12 percent coarse sand. Only traces of larger and smaller sizes are present. A typical suite of glacial sediments is present, but glauconite suggests the Cambrian sandstone influence in source also. In contrast the sand lenses with horizontal bedding in the host kame are coarser textured. One that underlies the cast contains 55 percent coarse and 41 percent medium sand which is yellowish red to reddish brown (5YR–5/8 to 4/4). The sand in the gravel is still coarser and darker (5YR–4/8 to 3/4). Clay skins are abundant.

At the extreme south end of the pit, 100–300 m from the casts, fine sand is bedded parallel to the slope of 5–15 degrees. It is 0.5–1.2 m thick and suggests a climbing dune from the south. Unfortunately the area is much disturbed through dumping of trash, and the field relations are not clear. In the area of the casts 0.5–2.0 m of loess and colluvium cover the truncated casts.

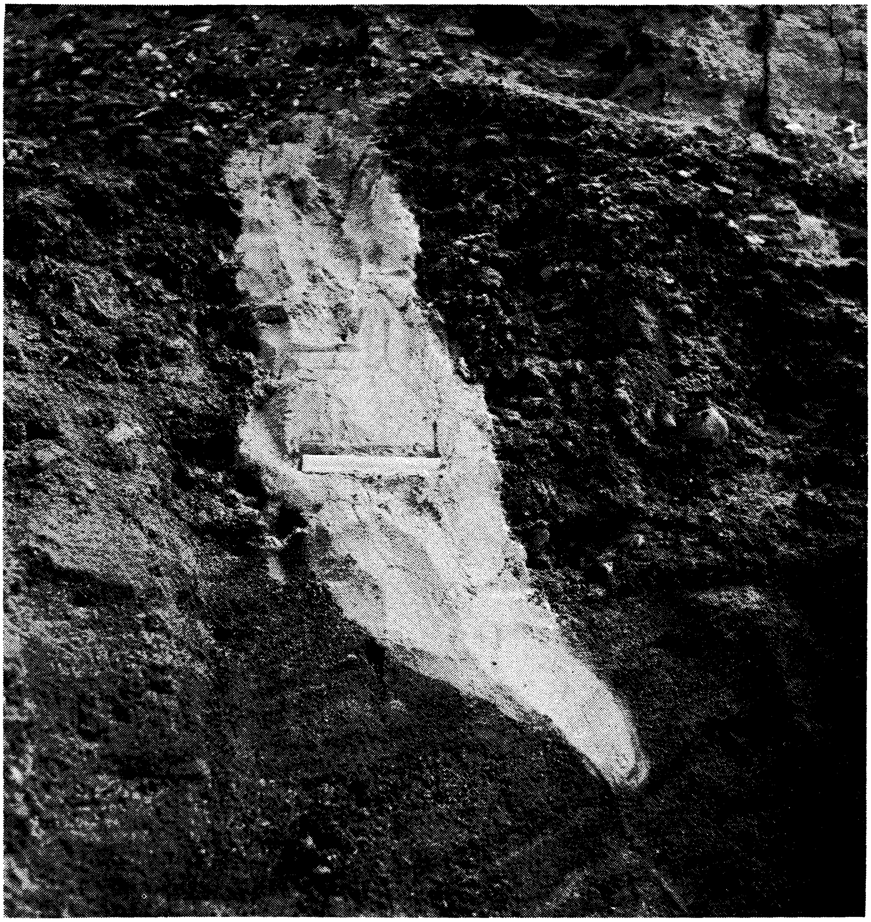

FIGURE 17. Ice-wedge cast, Locality 21, Green County. Six-inch scale.

A worker who was involved with the opening and working of the original pit stated that the wedges of sand were much larger and more common along the axis of the ridge of kames.

Locality 22, Green County

On June 5, 1961, the writer saw a wedge-shaped filling in a road cut at the junction of County N and C, 3 miles west of Monticello. Basal variegated shale and sandstone beds of the St. Peter formation of Ordovician age are contorted along a northeasterly axis which is cut obliquely by a wedge-shaped filling that is 55 cm wide and 80 cm high. The filling of poorly-sorted reddish brown (5YR-5/3 to 4/4) colluvium or till contains some clay, abundant silt and sand up to coarse size, and granule size fragments of shale and dolomite. It is very hard and compact when dry. The horizontal axis of the wedge is oblique to slope and structure and is difficult to explain. Upturning of the St. Peter bedding planes along the wedge demonstrate pressure effects, but proof that this feature was an ice wedge is not available.

Mode of Formation

If it is conceded that large till or drift patches that cross much if not all the width of many casts and that horizontal or diagonal bedding and flow structures are proof of filling of voids essentially the size of the wedges, then most casts were true ice wedges initially rather than sand wedges. At least the development of seasonal frost wedges and solution phenomena seem not to be applicable, and no alternative origin comes to mind. Rarely, as at localities 14 and 16 particularly, the lowermost tip of some casts indicate possible sand wedge growth initially. At least vertically oriented cracks up to a few millimeters in width are filled with sand and cut the host as in active sand wedges in Antarctica. Yet those same wedges have typical large inclusions and slump structures in the middle and upper parts and must be considered true ice-wedge casts or at least composites with more ice than sand.

If we accept the ice-wedge origin initially, then we must account for the remarkable similarity of the sand filling the casts in 20 of the 22 localities (filling at localities 19 and 22 are loess and colluvium or till). Such similarity suggests uniform conditions throughout the state during the replacement of the ice by the sand and also a single or common mode of emplacement. Although a lake can be demonstrated to have inundated locality 2, lakes with such uniform bottom sands cannot be demonstrated for the other localities which commonly are on the highest land in the area. The textural analyses, rounding, frosting, and mineral distribution point toward wind as the agent of transportation that brought the sand to the casts. However, the situation is still somewhat perplexing because sand identical to that in any one cast is not now found on or anywhere in the vicinity of any cast (at locality 16 the sand is somewhat different and at locality 21 sand 100–300 m away has not been studied.) Stone lines show marked truncation of all casts, except possibly some of those at locality 16, but such sand is not found in the colluvium or soils nearby. Where has it gone? Or was it ever widespread? We don't really know.

Composition of the sand suggests multiple sources, particularly the local drift surface and the Cambrian–Ordovician sandstones. The amount of contribution from each source is not known but seems to differ somewhat depending on the locality. We seem to have no problem getting the sand in the first place, but concentrating it in the casts without building up deposits nearby is difficult and not explained. In order for such large fillings with so little contamination to form, one would expect to see dunes over the casts as at locality 16. Migrating dunes would permit textural and mineralogical variations at any one cross section such as seem to have taken place there. If such dunes were more commonplace on and near the other localities, the writer would feel better about the situation.

In addition the uniformity of filling in the casts from top to bottom indicate that surface conditions did not change appreciably during the emplacement. Fillings worked downward and laterally with remarkably little contamination from the walls of many inclined casts or those whose lower apices were almost horizontal as in figure 7. Flow structures of till and other patches of unconsolidated material or stratification indicated water was present. The details of the filling mechanism are obviously open to various interpretations.

From these few observations and conclusions it is readily apparent that details of the origin of the casts, require many more observations before any definitive answers are likely to be forthcoming.

Time of Formation

We do not know either the time when the original ice wedges were formed nor when they were destroyed and replaced with sand. No definitive criteria even suggesting their time of formation have been found. At the present time we can do no more than suggest a time by analogy—that is by parallelism of events or changes of climate. This procedure is fraught with difficulties and leaves much to be desired.

The climatic changes of the late Pleistocene in Wisconsin are not known in detail, but the broad pattern is recognized (Frye, Willman, and Black, 1965; Black, Hole, Maher, and Freeman, 1965). We know that permafrost does not exist anywhere in the state today and that filling of the casts ceased long enough ago for all to develop weak-moderate stains of iron oxide and clay skins at former groundwater levels or levels of wetting and drying. These require presumably only a few centuries or millenia, but do not exclude a time encompassing many millenia. The presence of fresh easily weathered rocks and minerals, including glauconite, olivine, pyroxene, amphibole, and calcic plagioclase, suggest a relatively short but vague time since replacement. Truncation by colluviation and mass movements is extensive and universal; such processes are going on today at least locally, but most casts are protected by a cover of loess. Hence, truncation of the casts largely ceased prior to the deposition of the bulk of the loess over them. Unfortunately loess deposition seems to have been continuous in many places beginning about 29,000 years ago up to the present day, and cannot be used as a time indicator. Thus, we have no good clue when replacement ceased, although it seems to have been some thousands of years ago.

At the opposite extreme the age of the material in which casts are found defines the maximum limit for a wedge. Most casts are in Paleozoic strata or drift of Rockian age—29,000 to 32,000 years ago—but casts in two localities (16 and 17) are in till considered Cary in age, about 12,500 to 16,000 years ago. (The Valders ice advance of about 11,000 to 9,500 years ago either went over or around locality 16, but the till in which the casts are found seems typical of the Cary rather than the Valders. The Cary ice closed around but apparently not over the hill at locality 1.) Those casts in Cambro–Ordovician bedrock without drift cover of Rockian age have loess filling that is less than the maximum age found in the state (29,000 years old; Hogan and Beatty, 1963) based on the degree of weathering. Consequently, no wedge formation is considered as old as the Rockian advance, with the possible exception of the buried and truncated wedges (?) at locality 15. It seems clear that the Rockian ice advanced over a spruce forest, but no trace has been found that trees grow again in the state until Two Creeks time, about 11,000 to 12,500 years ago. The interval from 12,500 to about 29,000 years ago seems then to be the logical time for growth of the original ice wedges. However, the wedges need no more than a few thousand years at most and more likely only 1,000–3,000 in which to grow to their present size when compared with growth rates of ice wedges measured in Alaska and Antarctica (Black, 1952a and 1963; Black and Berg, 1963 and 1964). It seems reasonable then to assume that most wedges grew at about the same time during a particularly cold period that logically would be related to a glacial advance.

In Illinois the Farmdalian Substage of deglaciation spans much of the early part and the Woodfordian Substage of multiple ice advance and retreat the latter part of the time from 29,000 to 12,500 years ago (Frye and Willman, 1960; Frye, Willman, and Black, 1965). The peak or maximum extent southward of ice in the middle United States during that interval seems to have been about 20,000 years ago (Flint, 1963). It is not axiomatic that permafrost conditions in Wisconsin were most severe at precisely that same time, but they can be presumed to be because of the southward shift in storm tracks that should have accompanied the southward flow of ice. Such a southward shift would be brought about by the ice in the Des Moines lobe west of Wisconsin and the Lake Michigan lobe east of Wisconsin. Those lobes left central and southwest Wisconsin free of ice where the Rockian drift had been 10,000 years before. Almost continuous cold high pressure air would have existed over the area of the ice sheet, leaving the relatively small reentrant in Wisconsin largely outside the zone of influence of the moist air from the Gulf of Mexico, which supplied the bulk of precipitation to the state. Hence, it is expected that winters would be very cold and with relatively little snow; summers would be cloudy from overrunning Gulf air but still cold. Permafrost conditions would be optimal. They would last at their peak only a few thousand years.

In theory this might explain the origin and time of formation of the ice wedges in the Rockian drift, but not those of the two localities in the Cary drift. No evidence that they are in older drift overrun by the Cary ice has been found. Whether permafrost was able to develop locally in connection with the Valders glaciation is not known, but climatic changes during that time seem not to have been so severe (West, 1961). Both locations are high, wind swept, and near former lakes associated with the Valders retreat; sporatic permafrost seems possible and a ready supply of sand was available. Not all other localities were, however, and no case can be made to have all wedges produced so late in the Wisconsinan Stage. At least two times then—20,000 and about 10,000 years ago—seem most likely for permafrost and ice wedge formation, but presumably other climates were such as to have permitted sporadic permafrost to develop.

Destruction of the ice wedges and replacement with sand is even more difficult to place into proper time sequence. Glaciation and cold climates are in general a smaller part of the interval from 29,000 years ago to the present than are warmer climates without permafrost conditions. Although buried glacial ice from the Rockian glaciation seems to have survived in southern Wisconsin until Two Creeks time, as in the buried bedrock valley now containing Lake Geneva, and in northern Wisconsin until after the Valders glaciation, such deeply buried ice masses melt out very slowly. They would have no affect on the formation of ice wedges nor on their destruction. Only climatic conditions would have been important. A ready supply of sand, wind, and rapid thaw of the ice wedges are required. Abundant vegetation, particularly forests, would not favor the sand fills, but prairie conditions could. Hot dry summers seem to be called for to promote melting and evaporation. We cannot pinpoint one or more such periods with much assurance, and the arguments are very tenuous (West, 1961). At our present state of knowledge we can do no more than suggest that destruction of those wedges that might have been produced 20,000 years ago could easily have accompanied the climatic changes of the late Woodfordian (Frye and Willman, 1960) or following the Tazewell–Cary substages; those possibly produced during the Valders must have accompanied the destruction of that ice for no indicators suggest any permafrost existed in the state after that ice disappeared. Such unsatisfactory chronology does not tell us whether wedges were produced at different times in the area of the Rockian drift or were destroyed during more than one period.

Paleoclimatologic Significance

As ice wedges grow only in permafrost and permafrost forms only where the mean annual air temperature is close to or below 0°C, a marked change in the climate of Wisconsin must have taken place for mean annual air temperature today is about 5–7°C. An analogy with ice wedges growing today in polar regions, where their growth rates can be compared with their physical environment, is interesting (Black, 1954 and 1963; Black and Berg, 1963 and 1964; Lachenbruch, 1962). Without going into the many details or exceptions it can be said that primary and secondary networks of ice-wedge polygons are generally found only in continuous permafrost where mean annual air temperatures are generally colder than –5°C. Ice wedges are growing more readily in fine-grained materials with high moisture contents and are less common and poorer developed in the sandier and more permeable materials which characterize the hosts in Wisconsin. Lack of casts in frost-susceptible materials can be contributed not to the absence of wedges, nor to the climate, but perhaps to concurrent flow and collapse of the host material during melting of the ice which prevented formation of wedge-shaped voids that could collect sand. Consequently we can conclude that the well-developed networks of primary and secondary polygons in western Wisconsin represent continuous permafrost with annual ground and air temperatures at least as cold as –5°C; the less well developed nets of primary polygons and isolated wedges in southern Wisconsin call for discontinuous to sporadic permafrost with ground and air temperatures slightly warmer than –5°C. Humidity was higher than that which characterizes much of Antarctica where so many sand wedges are growing actively. No quantitative values can be given at this time because they are not known well enough for existing wedges.

The shape of the wedges can at times or certain places be related to rapidity of seasonal temperature charges in the ground and consequently to climatic conditions. Short wedges that have not been truncated indicate only a shallow penetration of the seasonal temperature cycle whereas deep ones prove that large temperature changes carried to those depths. It seems necessary to have a rapid seasonal change in ground temperature of at least 4°C to initiate contraction cracks and changes of at least 2°C to propagate them to depth where the ground has more ice than pore space—that is where mineral matter is a suspension in ice. As thermal coefficients of rock are only about one-fifth that of ice, correspondingly greater temperature differences are needed to affect cracking in under-saturated sediment or rock. Rapidity of temperature change is perhaps equally important as total change in initiating cracking. At least relatively long cold periods of many days are required to permit loss of heat in the ground to extend to depths of 2 to 4 m. Rapidly alternating warm and cold periods of a few days each produce only short wedges. The former seems more characteristic of western Wisconsin and the latter of southern Wisconsin during the time of growth of the ice wedges.

Destruction of the ice wedges calls for rapid thawing and emplacement of the sand to avoid more contamination than is present. Abrupt climatic change seems needed. Furthermore, wind action to move the sand to the casts implies paucity of forests and relatively dry periods during each year. Lack of evidence of surface runoff following the troughs of the ice wedges or of vegetation in the casts suggest relatively low total precipitation. Replacement of the ice with sand hardly could have taken more than some decades in order to avoid more modification of the wedges and casts than is seen. Moreover, truncation of the sand casts by colluviation and mass movements indicates a change of climate to more moist conditions prior to deposition of the loess.

The whole story seems so complicated and the facts so few that much more field evidence is needed to constrain our musings. At least it is clear that our climate has changed abruptly and over a wide range of conditions during the time from perhaps 20,000 to 10,000 years ago.

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SOME MINERALOGIC CHARACTERISTICS OF SANDY SOILS IN WISCONSIN

*Frederick W. Madison and Gerhard B. Lee**

Sandy soils occupy about 7300 square miles, or 13.8 percent, of the total land area in Wisconsin (Whitson, 1926). Some of these soils are farmed, others are used for forestry, wildlife, recreation, or other purposes. While considerable effort has been devoted to the study of sandy soils, particularly in regard to their use and management for agronomic or silvicultural purposes, relatively little is known about some of their basic characteristics. This is reflected in their present classification which groups them into a few, broadly defined soil series. While it has been observed that differences exist among the soils that comprise these series, the magnitude of this variation and its relative importance is not well known. Conversely, several series of sandy soils include very similar soil individuals. Both problems result in part from the historical practice of using geographic and physiographic factors as criteria for grouping. Present-day efforts in classification, however, are aimed at ordering soils according to their morphology and other genetic characteristics. In many cases we lack the knowledge necessary to do this well.

The purpose of the present study has been (1) to establish some basic mineralogical characteristics of sandy soils in Wisconsin and of the sediments from which they formed and (2) to delineate general geographic areas in which sandy soils are apt to be mineralogically similar.

Location of Samples

Soils used were selected in order to obtain samples representative of the principal soil series in major sandy soil regions of the state (Fig. 1)[1]. In some cases it was possible to include two or

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[1]Among the samples used were several collected during an earlier study of Plainfield and associated soils (Soil Survey Staff, 1957) and several collected for subsoil fertility studies (Corey & Beatty, 1961).

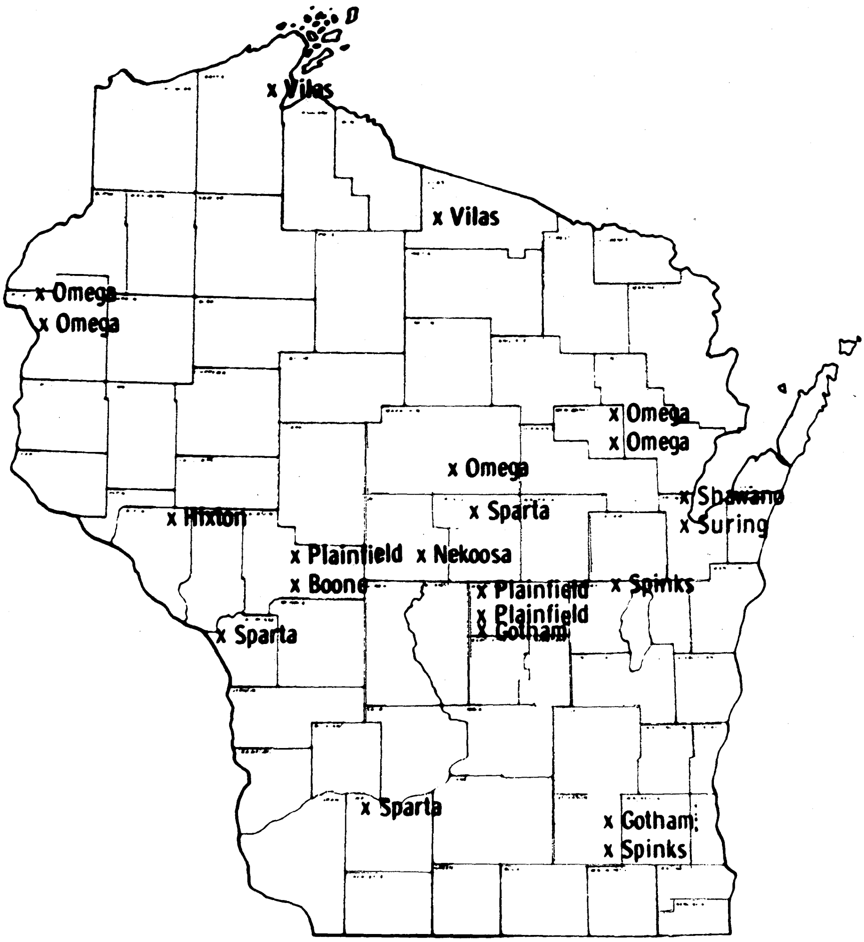

FIGURE 1. Map of Wisconsin Showing Location of Sample Sites.

more widely separated profiles of the same kind of soil. This made it possible to compare the mineralogical composition of soil individuals classified in the same series which may have been formed in sediments from different source areas or which may have been subjected to different degrees of reworking or weathering. Conclusions regarding the mineralogic character of these soils and their parent sediments are based on lithological studies of the gravels (particles greater than 2 mm. in diameter), grain-size analysis and mineralogical studies of the light and heavy minerals, heavy minerals being those minerals with specific gravities greater than 2.95.

METHODS OF ANALYSIS

Air-dried samples were passed through a 2 mm square mesh screen. The gravel fraction was treated with 6N HCl to remove iron oxide coatings after which individual pebbles were identified and counted.

Particle-size distribution of the less than 2 mm fraction was determined by the hydrometer method of Day (1956), except in the case of the six profiles collected for a study of Plainfield and related sandy soils (1957) whose particle-size distribution had previously been determined by the pipette method (Kilmer and Alexander, 1949).

Volume measurements of heavy minerals were made as described by Madison and Lee[2] using pear-shaped centrifuge tubes having a calibrated neck in which the heavy minerals settled and where their volume could be easily determined to the nearest hundredth of a milliliter. Weight percentages of heavy minerals was also determined.

Very fine sand-sized heavy minerals were mounted on glass slides with Lakeside #70 cement. Light mineral grains were impregnated with a 3:1 mixture of Castoglas and Styrene, mounted on glass slides and thin-sectioned (Madison, 1963)[3]. Slides were etched with hydroflouric acid and the potassium feldspars stained with sodium cobaltinitrite as described by Baily and Stephens (1960). Percentages of the various minerals present were determined by point counting with a standard petrographic microscope.

RESULTS AND DISCUSSION

Lithology of Gravel Fraction

Lithological studies of gravel fractions were made to determine if any particular rock type was dominant in the suite, this dominance serving in turn as a basis for interpretation of source area. A further purpose was to determine the presence of lithological discontinuities which would imply a change in source area. The gravel fraction in soil profiles from the central sand area reflected the influence of the Pre-cambrian rock complex in the Wausau area. Amounts of coarse materials decrease rapidly southward down the Wisconsin River Valley. This is attributed to two factors: namely, increased distance from source area and dilution of the sediment by the addition of quartzose materials from the Paleozoic sandstones. A great variety of rock types and general lack of con-

[2]Madison, F. W. and G. B. Lee, 1965. A simple method for determining the heavy mineral content of sands and its application to soil genesis research. In manuscript.

[3]Madison, F. W., Mineralogical studies of some sandy soils in Wisconsin. M. S. Thesis, University of Wisconsin, 1963.

sistent patterns are the dominant characteristics of the gravel fractions of the sandy sediments of northern Wisconsin. This is a reflection of the complexity and diversity of rock types found in the Pre-cambrian shield. A lack of coarse clastic material can be attributed to (1) reworking of sediments, (2) fine and medium grained source rocks, (3) moderate competency of the transporting medium, or (4) extensive transport of sediments prior to deposition. Results of the present study suggest that the first two of these processes have been primarily responsible for the textural characteristics of the sands of the "Driftless Area", whereas all of the first three processes have been operative in producing the textural characteristics of the sands of northeastern Wisconsin.

Mineralogical Composition of Soil Parent Materials

Results of mineralogical studies of C horizons are summarized in Table 1. In this table, soils are grouped according to geographical location.

Vilas soils are representative of podzolized sandy soils of northern Wisconsin. The wide ranges shown for all constituents reflect the mineralogic complexity of the Pre-cambrian shield area. Generally high feldspar percentages as well as high volume percentages of heavy minerals suggest that source rocks are primarily igneous and/or metamorphic and that these sediments are in their first cycle of erosion. The latter suggestion is further supported by the occurence of large percentages of augite and hornblende in the heavy mineral fraction, as well as lesser percentages of andalusite, sillimanite, hypersthene and diopside, all of which are relatively unstable in the zone of weathering.

Omega soils often occur in complex association with Vilas soils. They are also associated with other podzolic soils in northern Wisconsin in a zone extending from Polk and Burnett counties in the west through Marathon county to Shawano and Menominee counties in the east. Geologically this region coincides roughly with the contact between the Pre-cambrian shield rocks and the Cambrian sandstones which overlap them. The data (Table 1.), particularly values for quartz and feldspar, show a mineralogic similarity of parent materials over a wide geographic range. Two samples from Polk county showed the influence of the Pre-cambrian Iron Formation in that their volume percentages of heavy minerals ranged from 3.08 to 4.24 and that their heavy mineral suites were dominated by iron oxide minerals. The mineralogy of these sediments also implies geologically young materials which are probably in their first cycle of erosion.

Shawano and Suring soils are formed primarily from glaciolacustrine sands in the Valders drift region of northeastern Wis-

TABLE 1. MINERALOGICAL COMPOSITION OF SANDY SOIL PARENT MATERIALS

Soil Series	Location in Wisconsin	Number of Samples	Range in Percent Frequency of Light Minerals (by Count)[1]				Volume Percent of Heavy Minerals[1]		Dominant Heavy Mineral Species[2]
			Quartz	Feldspars					
				Orthoclase	Plagioclase	Total	Range	Average	
Vilas	N	2	60–80	11–17	2–12	12–29	1.12–4.00	2.35	Opaques[3] Augite Hornblende
Omega	N	5	62–68	16–19	5–9	24–27	1.24–4.24	2.54	Opaques Augite Hornblende Garnet
Shawano Suring Spinks	NE	3	75–77	13–15	5–8	18–20	0.80–1.80	1.71	Opaques Zircon Hornblende
Plainfield Nekoosa Gotham	C	4	76–83	5–10	2–4	8–12	0.44–1.12	0.90	Opaques Hornblende Garnet
Plainfield Boone Hixton	WC	3	85–96	1– 8	2–3	2–12	0.01	0.01	Zircon Tourmaline Garnet
Gotham Spinks	SE	2	60–80	6–16	6–7	12–23	1.20–1.96	1.48	Opaques Hornblende Garnet
Sparta	C SW	3	70–83	6–13	5–8	10–20	0.88–1.48	1.06	Opaques Hornblende Garnet

[1]Total sand (2.0–0.05 mm) fraction.
[2]Very fine sand (0.10–0.05 mm) fraction.
[3]Mainly magnetite, hematite, ilmenite, and leucoxcene.

consin. Spinks (and Leeman) soils in this area are developed in eolian deposits associated with these glacio-lacustrine basins. Parent materials of these soils appear to be very uniform both in particle-size distribution and mineralogical composition of major constituents. Data from mechanical analyses of these samples showed more than 80 percent fine and medium sand; that is, material ranging from 0.5 to 0.1 mm in diameter. The general uniformity of these materials is believed due to extensive reworking in glacio-lacustrine environments associated with the Valders glaciation. Paleozoic sandstones of the area have also contributed to this uniformity because of their own textural and compositional maturity.

Plainfield, Nekoosa, and Gotham soils, with associated Morocco and Kellner soils, occur over extensive areas in the central sand plain of Wisconsin. Mineralogically these materials showed higher quartz contents and lower contents of feldspars and heavy minerals as compared to sands in the northern part of the state. This appears to be due to the addition of quartzose materials from local Paleozoic sandstones which have, in effect, diluted the sediments derived from Pre-cambrian rocks in the Wausau area. Heavy mineral suites of these sands were found to contain monazite, a cerium phosphate mineral, in equal or greater amounts than apatite, suggesting that the former mineral may be, in some instances, an important source of the nutrient element phosphorus.

Boone and Hixton are residual soils formed from sandstone and are found primarily in the "Driftless" area of west central Wisconsin. Many valleys in this area are filled with fluvial sands and soils formed in these sediments have been classified as Plainfield. The Paleozoic sandstones of Wisconsin have been through several erosional cycles and, hence, are both texturally and compositionally very mature. From the data (Table 1) it is apparent that residual soils from these rocks, as well as related soils formed in transported sediments, reflect this maturity. Authigenic feldspars, which are potassium feldspars formed during the lithification of the sandstones, were the most variable constituent of these sediments. Heavy mineral contents of these materials were found to be extremely low; heavy mineral suites were made up of only the most resistant minerals.

The remaining groups represent two mineralogically anomalous situations. One of these groups included samples of Gotham and Spinks soils obtained from the interlobate moraine in southeastern Jefferson county. This area is underlain by Ordovician limestones. The ablation of glaciers, however, has concentrated large numbers of igneous and metamorphic erratics in this area which is believed to account for the mineralogic complexity and variability of these sediments.

The other group includes samples from Sparta soils. Two of these were obtained from terraces along the Wisconsin River in Iowa and Portage counties while the third came from a terrace along the Mississippi River in La Crosse county. These sands, because of their association with major drainageways, are made up of materials derived from a variety of sources and, as such, are mineralogically anomalous in the areas where they occur.

Weathering of Sandy Soils

Weathering studies were made in an attempt to determine if differential weathering has occurred within a sequence of sandy soils in which varying degrees of podzolization can be recognized morphologically. To assess the intensity of weathering, the ratio of zircon plus tourmaline to hornblende was calculated for the A, B, and C horizons of four soils; namely, Vilas—a Spodosol, Omega—a podzolized Entisol, and Shawano and Plainfield—two less podzolized Entisols.

Figure 2 shows the results of this study. Based on the formulae of Frye et al (1960), calculations were made which showed a 55 percent depletion of hernblende in the A2 and 15 percent in the Bhir of the Vilas. Weathering in the Omega appears to have been less intense with only a 22 percent depletion of hornblend in the A1 and 12 percent in the Bhir. The two less podzolized soils showed little, if any, effects of weathering. It is recognized that hornblende is not the most sensitive indicator of weathering; however, it does appear that this mineral can be used as a qualitative means for estimating weathering intensity.

Conclusions

Results of this study suggest that it is possible to delineate general areas of sandy soil in Wisconsin that are mineralogically similar. On the basis of results obtained, the following conclusions appear to be warranted: sandy soils derived from local Cambrian or Ordivician sandstones in west-central Wisconsin are characterized by their quartzose nature, by the presence of authigenic feldspars, and by heavy mineral contents of less than .01 percent by volume. Sandy soils of the northern third of the state are less quartzose, contain 15 to 25 percent feldspar, have volume percentages of heavy minerals suggesting that these sediments are in their first cycle of erosion. Sandy soils of central Wisconsin have less than 15 percent feldspar and have volume percentages of heavy minerals ranging from .44 to 1.12 percent. In the area south of Wausau, monazite, a cerium phosphate, is a constituent of sand de-

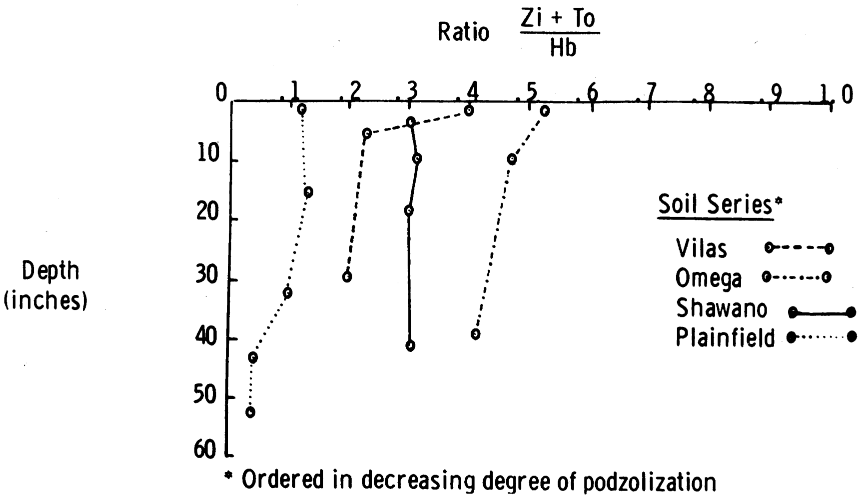

FIGURE 2. Weathering Ratios as a Function of Depth in Sandy Soils Showing Varying Degrees of Podzolization.

posits. In northeastern Wisconsin sands are distinguished by their fine grain size, their quartzose nature, and volume percentages of heavy minerals ranging from .80 to 1.80%. Within any of these general areas, local variations are apt to occur; these may be related to differences in source area or to mode of transport and deposition.

Studies of four profiles using depletion of hornblende as an index of weathering indicate increased weathering related to podzolization in sandy soils. Observed differences in weathering are believed to be primarily a function of the climatic and vegetative factors of soil formation.

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ART AS SETTING IN *THE MARBLE FAUN*

*Gene A. Barnett**

One hundred years after its publication, Hawthorne's *The Marble Faun* is at last being approached on its own terms as regards the much criticized Italian setting. Major critics from James to Matthiessen have made substantially the same complaint—that setting gets altogether too much attention in the novel. Even after second thoughts and a revised edition of his excellent work on Hawthorne, H. H. Waggoner still objects that there is "too *much* of Rome, and too much about art."[1] In my 1961 dissertation, I undertook a defense of the Italian setting, including the art,[2] and the same year Edward Wagenknecht noted the extent of Hawthorne's use of art as setting in his study of the romancer: "Every stage in its [*The Marble Faun's*] development, every important idea expressed in it, is suggested by or symbolized by or embodied in a work of art, and the reactions and relationships of the characters to various works of art became a very important element in characterization."[3] More recently, Gary J. Scrimgeour briefly advanced a similar argument concerning works of art in his very fine article on the general importance of Italy as a setting for the novel,[4] but in disagreement with him, I submit that critical analysis of such material, far from being "wordy and impertinent," can be quite worthwhile.

A close examination of the uses of art in *The Marble Faun* reveals that art works are employed consistently and much more organically and functionally throughout the novel than any other aspect of setting, even the historical ruins of the Roman landscape. Furthermore, a variety of uses may be noted. Most obvious, of course, is the use of such works simply to make the scene interesting, to capture the atmosphere of Rome and Italy as an age-old center for the development of the arts. Hawthorne's American readers, delighting in romances set in somewhat exotic foreign countries, would naturally expect to encounter at least a few of the world-famous statues and pictures, and the romancer would not

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[1]*Hawthorne: A Critical Study*, rev. ed. (Cambridge, Mass., 1963), p. 223.

[2]*Hawthorne's Use of Setting in His Major Novels*, University of Wisconsin, Department of English.

[3]*Nathaniel Hawthorne: Man and Writer* (New York, 1961), p. 43.

[4]"*The Marble Faun:* Hawthorne's Faery Land," *American Literature*, XXXVI (November, 1964), 271–287.

disappoint them. A second reason for bringing such objects into the scene is that they afford the author an opportunity to make his own comments on certain works, or more broadly, on the two principal media: painting and sculpture. And this he does, albeit not always to the delight and edification of the modern reader. In general, however, Hawthorne's remarks on art command a certain amount of respect, occasionally for their validity, but more often for their honesty. As Norman Holmes Pearson notes, he frequently came close to absurdity in his praise of the work of his countrymen who were painters, but his remarks on the work of American sculptors evoke "only admiration for the perspicuity which kept him aware of their inadequacy."[5]

There are more meaningful employments for art, however. One of these is that art objects are made to become highly functional in a scene. For example, the statue of Pope Julius seems to bestow the blessing of heaven on the reunion of Donatello and Miriam. It is a reminder that their sin as well as their love has brought them together, and that heaven will exact expiation for the one by forbidding them the joys of the other. Another important—perhaps the most important—use of art is as a symbol for or comment on character. There are few instances in the novel in which art figures which fail to fill out in some way the personality and character of one of the chief players. The "Faun" of Praxiteles would certainly be foremost in this category. Finally, works of art offer thematic connotations. The busts which Kenyon makes of Donatello are excellent illustrations of this, for they successively mirror in stone and plaster the moral growth of the young Italian as sin seems to elevate and deepen his character through remorse over his murder of the monk. These devices just mentioned suggest the several possibilities which Hawthorne has explored in his attempt to make art functional in his novel, and it remains now to consider specific variations or instances as they relate to the four principals, beginning, appropriately enough, with Donatello, the "Marble Faun" come to life. Since he and Kenyon are most frequently associated with sculpture rather than painting, the two male characters will be considered before going on to Hilda and Miriam who work in the (for Hawthorne) more feminine medium of paint.

The opening paragraph of the novel serves several purposes. The four principal characters are introduced, though not by name; the setting is pinpointed—"one of the saloons of the sculpture gallery in the Capitol at Rome"; the theme is implied in the age-old choice of good or evil symbolized in the statue of a child "clasping a dove to her bosom, but assaulted by a snake"; and the major

[5]*The French and Italian Notebooks,* I (unpublished Ph.D. dissertation, Department of English, Yale University, 1941), lxvii.

role of art within the setting is indicated. By mentioning the names of several famous statues—the "Dying Gladiator," the "Lycian Apollo," "Antinous" and others—Hawthorne immediately attempts to capitalize on his famous setting to lend a glamorous reality and authenticity to it. The "Faun" of Praxiteles is not introduced until the third page when attention is immediately called to it by Donatello's resemblance to it. Miriam declares that the " 'portraiture is perfect in character, sentiment, and feature,' "[6] and these first two chapters are given over to, among other things, developing this parallel. A paragraph on the character of the "Marble Faun" is worth quoting for what it tells of Donatello's character, and for what it implies about the story to be told and the theme to be unravelled:

> Perhaps it is the very lack of moral severity, of any high and heroic ingredient in the character of the Faun, that makes it so delightful an object to the human eye and to the frailty of the human heart. The being here represented is endowed with no principle of virtue, and would be incapable of comprehending such; but he would be true and honest by dint of his simplicity. We should expect from him no sacrifice or effort for an abstract cause; there is not an atom of martyr's stuff in all that softened marble; but he has a capacity for strong and warm attachment, and might act devotedly through its impulse, and even die for it at need. It is possible, too, that the Faun might be educated through the medium of his emotions, so that the coarser animal portion of his nature might eventually be thrown into the background, though never utterly expelled. (24).

A great part of the story of the novel is to be seen here in the description of the character of the stone figure. Donatello's love for Miriam is implied, along with the sacrifice of his innocence for her—the "death" of the old Donatello—and his moral growth through expiation. Significantly, it is Miriam who comments further on the nature of the "Faun" (27–28), incidentally implying a contrast between its carefree nature and a shadow on her own heart. Hawthorne then illustrates what she has seen in the stone figure by describing the utter amorality of the flesh-and-blood counterpart, Donatello, in his childlike admiration of her. Finally, the romancer provides a lengthy literal description of the "Faun," though it is interesting to note that he has not described it accurately, a fact easily noticed by comparing his account with any photograph of the statue. Julian Hawthorne calls attention to it in *Hawthorne and His Circle,* noting that his father "could not have visited it often; for both in his notes and in his romance he makes the same mistake as to the pose."[7]

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[6]*Works.* VI (Boston and New York, 1891), p. 21. Further references to this volume will be indicated by page number placed in parentheses in the text.

[7](New York, 1903), p. 325. Contrary to Hawthorne's description, the "Faun" has nothing in his right hand and his left arm is akimbo.

Certainly one may assume that most of the description of the "Faun" is meant to apply to Donatello also. " 'If there is any difference between the two faces,' " remarks Hilda, " 'the reason may be, I suppose, that the Faun dwelt in woods and fields, and consorted with his like; whereas, Donatello has known cities a little, and such people as ourselves. But the resemblance is very close, and very strange.' " (21–22) Mariam adds to this by disagreeing. " 'Not so strange, . . . for no Faun in Arcadia was ever a greater simpleton than Donatello. He has hardly a man's share of wit, small as that may be.' " (22) Later they both agree that Donatello's gamboling play is " 'the very step of the Dancing Faun.' " (29) The two are alike even in age, though so many years separate them, for Donatello, like his stone counterpart, " 'has a look of eternal youth in his face.' " The statue, morally as well as physically, represents the Donatello who exists at this point in the novel. The living faun's transformation will be viewed in terms of his departure from this stone norm, and the humanizing process will also be depicted at certain stages in other statuary shaped by Kenyon who, as spectator, is best able to view the change objectively.

While Praxiteles' "Faun" depicts and characterizes the young Count as he is at the beginning of the story, the two busts Kenyon makes of him portray him at other points in his moral development. The first of these is executed at Monte Beni. Since this is not long after the murder, Donatello's features mirror the emotional shock and the death of his innocence. This is difficult for the sculptor to capture, and indeed he gives up, but by "some accidental handling of the clay, entirely independent of his own will," Kenyon gives the countenance "a distorted and violent look, combining animal fierceness with intelligent hatred." (314) Hawthorne adds that, had Miriam and Hilda seen this bust, they would have recognized the face of the boy-faun as he was when in the act of murder. Donatello insisted that the bust not be changed so that he would have before him a reminder of his crime, but Kenyon would not agree.

Later in the novel, Kenyon executes another bust of his friend. Through Hilda's response to it, the reader becomes aware that this work has symbolic significance and, further, that it makes Kenyon's first attempt more significant too. " 'It gives the impression of a growing intellectual power and moral sense,' " Hilda says. " 'Donatello's face used to evince little more than a genial, pleasurable sort of vivacity, and capability of enjoyment. But, here, a soul is being breathed into him; it is the Faun, but advancing towards a state of higher development.' " (433) Kenyon is surprised at this, but Hilda advances the parallel a bit further. " 'Is it not, perhaps, the chance result of the bust being just so far shaped out, in the marble, as the process of moral growth had advanced in the original?' " It is indeed, but not by chance on the romancer's part, for previous to this discussion, he had mentioned in an aside that his reader was probably acquainted with Thorwaldsen's "three-fold analogy": "the clay model, the Life; the plaster cast, the Death; and the sculptured marble, the Resurrection." Donatello himself is the clay model, the living image of Praxiteles' "Faun" which captures the essence of the spirit of life. Kenyon's plaster cast was never put in a more permanent form and existed only for a few moments, but this was long enough for it to become symbolic of the instant death of Donatello's innocence and his immediate awareness of sin. The second bust, which Kenyon was executing in marble, captured the resurrection of a human being who had tasted sin and had developed morally through contact with it. In these three pieces of statuary there is a working out of the *felix culpa* theme which, because of Hawthorne's reticence to allow his characters to fully accept it, must finally be discounted. However, it does remain the theme of the novel, though phrased as a question rather than a statement.

Functioning in a more complex manner is the statue of Pope Julius. Here story, theme, and setting are all united as three of the four major characters come together at noon under the upraised hand of the venerable Pope, a reunion which signifies by Donatello's acceptance of Miriam that he has begun to develop, to realize that he must live in the world with his sin and share it with his fellow sinner. Here a familiar Hawthornian theme is being touched on: sin as a force which isolates man from his fellows and so damns him. But to a degree, this has been averted, for a divine approval seems to be given to Donatello's strange alliance with Miriam, for the "majestic figure" seems to bless them and approve "the pledge of a deep union that had passed under his auspices." (371) Donatello's attitude toward the stone pope also suggests a new reliance on God for mercy and forgiveness, for he compares it to the brazen serpent which Moses raised up in the wilderness for the healing of the Israelites when they were plagued by snakes. (361)

Two other examples of the use of sculpture may be mentioned briefly. One involves an analogy Hawthorne draws between the sylvan dance in the Borghese park and a bas-relief on an antique vase or the front of a sculptured sarcophagus. (110) Such ornamentation would depict a dance of satyrs, nymphs and other ancient poetic creatures; these are the stone counterparts of Donatello, Miriam, and their dancing comrades. But always in the art image, "some tragic event is shadowed forth or thrust sidelong into the spectacle," Hawthorne adds, and at this point, the spectre-model-monk enters the dance and the whole atmosphere of the scene changes, suggesting the evil influence he will presently have on Donatello and Miriam. Finally, there is the broken "Venus" which was found covered with earth in the excavations on the campagna. At first it seems it is Kenyon who discovered her, but this would be less appropriate, and the original find is attributed to Donatello. The "Venus" here is undoubtedly meant to symbolize the shattered ruin of the Faun's early pagan-like attraction to Miriam. Now, out of the ruins of their lives, suggested by the physical ruins in the area of the excavations, a mature, Christian-oriented relationship could develop, thanks to the humanizing experience Donatello has undergone.

Only in two or three instances are paintings or portraits important in connection with Donatello. In Miriam's studio he is startled by a picture of "a woman with long dark hair, who threw up her arms with a wild gesture of tragic despair, and appeared to beckon him into the darkness along with her. . . . 'When my eyes first fell upon her, I thought her arms moved, as if beckoning me to help her in some direful peril,' " he admits, foreshadowing the beseeching glance by which Miriam would cause him to murder the monk. (58) At this point, the innocent nature of the boy only occasionally recognizes the deeper, spiritual struggle Miriam (the woman in the portrait, of course) is having with her past which has come to light and life in the shape of the spectre-model.

At another point, the frescos in a saloon at Monte Beni are a comment on the frame of mind of the owner of the castle. Though they are faded and appear to be "like the ghosts of dead and buried joys," Donatello recalls that " 'when I brought my own cheerfulness into the saloon, these frescos looked cheerful too.' " (262) Now that the observer has changed, the faded paintings reflect the loss of *joie de vivre* of the Monte Beni descendant. Similarly, after his great sin Donatello comments on Fra Angelico's pictures to Kenyon, who is trying to pursuade him to look at some of them. " '. . . His angels look as if they had never taken a flight out of heaven; and his saints seem to have been born saints, and always to have lived so. Young maidens, and all innocent persons, I doubt not, may find great delight and profit in looking at such holy pictures. But they are not for me.' " (356) The beginnings of a conscience are evinced in this rejoinder, marking in yet another way the evolutionary process through which Donatello will completely lose his natural innocence.

Kenyon is the "man of marble," and he is consistently and naturally associated only with statuary throughout the novel. His work as an artist is to attempt to capture the idealized essence of a subject, and as Darrel Abel suggests, he himself represents something of an ideal in his role as a self-contained, fully developed artist—a standard, as it were, by which the other two artists may be measured.[8] It is inherent in the general role of the ideal artist to be detached somewhat from life about him; thus he is capable of looking more objectively at his surroundings. Kenyon is such a figure. He moves easily and unobtrusively through the narrative, for he is in accord with the other three major characters, yet somehow aloof from their susceptabilities. He is more stable intellectually and more fully developed aesthetically than the others, and this is why he can be a close friend and confidant to all three, different as they are. He is created in the mould of other Hawthornian characters such as Holgrave and Coverdale in that he is more often the spectator than the active participant in the action of the novel. Finally, he is able to see his art in relation to time. What is good is timeless and will endure; what is not is, like the portrait busts of contemporaries, simply "concretions and petrifactions of a vain self-estimate." (144)

Aside from the busts of Donatello already discussed, the "Cleopatra" is probably the most notable example of Kenyon's art. After a lengthy description of the statue which was really the work of William Wetmore Story, an intimate friend of the Hawthornes, the romancer comments on the "repose" of the work: "The spectator felt that Cleopatra had sunk down out of the fever and turmoil of her life, and for one instant . . . had relinquished all activity, and was resting throughout every vein and muscle." (152) Then, following a succinct comment on the features of the figure ("The face was a miraculous success"), there is a summing up of the spirit of the statue: "fierce, voluptuous, passionate, tender, wicked, terrible, and full of poisonous and rapturous enchantment. . . ." (153) This is Kenyon's work of art, and a strange one it is for the "man of marble" to have created. It may be that Hawthorne's enthusiasm for his friend Story's work carried him too far here, or it may be as Rudolph von Abele has suggested, that the "Cleopatra" represents a duality in the sculptor's attitude, for while he was fashioning her, "full of 'hot life,' fresh from the 'fire' of his imagination," he was also in love with the "spotless virgin" Hilda.[9] But as Kenyon shows his masterpiece to Miriam for the first time, she immediately recognizes a kindred being in her friend's creation, for she too is a strong, passionate woman. On the supposition that Kenyon has the insight into such a nature to be able to create a work like the "Cleopatra," Miriam appeals

[8]Darrel Abel, "A Masque of Love and Death," *University of Toronto Quarterly*, XXIII (October, 1953), 18.

[9]*The Death of the Artist* (The Hague, 1955), p. 90.

to him for sympathy and is about to take him into her confidence.[10] Just in time she senses his reluctance to share her secrets—perhaps a sensible Victorian attitude on his part, but also a reluctance peculiar to the artist who must look at the world with detachment, without becoming too involved in it. The "Cleopatra" characterizes him in his role as the artist who must have the insight to create an art product with life, yet with ideality; a timeless work, yet a work of individuality and particularity for his time and place. This statue also is a comment on Miriam, for she has in common with the Queen of the Nile her rich passionate nature. Her character is made more vivid and alive by her recognition of the kindred vitality in Kenyon's work of art.

Somewhat later in the novel, Hilda also sees the "Cleopatra," and though she sincerely admires it, it does not have the appeal for her that it has for Miriam. Her own nature and character are not reflected in it, and neither her aesthetic sense nor her womanly passion can give her an insight to equal that which her good friend experienced.

The small sculptured hand modeled on Hilda's is another interesting example of Kenyon's art. Illustrated here, of course, is not only his love for Hilda and his determination to possess her hand in marriage, but also his way of viewing every aspect of life about him in terms of his art. He also models "a beautiful little statue of maidenhood gathering a snow-drop." (427) Such a fragile, airy creation was never put into marble, but it suggests the "delicate character" the sculptor assumed while being "unconsciously wrought upon" by Hilda's influence.

Two other examples of Kenyon's art must be mentioned. One is a statue of a youthful pearl-fisher "who had got entangled in the weeds at the bottom of the sea, and lay dead among the pearl-oysters, the rich shells, and the sea-weeds, all of like value to him now." (142–143) This symbolizes the search and the sacrifice of the artist for the ideal in his art. Miriam, however, sees only a moral in it: " '. . . what a strange efficacy there is in death. If we cannot all win pearls, it causes an empty shell to satisfy us just as well.' " Perhaps this suggests her contentment with something less than the ideal in her own art. Finally, there is a bust of Milton which Kenyon has executed. It has been suggested that this piece of work is simply a tribute on Hawthorne's part to "one who had preceded him in probing deep into man's universal nature."[11]

[10]This incident recalls a moment during the "moonlight ramble" when Miriam looks at the bronze equestrian statute of Marcus Aurelius on the Capitoline Hill and longs for someone such as the fatherly-looking old ruler to go to with her griefs and problems. Both statues, though the "Cleopatra" indirectly, draw from her an appeal for comfort and consolation.

[11]Roy R. Male, *Hawthorne's Tragic Vision* (Austin, Texas, 1956), p. 162.

The bust is then a reminder that Milton had considered in *Paradise Lost* the same theme of the fall of man which occupies Hawthorne in this novel.

Any work of art which relates to Miriam, whether she is the artist or whether she simply comments on it, is invariably highly significant. Since she, like Kenyon, is an artist with an artist's sensitivity, Hawthorne takes care that this aspect of the character-setting relationship is worked out very carefully. The first reference to Miriam's work serves to underline her predicament in the novel by characterizing her relationship with the spectre. After she meets him in the catacombs, he follows her about and serves as model for some of her work. Since he is evil, his influence immediately becomes apparent, for art is ideally a clear, pure medium of expression which would not fail to be changed by a negative element. The "shadow or reminiscence" of the features of the monk lingers in Miriam's drawings, and the "moral atmosphere of these productions was thereby so influenced, that rival painters pronounced it a case of hopeless mannerism, which would destroy all Miriam's prospects of true excellence in art." (47)

The chapter on Miriam's studio is especially interesting for its use of art. Through the device of having her show Donatello some examples of her work, the reader is introduced to a series of functional and symbolic pictures and drawings from which he may deduce Miriam's psychological attitude. (60–61) Each one of this stack of "pen-and-ink sketches and pencil-drawings" deserves some comment. In the first, Jael is depicted driving a tentnail through the temple of Sisera. (Judges, Ch. 4) In its initial conception, Jael had been pictured as "perfect womanhood," but by a "wayward quirk of her pencil," Miriam made her into a "vulgar murderess." The second sketch is of Judith after she had decapitated Holofernes. A third represents Salome receiving John's head on a charger. Hawthorne apparently got the idea for this sketch from Luini's picture in the Uffizzi Gallery, but he has Miriam imparting to the Roman daughter a sense of remorse and love which others have not so generously granted her. "Over and over again," Hawthorne writes, "there was the idea of woman acting the part of a revengeful mischief towards man," and the "moral" was always that "woman must strike through her own heart to reach a human life, whatever were the motive that impelled her." (61) One writer suggests that by "drawing sketches of violence, she tries to purge herself of the model's presence, but . . . fails by recognizing that the violence she imagines would be even more wicked if practiced than anything the model himself has done."[12] Hawthorne, however,

[12] Merle E. Brown, "The Structure of *The Marble Faun*," *American Literature*, XXVIII (November, 1956), 304.

seems to be implying here that Miriam has committed some deed for which she cannot be altogether condemned, but still a deed which may be held over her by someone who knows of her guilt or shares it with her. As a heroine she may have a mysterious background which must remain fascinatingly vague, but she must also be acceptably innocent to the other characters and the reader until her involvement in the crime of murder which motivates the novel. These sketches do not please Donatello, and even their creator admits that they are " 'ugly phantoms that stole out of my mind; not things that I created, but things that haunt me.' " (62)

Miriam has drawings of a different kind, however, things created in "a happier mood of mind, and one, it is to be hoped, more truly characteristic of the artist." (62) The subjects here are scenes of everyday life, and once again one may note Hawthorne's emphasis on the semi-Platonic ideal which shines through a work of art, for he writes that they were "so finely and subtilely idealized that they seemed such as we may see at any moment, and everywhere; while still there was the indefinable something added, or taken away, which makes all the difference between sordid life and an earthly paradise." The significant aspect of this group of sketches is that in almost every one "a figure was portrayed apart" which looked in as a spectator on the homey scenes of day-to-day life, a figure of which "the face and form had the traits of Miriam's own." (63–64) Again Hawthorne's theme of sin as an isolating force is touched on, though the exact sin which figures in Miriam's past is never made clear. Plainly she feels some guilt or responsibility and recognizes, in her own view at least, that this sets her apart morally from society about her.

One other picture in Miriam's collection must be mentioned. This is a self-portrait, a picture of a woman so beautiful "that she seemed to get into your consciousness and memory, and could never afterwards be shut out, but haunted your dreams, for pleasure or for pain. . . ." (65) She is one "Jewish aspect," and Donatello had no trouble at all in recognizing the subject. But what would a more refined observer have seen? Hawthorne suggests that the artist "had doubtless conveyed some of the intimate results of her heart-knowledge into her own portrait, and perhaps wished to try whether they would be perceptible to so simple and natural an observer as Donatello." (66–67) In yet another way, then, the author implies that Miriam has some secret to hide, but that it would take a kindred eye to detect it.

In another chapter, there is a third set of sketches. When the "aesthetic company" gathers in the apartment of one of its members, a discussion comes up over a group of faded and yellowed drawings. Hilda affirms that one of these had been executed by

Guido, a favorite of hers, and that the sketch was a rough draft for a painting that hung in the Church of the Cappuccini. This painting in turn had served as the model for a mosaic in a shrine in St. Peter's, the shrine at which Hilda was later to kneel in prayer. The sketch shows the Archangel Michael in the act of subduing a demon, and Hilda recalls that the artist had found it necessary to state publicly that no resemblance was intended between the demon of the painting and a certain Cardinal Pamfili. But the features of the devil seem somehow familiar to Hilda and Kenyon; Donatello immediately identifies them as those of Miriam's model. Hawthorne, as he often does, suggests by a series of questions all the possibilities for such a resemblence. It seems likely that a family relationship might be intended between the old Cardinal of Guido's time and Brother Antonio, Miriam's tormentor.

A visit to the Church of the Cappuccini for the purpose of reexamining the painting is proposed for the following day, and it is at this point that the painting begins to be revealing in connection with Miriam, for later on that very same evening of the discussion of the drawing, he and Donatello become guilty of murder. The next day at the church, Miriam, being the more articulate of the two, expresses a much stronger feeling about the painting when she views it and questions whether it is a valid representation of the struggle between good and evil. For her auditors she pictures the scene as it should be painted. The struggle would be grim and fierce; the Archangel would be wounded and the devil would writhe under his foot, still contesting the victory. But with all " 'this fierceness, this grimness, this unutterable horror, there should still be something high, tender, and holy in Michael's eyes, and around his mouth.' " (217)

Kenyon is impressed with her approach to the subject and suggests that she paint such a picture. Miriam replies that she is " 'sadly afraid the victory would fall on the wrong side.' " In her response to the picture, she is relating her own struggle with evil; victory in such a battle is not easy, as it would seem to be for Hilda, but involves a desperate struggle, one which Miriam herself has, in fact, just lost, for her final pronouncement is made as she recollects the murder on the preceding evening.

Hilda's admiration of Guido's dainty Archangel who, with unruffled wings and unhacked sword, has defeated the demon is indicative of the ease of her victory in her own struggles with evil, and recalls that she herself has throughout the novel been associated with the Virgin of her aloof shrine. In this instance she is characterized as the New England Puritan who really is pure in heart and whose Calvinism is sufficient unto any day. Her perception of evil is no greater than her perception of the depths of human character, for Hilda is a copyist, one who copies or imitates repeatedly the famous works of the European museums. She is so morally pure and aesthetically sympathetic that it is easy for her to enter into the intent of the artist and so achieve a better copy, a copy which captures the spirit of the work more satisfactorily than the work of her rivals. The old masters, Miriam tells Kenyon, are his " 'only rivals' " for Hilda's hand. She does not wish to be a creative artist, and her aloof nature limits her to dealing only with such works as are wholly moral, as for example Guido's "Archangel Michael." Even his "Beatrice," she insists at first, is sinless, though later she agrees that the luckless heroine deserved her fate. Still, the moral note is inherent in either attitude. A work with no obvious moral intention she would not have attempted to copy, and it was not her practice anyway to reproduce the whole painting, but to choose "some high, noble, and delicate portion of it, in which the spirit and essence of the picture culminated. . . ." (76) By subordinating her own talents, which were not inconsiderable, to those of the masters, she chose "the better and loftier and more unselfish part, laying her individual hopes, her fame, her prospects of enduring remembrance, at the feet of those great ones, who she so loved and venerated. . . ." (78) Such an attitude is obviously functional, underscoring dramatically the fact that Hilda is a conformist and an imitator, as contrasted with being a creative individualist.

After the tour of Miriam's studio, it is only to be expected that Hilda's studio will also be introduced into the story, but Hilda has only one painting that is significant, and it is more important for what it says about Miriam than about its creator. It is easy for Hawthorne to describe Hilda's work, for it is a copy of a famous painting by Guido, a portrait of Beatrice Cenci. The original was supposedly in the Barberini Palace and its owner would not let anyone copy it, though it was otherwise open for inspection. Like other artists, Hilda has studied the picture and carried it away in her heart bit by bit. According to Miriam, hers is the best copy yet made. The portrait of "a very youthful, girlish, perfectly beautiful face, enveloped in white drapery" is dominated by a note of sadness, and the eyes seem to make "a strange, ineffectual effort to escape." (82) The final effect is to make the viewer "shiver as at a spectre."

Hawthorne uses the portrait of Beatrice—and the connotations it must of necessity have—as a principal device in characterizing Miriam as tragically isolated from "the sphere of humanity." He never makes a definite connection between the two which would suggest that Miriam was directly modeled on Beatrice, nor does it seem likely that he meant it to be so. He simply uses the beauty of the subject and the aura of sin which the Cenci name evokes to suggest a similar vague background of sin for the beautiful Jewess who both condemns and understands the act imputed to Beatrice. The reader is undoubtedly meant to get the impression that she has been in a similar situation herself. She is not even certain herself of the extent of her own guilt and resents any reflection on her innocence. While looking at Kenyon's "Cleopatra," she surprises him with the statement that her conscience is " 'still as white as Hilda's' " and then adds, " 'Do you question it?' " Kenyon, of course, immediately replies in the negative. But as Miriam looks at her friend's copy of the "Beatrice," she is forced to disagree with Hilda's statement that the legendary beauty was a " 'fallen angel,—fallen, and yet sinless.' " " 'If I can pretend to see at all into that dim region, whence she gazes so strangely and sadly at us, Beatrice's own conscience does not acquit her of something evil, and never to be forgiven,' " Miriam says. Then she inquires of Hilda, " '. . . do you think that there was no sin in the deed for which she suffered?' " Hilda is forced to agree that Beatrice's was a " 'terrible guilt, an inexpiable crime' " and that " 'her doom is just.' " At this, Miriam becomes once more almost defensive: " 'Your judgements are often terribly severe,' " she replies to Hilda, " 'though you seem all made up of gentleness and mercy. Beatrice's sin may not have been so great: perhaps it was no sin at all, but the best virtue possible in the circumstances.' " The importance to Miriam of the degree of Beatrice's sin may be seen in her remark which sums up for her the whole conversation: " 'I would give my life to know whether she thought herself innocent, or the one great criminal since time began.' " (84–5)

At this point, the scene becomes most meaningful with the following development:

> As Miriam gave utterance to these words, Hilda looked from the picture into her face, and was startled to observe that her friend's expression had become almost exactly that of the portrait; as if her passionate wish and struggle to penetrate poor Beatrice's mystery had been successful. (85)

Here, in an attempt to fathom the secret of the picture, Miriam seems to give away some part of her own secret by unknowingly allowing Hilda to glimpse a sisterhood between her and the subject of the painting. Hawthorne's use of art in this case is highly functional, based on parallelism, for this is the first incident in a chain which leads Hilda to conclude the general nature of Miriam's guilt. In preparation for a later summary of the situation, it might be said at this point that if X equals the revealing expression on Beatrice's face, then Miriam's expression equals X, because in this scene they momentarily have this aspect in common.

The next step is an illustration of the innocence of Hilda which emphasizes her strange capacity to allow the mood of another artist to enter into her own so that she can duplicate the sprit of another's painting. Hawthorne comes to this in a scene just preceding that of Hilda's rejection of Miriam on the day after the murder. The picture of Beatrice is again the frame of reference, and this time a "peculiarity" of the portrait is mentioned which will be most important.

> It is a peculiarity of this picture, that its profoundest expression eludes a straightforward glance, and can only be caught by side glimpses, or when the eye falls casually upon it; even as if the painted face had a life and consciousness of its own, and, resolving not to betray its secret of grief or guilt, permitted the true tokens to come forth only when it imagined itself unseen. No other such magical effect has ever been wrought by pencil. (238–9)

Opposite the easel on which this picture rests is a mirror which reflects the faces of both the artist and the subject on the canvas. In "one unpremediated glance," Hilda experiences a moment of truth through her ability to enter into the mind of a subject. (239) "She fancied—nor was it without horror—that Beatrice's expression, seen aside and vanishing in a moment, had been depicted in her own face likewise, and flitted from it as timorously." She immediately feels guilt transferred to her own soul; yet she knows she is innocent of any sinful act. However, it was "the knowledge of Miriam's guilt that lent the same expression to Hilda's face," so she feels guilt simply by knowledge or "association," though she is, of course, innocent. Still, since her face mirrors Beatrice's expression for a moment, Hilda also assumes the quality associated with the expression X.

At this point, Hawthorne seems to step in in his own person to declare that Beatrice is indeed innocent. "Who . . . can look at that mouth . . . and not pronounce Beatrice sinless? It was the intimate consciousness of her father's sin that threw its shadow over her, and frightened her into a remote and inaccessible region, where no sympathy could come." (239) The lady's guilt, then, Hawthorne seems to be saying, is not really actual guilt at all, but a reflection of the guilt of her father—guilt by knowledge or "association." And X, the expression on the face of the picture, is now directly associated with Beatrice the subject whose innocence (for the purpose of the romance) Hawthorne has established.

Now, since Miriam's expression equals X, Hilda's equals X, and finally Beatrice's also equals X, presumably Miriam, Hilda and Beatrice should all be innocent, or if guilty in any degree, only so by "association," i.e., knowledge or acquaintance. Yet, of the three, presumably only Miriam may actually be considered guilty

—and this only since the night of the moonlight ramble—because she acquiesced in the murder of the monk. Before that time, it might be assumed that she, like Hilda and Beatrice, merely reflected the guilt of someone about her, possibly Brother Antonio—again guilt by "association." It is extremely subtle of Hawthorne to allow Hilda first to recognize Beatrice's innocence (which the romancer ascribes to her only later), and then, on Miriam's urging, to agree that Beatrice was guilty, though as Hawthorne suggests, only in her knowledge of a crime. This is the type of guilt Hilda recognizes in herself as she glimpses her image in the mirror; this is the type she knows Miriam harbors, for she has seen her give silent consent to the murder. In her shocked state of innocence, Hilda can show her friend no mercy. Hawthorne seems to suggest that true innocence is complete unawareness and ignorance of evil. At least, this seems to be so for such characters as Hilda and Donatello, who are never the same after their contact with sin. For both, however, such a contact led to a higher level of moral consciousness which recognizes sin in the world as an undeniable part of human existence. The portrait of Beatrice Cenci has functioned to demonstrate this, and to indicate subtly the type and degree of guilt of two major characters.

It only remains to note that the matter just discussed represents the principal instance in *The Marble Faun* of Hawthorne's use of the mirror motif. Here, the mirror, as always, symbolizes the truth of the imagination which finally is a more enduring and eternal truth than that reported through the medium of the physical world. Hawthorne is careful to use the right verb—"fancied"—when he has Hilda recognize in a moment the nature of Beatrice's guilt, for "fancy" here suggests the imagination, though Hawthorne did make some distinctions between them.

The portrait of Beatrice figures in the story once more, though somewhat incidentally. A young Italian artist notices Hilda standing before a portrait entitled "Joanna of Aragon" and captures on his canvas her expression at that moment. Hilda is attracted to the picture because she thinks she detects a slight resemblance to Miriam, but the young artist draws her gazing "with sad and earnest horror" at a spot of blood on her white robe. Hawthorne adds that the picture of Hilda attracted considerable attention and was thought to have been suggested by a copy of Guido's "Beatrice." The young artist called the picture "Innocence, dying of a blood-stain," and was laughed at for his trouble, for a viewer was all too apt to assume that the subject of the painting had perpetrated some dark deed to cause her to have that sad expression. But the young artist was insistent. " 'Can you look at the innocent anguish in her face, and ask that question?' " he demands. " 'No; but, as I read the mystery, a man has been slain in her presence, and the blood, spurting accidentally on her white robe, has made a stain which eats into her life.' " (378) The artist painted more wisely than he knew, of course, for the parallel of his interpretation with what actually happened is figuratively quite correct.

Two other chapters remain to be considered. Hilda is the only major character in these, for her friends have departed from Rome and she is left to herself with her knowledge of the crime of Miriam and Donatello. At such a time and in such a mood of despondency as is upon her, it is only natural that she turn to the great interest of her life—art—for solace. In Chapter XXXVII, "The Emptiness of Picture Galleries," Hawthorne does three things. First, there is a casual tour of the work of several famous painters that must have delighted readers who were familiar with Rome's art treasures. He also steps aside to make a few comments of his own which are relevant to Hilda and her immediate situation. For examples, he discusses Sodoma's fresco at Siena of Christ bound to a pillar. In her desolation, Hilda wishes to see this picture again, and the implication is that the artist captured emotions (e.g., "a sense of loneliness") which Hilda is experiencing at this time. Finally, and probably most important, Hawthorne illustrates in these two chapters (XXXVII–XXXVIII) the inefficacy of art as a consoling force for sorrowing mankind. He does this by causing Hilda, who is alone in the city to turn to art for comfort in her anxiety. But she has lost her sympathetic insight into the old masters, and with it the ability which had made her the best copyist in Rome. Why and how such a loss? Hawthorne seems to imply that her knowledge of the murder has brought about this "transformation," for he notes that "her capacity of emotion was choked up with a horrible experience," and "it inevitably followed that she should seek in vain, among those friends so venerated and beloved, for the marvels which they had heretofore shown her." (383) However, the fault is not all Hilda's. In writing of certain "Italian masters," Hawthorne puts a portion of the blame on the artists and their approach to their art. They were "not human," he says, "nor addressed their work to human sympathies, but to a false intellectual taste, which they themselves were the first to create. . . . they substituted art instead of nature."

Though Hawthorne does not directly say so, one wonders too if Hilda is not suffering because she has cut herself off from Miriam, her true friend. If this idea is acceptable, it would be another variation on the usual handling of the theme of the fall of man, for it would have Hilda sinning and suffering by deliberately isolating herself from another who needed her help and sympathy.[13]

Hilda, then, can no longer console herself with art. In Chapter XXXVIII, "Altars and Incense," she is to be found making a series of pilgrimages to the churches of Rome. Since art provides no consolation, she has begun to turn to God. Hawthorne toyed with the idea of the Virgin Mary as a mother-image for his character, but suggests his own rejection of Catholicism when he concludes that Hilda "never found just the virgin mother whom she needed." (396) Always there is a human element in the picture or statue which keeps the girl from kneeling to her. Only once does she go this far—at the shrine in St. Peter's which was decorated by the mosaic of Guido's "Archangel Michael and the Demon"—and then she quickly retracts her tribute.

The shrine adjacent to that decorated by the Guido mosaic is adorned with a painting by Guercino. It represents "a maiden's body in the jaws of the sepulchre, and her lover weeping over it; while her beatified spirit looks down upon the scene, in the society of the Saviour and a throng of saints." (401) Hilda comes to wonder whether she may not rise above her despondency and look at her situation as objectively "as Petronilla in the picture looked at her own corpse." This hope born in her foreshadows the scene in the confessional in the next chapter when Hilda does indeed get some relief from her anguish by telling a priest what she has witnessed.

The art in the setting of *The Marble Faun,* so well integrated with plot, theme and characterization, is the most colorful and interesting aspect of this romance. Without it, the book could hardly exist, for it provides an "objective correlative" around which the theme of "transformation"—the spiritual rise through a moral fall—is worked out. Art is used as a device for characterizing the several aspects of all four principal characters. It contributes to thematic development, and such works as the "Faun" and the "Beatrice" are unifying devices for the novel and important to its structure. But even were it not for these matters, the intrinsic value of art as a setting justifies Hawthorne's attempt to capture this aspect of the Roman scene of the 1850's. Surely it is not exaggerating to say that the American romancer was something of a pioneer in developing to such a great extent the role of art in a romantic fictional setting.

[13]Arlin Turner, *Nathaniel Hawthorne, An Introduction and Interpretation* (New York, 1961), p. 64.

PREDATION BY INTRODUCED MUSKELLUNGE ON PERCH AND BASS, I: YEARS 1–5

*James R. Gammon and Arthur D. Hasler**

Introduction

This report summarizes the results of experiments in which young muskellunge were stocked in two small, bog lakes containing small numbers of normally-growing bass and large populations of stunted perch. Johnson (1954) initiated the study. He described the unbalanced perch and bass populations, found that many young bass were eaten by perch and postulated that a reduction in density of the perch would increase bass survival and eventually lead to a better balance between the populations. Similar conditions were found in nearby Corrine Lake and it was included in the study.

From 1953 to 1955, various methods, including the stocking of largemouth bass and walleye pike, netting and local application of rotenone, failed to reduce the numbers of perch. In May, 1956, 400 yearling muskellunge obtained from the Wisconsin Department of Conservation, Woodruff, Wisconsin, were stocked in George Lake. 395 large, young-of-the-year muskellunge were introduced into Corrine Lake in October, 1956.

The objectives of the study were to determine (1) the efficiency of the muskellunge as a predator (2) the growth rates of perch and bass and (3) the mortality rate of stocked muskellunge.

The Experimental Lakes

About 5% of the shoreline of George Lake (17.3 ha) and 80% of that of Corrine Lake (14.6 ha) consist of bog. In George Lake, the littoral area is mostly sand and rubble, while in Corrine Lake it is mostly muck. Aquatic vegetation is sparse in both lakes. There is a mid-summer absence of oxygen below three meters in Corrine Lake and below five and a half meters in George Lake. Morphometric characteristics are described by Gammon (1961).

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METHODS

Fish were captured by a combination of fyke nets, electrofishing and angling. The initial annual estimate was the Schnabel type if less than 25% of the estimated population was marked or a Schumacher–Eschmeyer type if more than 25% were marked. This was followed by a Petersen estimate based on recapture data collected immediately after the initial estimate or during the following year. The majority of sample sizes were higher than those recommended by Robson and Regier (1964) for management studies. The independent estimates for most years were averaged since there was little reason to select one over another. The 1957 Corrine Lake estimates were generally poor because the fyke nets used were left stationary during a study of bass homing (Parker and Hasler, 1959) and the estimate based on 1958 data was regarded as the best. The marks and tags used on George Lake muskellunge permitted the useful calculation of 1956 and 1957 virtual populations, discussed by Parker (1958).

Scales were collected in 1958, 1959 and 1960 from members of all species of fish except muskellunge. These were removed from the right side near the tip of the pectoral fin, mounted dry and projected at 50 diameters magnification by means of a bioscope. Several scales from each fish were examined. Linear relationships between total lengths and anterior scale radii were determined for each population, but an acceptable regression was obtained only for the smallmouth bass, the only population in which good representation of all age groups was attained ($Y = 38.01 + 1.290\ X$, where Y = total length in mm and X = anterior scale radius in mm $\times$ 50). Accurate estimates of this relationship for the other populations were not possible because of the scarcity of largemouth bass younger than age 6 and perch older than age 2. Therefore, the X-intercept (22.8 mm) derived by Parker (1958) for largemouth bass in nearby Flora Lake was used for this species, while an X-intercept of 25 mm was used for perch. These latter correction factors, used in conjunction with a nomograph (Carlander and Smith, 1944; Hile, 1950), led to back-calculated growth rates at ages 1 and 2 which closely corresponded to those obtained by length frequency determinations.

The back-calculated lengths were used to determine the average rates of growth before and after the introduction of the muskelunge and the mean lengths at each age were then compared statistically by means of the "t" test.

The lengths and weights of all largemouth and smallmouth bass captured from 1955 through 1960 were transformed into common logarithms which were then used to calculate a regression of log weight on log length for each year of the study. An analysis of covariance was used to compare the adjusted mean weight found in 1955 with that of each subsequent year. The comparison for perch in George Lake was between a random sample selected from the 1955 catch and the combined catch of 1958, 1959 and 1960. The vast majority of these comparisons showed no statistical differences and it was concluded that the length-weight relationships of all species were unaltered after the introduction of muskellunge.

The food habits of bass and muskellunge were investigated by means of a stomach-flushing apparatus similar to that described by Seaburg (1957). This method has some disadvantages over the traditional procedure, but these were outweighed by the advantage of being able to return the fish to water unharmed, after flushing out the stomach. The stomach contents were examined, identified and enumerated as to frequency of occurrence.

Results

Largemouth Bass

There was little annual variation in the number of largemouth bass two years old and older before the introduction of muskellunge into George Lake (Table 1 and Figure 1). The relatively low estimate of 1952 does not include age II bass. Enough young bass entered the population annually to balance the losses during this period. The population doubled in size in 1957, apparently because of an unusually successful hatch in 1954, also recorded in nearby Flora Lake by Parker (1956), then decreased to its former level. With the exception of 1958, young largemouth bass were notably absent following the introduction of muskellunge. This was not the result of poor hatching conditions, because good numbers of fry were observed in 1957 and 1959 and excellent hatches occurred in 1958. This latter year class was only moderately abundant by 1959 and almost absent by 1960. With little recruitment, the population steadily declined following the introduction of muskellunge.

The changes in the largemouth bass population of Corrine Lake were generally similar, but more extreme (Table 2). Beginning in 1954 at a fairly high level, the population level dropped steadily until 1960. Few young bass entered the population following the introduction of muskellunge (Figure 2). An excellent hatch of young was observed in 1957, but few were found the next year. Reproductive success was poor thereafter until 1960 when fair numbers were again observed.

The mean length, its variance and 95% confidence interval at each age before and after the introduction of the muskellunge and the statistical comparison of each pair of means at each age are summarized in Tables 3 and 4. The only statistically significant

TABLE 1. SUMMARY OF POPULATION ESTIMATES OF LARGEMOUTH BASS OF AGE GROUP II AND OLDER IN GEORGE LAKE

Date	Sample Size	No. Recaps.	Estimated Population	95% Confidence Interval	Type of Estimate	Average of Estimates
1951[1]	55	25	93		S	
1951[1]	46	25	101	79–140	P (1952 data)	97
1952[1]	54	19	75[2]		S	
1952[1]	51	35	78[2]	66–101	P (1953 data)	77
1953[1]		45	27[3]		S	
1954	34	7	115		S	115
1955	145	321	147	122–166	SE	147
1956	66	24	132	98–198	SE	
1956	24	14	102	75–160	P (1957 data)	115
1957	69	16	200	149–302	SE	
1957	52	16	240	163–400	P (1958 data)	220
1958	53	26	88	63–146	SE	
1958	47	25	100	78–138	P (1959 data)	94
1959	35	13	112	53–∞	SE	
1959	26	10	91	57–182	P (1960 data)	101
1960	22	4	76	37–∞	SE	76

[1]Johnson, W. E. (1954).
[2]Excluding age group II.
[3]Age group II only.
S—Schnabel estimate.
P—Petersen estimate.
SE—Schumacher–Eschmeyer estimate.

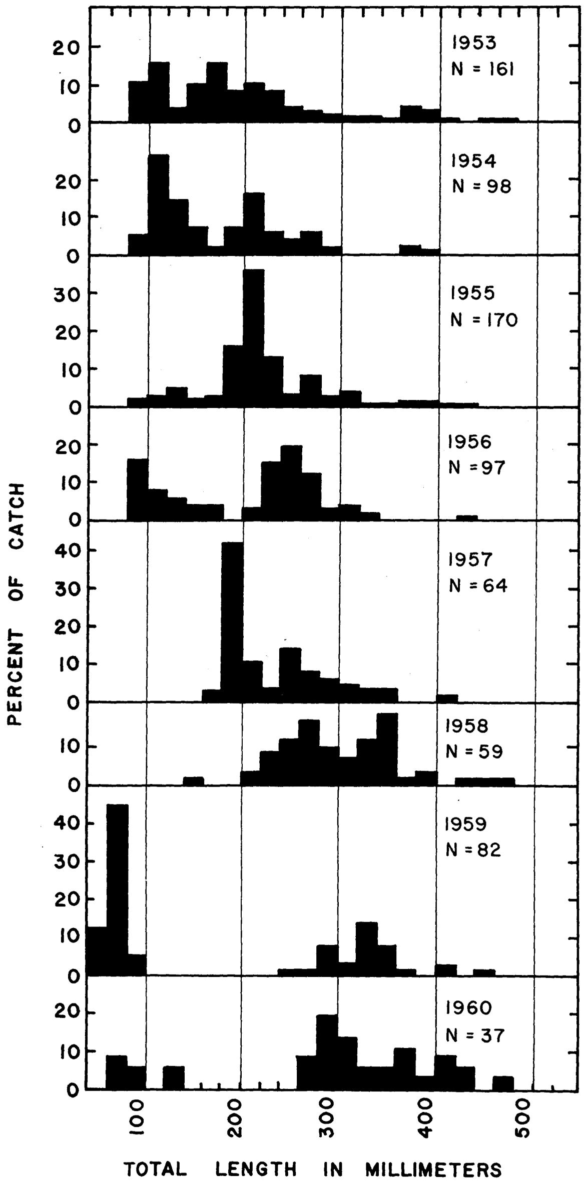

FIGURE 1. Annual catch of largemouth bass in George Lake from 1953 through 1960.

TABLE 2. SUMMARY OF POPULATION ESTIMATES OF NATIVE LARGEMOUTH BASS, AGE GROUP II AND OLDER, IN CORRINE LAKE

DATE	SAMPLE SIZE	NO. RECAPS.	ESTIMATED POPULATION	95% CONFIDENCE INTERVAL	TYPE OF ESTIMATE	AVERAGE OF ESTIMATES
1954.........	128	26	207	156–308	SE	
1954.........	188	54	445	349–587	P (1954 data)	326
1956.........	279	108	231	192–29C	SE	
1956.........	54	45	228	200–270	P (1957 data)	230
1957.........	88	36	58	30–100	SE	
1957.........	58	23	136	98–209	P (1958 data)	136
1958.........	110	44	77	62–101	SE	
1958.........	41	23	103	82–132	P (1959 data)	90
1959.........	58	13	94	66–156	SE	94
1960.........	8	0				40?

S—Schnabel estimate.
P—Petersen estimate.
SE—Schumacher–Eschmeyer estimate.

change in the growth of largemouth bass in George Lake was a reduced rate of growth in young-of-the-year. In Corrine Lake a statistically significant decrease occurred at age five.

Smallmouth Bass

The changes in the numbers of smallmouth bass, of George Lake, are quite different from those of the largemouth bass (Table 5). An initial increase in numbers occurred in 1956 owing to a large 1954 year class. Unlike the largemouth bass, however, the numbers did not return immediately to the original level but remained fairly level at more than twice the former abundance. This high level was maintained by a small, but steady production of young bass during the years following 1956 (Fig. 3), although a decline was measured in 1960.

A statistically significant increase in rate of growth was demonstrated only at age three (Table 6).

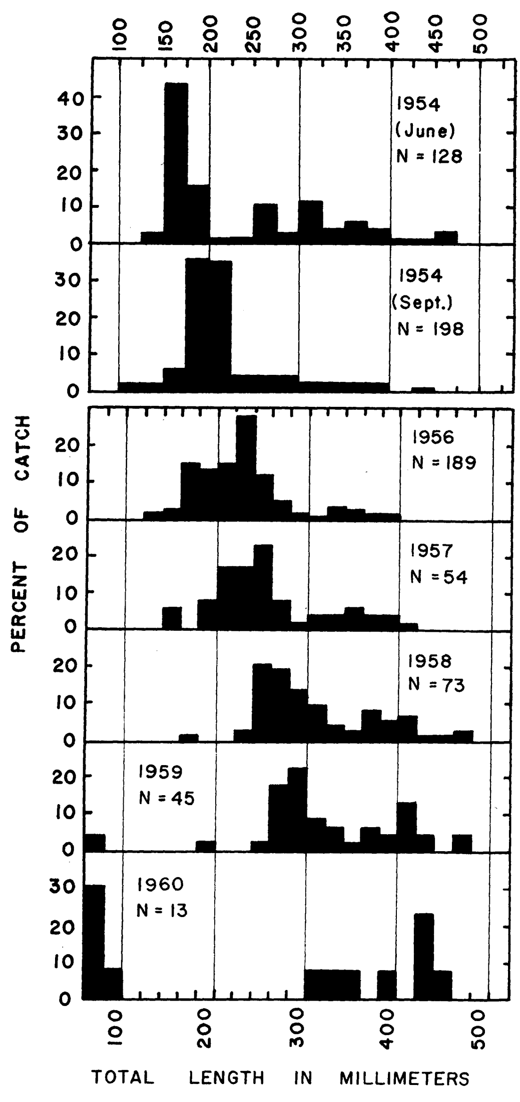

FIGURE 2. Annual catch of largemouth bass in Corrine Lake from 1954 through 1960.

TABLE 3. SUMMARY OF STATISTICS FOR COMPARISON OF THE GROWTH OF LARGEMOUTH BASS IN GEORGE LAKE BEFORE AND AFTER THE INTRODUCTION OF MUSKELLUNGE

AGE	PERIOD OF OBSERVATION								t
	Pre-treatment				Post-treatment				
	No.	s^2	mean length (mm)	$t_{05}s_{\bar{x}}$	No.	s^2	mean length (mm)	$t_{05}s_{\bar{x}}$	
1.........	42	284.3	82.8	5.25	8	35.4	70.8	4.98	3.616**
2.........	36	1115.6	159.6	11.32	9	1058.9	181.9	25.01	—1.695
3.........	31	1452.3	212.5	13.97	13	2033.7	231.5	27.25	—1.429
4.........	23	1581.9	246.4	17.20	20	1498.2	266.6	18.14	—1.682
5.........	17	1793.7	269.1	21.78	21	1246.5	293.2	16.07	—1.914
6.........	11	1378.9	295.6	24.94	24	1432.7	311.5	15.99	—1.160
7.........	7	1317.3	332.4	33.57	20	1443.3	331.0	17.78	0.091
8.........	5	1477.7	348.2	47.72	14	1650.6	342.5	23.46	0.273
9.........	3	2863.0	378	132.93	11	1024.7	345.6	21.50	1.363
10.........					8	1866.0	351.6	36.12	

**Acceptance probability 0.01.

TABLE 4. SUMMARY OF STATISTICS FOR COMPARISON OF THE GROWTH OF UNTAGGED LARGEMOUTH BASS IN CORRINE LAKE BEFORE AND AFTER THE INTRODUCTION OF MUSKELLUNGE

AGE	PERIOD OF OBSERVATION								t
	Pre-treatment				Post-treatment				
	No.	s^2	mean length (mm)	$t_{05}s_{\bar{x}}$	No.	s^2	length (mm)	mean $t_{05}s_{\bar{x}}$	
1.........	27	127.7	79.5	4.47					
2.........	27	586.5	151.8	9.58					
3.........	27	859.6	194.5	11.60					
4.........	19	1033.8	239.3	15.50	7	446.3	222.4	19.54	1.283
5.........	9	1132.6	297.1	25.87	10	615.6	266.7	17.75	2.257*
6.........	7	1363.5	336.9	34.15	10	1261.1	309.0	25.40	1.569
7.........	5	1163.7	361.8	42.35	4	2035.7	343.5	71.79	0.695
8.........	2	98.0	354.0	88.94	4	988.3	379.5	50.02	—1.064
9.........					3	276.5	412	41.31	
10.........					2	761.0	424	247.86	

*Acceptance probability <0.05.

TABLE 5. SUMMARY OF POPULATION ESTIMATES OF SMALLMOUTH BASS AGE GROUP II AND OLDER IN GEORGE LAKE

Date	Sample Size	No. Recaps.	Estimated Population	95% Confidence Interval	Type of Estimate	Average of Estimates
1951[1]	52	21	87		S	
1951[1]	55	33	87	70–115	P (1952 data)	87
1952[1]	68	29	81		S	
1952[1]	37	21	119	90–160	P (1952 data)	97
1952[1]	54	41	90	80–115	P (1953 data)	
1953[1]	?	34	60[2]		S	60
1954	25	2	97		S	97
1955	87	137	94	93– 95	SE	94
1956	138	82	203	176–239	SE	
1956	68	50	188	164–228	P (1957 data)	195
1957	101	63	147	116–202	SE	
1957	96	27	360	262–510	P (1958 data)	250
1958	109	40	238	192–313	SE	
1958	84	40	229	170–305	P (1959 data)	233
1959	84	26	249	199–333	SE	
1959	66	32	173	135–241	P (1960 data)	211
1960	56	21	132	104–179	SE	132

[1]Johnson, W. E. (1954).
[2]Age group III and older.
S—Schnabel estimate.
P—Petersen estimate.
SE—Schumacher–Eschmeyer estimate.

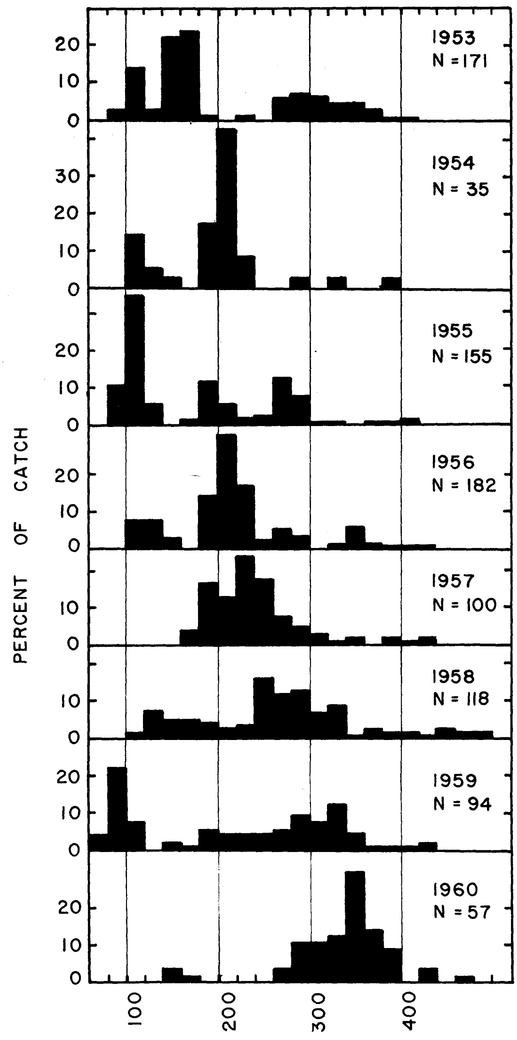

FIGURE 3. Annual catch of smallmouth bass in George Lake from 1953 through 1960.

Perch

The numbers of George Lake perch were decreasing before the muskellunge introduction (Table 7). By 1957 the numbers were so low that no population estimates could be obtained. In 1957 an effort of 104 fyke-net-days yielded only 21 perch. Ten days of fyke

TABLE 6. SUMMARY OF STATISTICS FOR COMPARISON OF THE GROWTH OF UNTAGGED SMALLMOUTH BASS IN GEORGE LAKE BEFORE AND AFTER THE INTRODUCTION OF MUSKELLUNGE

AGE	PERIOD OF OBSERVATION								t
	Pre-treatment				Post-treatment				
	No.	s^2	mean length (mm)	$t_{05}s_{\bar{x}}$	No.	s^2	mean length (mm)	$t_{05}s_{\bar{x}}$	
1	81	59.0	89.6	1.70	40	153.2	93.2	3.96	—1.621
2	69	361.2	154.0	4.58	46	344.4	155.8	5.53	—0.508
3	53	544.1	202.0	6.43	38	479.6	218.6	7.19	—3.433**
4	25	722.2	254.0	11.09	35	777.4	265.5	7.22	—1.591
5	15	1122.4	295.5	18.56	19	725.7	304.8	12.99	—0.895
6	11	1020.1	345.1	21.46	10	1121.9	332.2	23.96	0.903
7	7	1655.2	378.0	37.63	7	845.3	348.6	26.89	1.556
8	3	250.5	414	39.32	6	1493.4	384.0	40.56	1.271
9	3	90.5	430	23.64	2	1478.0	429	345.40	0.062
10	3	212.5	443	36.21					

**Acceptance probability <0.01.

TABLE 7. SUMMARY OF POPULATION ESTIMATES OF AGE GROUP II AND OLDER PERCH IN GEORGE LAKE

DATE	SAMPLE SIZE	NO. RECAPS.	ESTIMATED POPULATION (THOUSANDS)	95% CONFIDENCE INTERVAL (THOUSANDS)	TYPE OF ESTIMATE	AVERAGE OF ESTIMATES
1953[1]	2880	30	157.9		S	
1953[1]	2299	48	137.9	96–221	P (1953 data)	147,000
1954			107.7		P	107,700
1955	6654	299	61.3		S	
1955	3124	173	120.2	88–149	P (1955 data)	90,720
1956	1748	102	22.1		S	
1956	1290	56	40.3	30– 55	P (1956 data)	31,200
1957 to 1960	NO ESTIMATE POSSIBLE					

[1]Johnson, W. E. (1954).
S—Schnabel estimate.
P—Petersen estimate.
SE—Schumacher–Eschmeyer estimate.

netting and electrofishing in May, 1958, produced only 18 small adult perch. The 19,600 perch removed by netting in 1953 and 1954 may have contributed to the early decline. The age structure can be seen in Fig. 4. Despite the extreme paucity of mature perch, excellent annual hatches of young were noted through 1960.

The moderately dense perch population of Corrine Lake increased slightly prior to the muskellunge introduction, stabilized at about 10,000 individuals thereafter, and then declined pre-

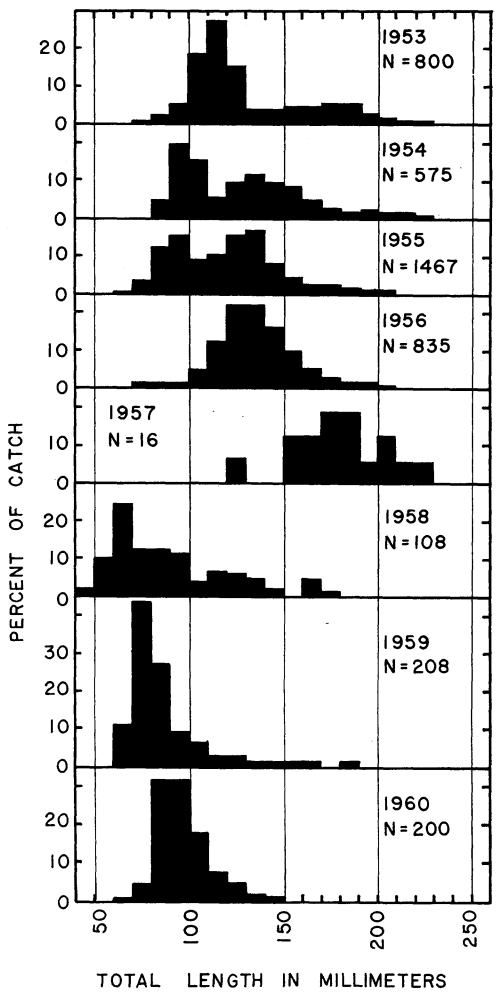

FIGURE 4. Annual catch of perch in George Lake from 1953 through 1960.

cipitously in 1959 (Table 8). In 1960 the age structure was similar to the George Lake population (Fig. 5).

An increase in the growth of the perch during the first two years of life occurred after the predators were introduced into George Lake (Table 9), but there was no increase in the growth of older fish. In Corrine Lake the average growth rate remained about the same (Table 10). The perch in both lakes grew at about the same rate as those in Weber and Silver Lakes (Schneberger, 1935) and Flora Lake (Parker, 1958). The growth rate of George Lake perch was also about the same as that found earlier by Johnson (1954).

Muskellunge

A high mortality seems to have taken place in George Lake muskellunge (Table II). Possibly as many as 25% perished during

TABLE 8. SUMMARY OF POPULATION ESTIMATES OF PERCH, AGE GROUP II AND OLDER, IN CORRINE LAKE FROM 1954 THROUGH 1960

DATE	SAMPLE SIZE	NO. RECAPS.	ESTIMATED POPULATION (THOUSANDS)	95% CONFIDENCE INTERVAL (THOUSANDS)	TYPE OF ESTIMATE	AVERAGE OF ESTIMATES
1954.........	469	9	8.7		S	7,630
1954.........	527	35	6.5	4.8–9.5	P (1954 data)	
1956.........	511	27	10.3		S	
1956.........	1959	102	9.8	7.5–12.9	P (1956 data)	10,030
1957.........	414	85	1.2	1.0– 1.6	SE	
1957.........	459	87	2.2	1.9– 2.6	P (1957 data)	11,200
1957.........	1016	37	11.2	8.3–15.6	P (1958 data)	
1958.........	1016	56	7.0		S	
1958.........	283	24	12.0	8.5–18.0	P (1958 data)	9,480
1959.........	294	27	1.9		S	1,900
1960.........	NO ESTIMATE POSSIBLE					

S—Schnabel estimate.
P—Petersen estimate.
SE—Schumacher–Eschmeyer estimate.

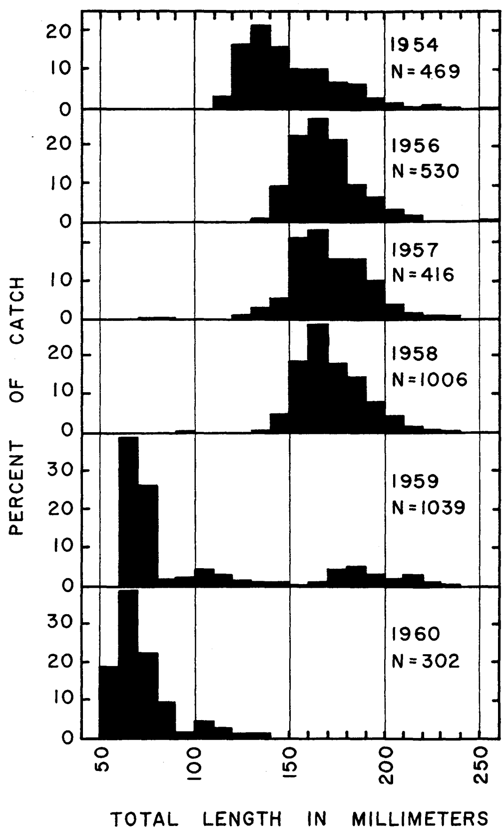

FIGURE 5. Annual catch of perch in Corrine Lake from 1954 through 1960.

TABLE 9. SUMMARY OF STATISTICS FOR COMPARISON OF THE GROWTH OF YELLOW PERCH IN GEORGE LAKE BEFORE AND AFTER THE INTRODUCTION OF MUSKELLUNGE

AGE	PERIOD OF OBSERVATION								t
	Pre-treatment				Post-treatment				
	No.	s^2	mean length (mm)	$t_{05}s_{\bar{x}}$	No.	s^2	mean length (mm)	$t_{05}s_{\bar{x}}$	
1..........	31	33.1	55.4	2.11	43	127.0	62.0	3.47	—3.327**
2..........	17	148.9	81.9	6.28	47	129.2	93.1	3.35	—3.412**
3..........	6	115.8	114.8	11.30	14	189.8	112.8	7.95	0.323
4..........	4	220.7	149.0	23.64	8	368.3	139.5	15.65	0.861
5..........					5	75.8	161.2	10.81	

**Acceptance probability <0.01.

TABLE 10. SUMMARY OF STATISTICS FOR COMPARISON OF THE GROWTH OF YELLOW PERCH IN CORRINE LAKE BEFORE AND AFTER THE INTRODUCTION OF MUSKELLUNGE

AGE	PERIOD OF OBSERVATION								t
	Pre-treatment				Post-treatment				
	No.	s^2	mean length (mm)	$t_{05}s_{\bar{x}}$	No.	s^2	mean length (mm)	$t_{05}s_{\bar{x}}$	
1..........	50	46.8	67.6	1.95	31	60.8	65.7	2.86	1.188
2..........	41	130.2	103.6	3.60	39	72.5	93.0	2.76	4.739**
3..........	34	132.9	129.7	4.04	15	285.4	124.2	9.39	1.145
4..........	30	194.3	145.8	5.21	9	569.2	154.8	18.34	—0.958
5..........	20	197.4	163.4	6.58	11	288.7	160.4	11.41	0.519
6..........	11	271.0	172.8	11.06	15	132.7	174.4	6.38	—0.288

**Acceptance probability <0.01.

TABLE 11. SUMMARY OF THE ESTIMATES OF THE MUSKELLUNGE POPULATION IN GEORGE LAKE FROM 1956 THROUGH 1960

DATE	SAMPLE SIZE	NO. RECAPS.	ESTIMATED POPULATION	95% CONFIDENCE INTERVAL	TYPE OF ESTIMATE	AVERAGE OF ESTIMATES
May 1956....			400			400
June 1956....	104	27	226	163–369	SE	
			274		V	300
	59	15	378	346–400	P (1957 data)	
June 1957....	58	8	210	150–350	SE	
			178		V	
	45	8	290	217–400	P (1957 data)	250
	72	15	261	181–400	P (1958 data)	
May 1958....	72	14	213	171–281	SE	
	44	23	137	108–189	P (1959 data)	175 [1]
May 1959....	39	11	113	73–400	SE	130
June 1960....	15	3	67	22–400	SE	67

P—Petersen estimate.
SE—Schumacher–Eschmeyer estimate.
V—Virtual population.
[1]45 muskellunge removed in August 1957.

the 49 day period following their introduction. A weighted estimate of the subsequent survival rate (0.76) was calculated as follows:

$$s = \frac{N_2 + N_3 + \ldots . + N_n}{N_1 + N_2 + \ldots . + N_{n-1}}$$

where s = annual survival rate
N_1 = estimated population size in 1956
N_2, N_3, etc. = estimated population size in later years

In Corrine Lake, where a similar mortality did not occur (Table 12), the estimated annual survival rate, excluding the 1960 estimate, was 0.87. These survival rates are higher than that reported by Crossman (1956), but are similar to the estimates of 0.78 and 0.71 derived from the catch data of Schloemer (1936) and Helm (1960).

TABLE 12. SUMMARY OF THE POPULATION ESTIMATES OF THE MUSKELLUNGE IN CORRINE LAKE FROM 1956 THROUGH 1960

DATE	SAMPLE SIZE	NO. RECAPS.	ESTIMATED POPULATION	95% CONFIDENCE INTERVAL	TYPE OF ESTIMATE	AVERAGE OF ESTIMATES
Oct. 1956.....			395			395
June 1957....	30	4	116		S	
	79	13	182	113–339	P (1957 data)	325
	141	13	325	201–604	P (1958 data)	
May 1958....	133	48	277	212–393	SE	
	81	33	346	272–497	P (1959 data)	310
May 1959....	79	15	263	154–984	SE	
	79	15	227		S	245
1960....	30	0				150?

S—Schnabel estimate.
P—Petersen estimate.
SE—Schumacher–Eschmeyer estimate.

During 1958 and 1959 the stomach contents of 220 muskellunge were examined (Table 13). About one-third of these contained food, all of which was fish except for two gyrinid beetles. Other studies have shown the muskellunge to be almost exclusively piscivorous, (Hourston, 1952; Parsons, 1958; Anderson, 1948). The bulk of the diet consisted of perch, the ratio of smaller to larger perch eaten corresponded closely to their actual ratio in the lakes.

The initial population estimates were made by fin-clipping. Beginning in 1958 all muskellunge captured were tagged with numbered plastic tags attached to stainless steel wire which was sewed around the preopercular bone. In 1959 it was found that the wire tended to move posteriorly through the preopercular bone leaving a distinguishable track. Annual tag losses were approximately 20%, a higher loss than that found by Crossman (1956).

Muir (1960) has shown this tag to be deleterious to the growth of muskellunge. There was no adverse effect on the growth of muskellunge in George Lake, but there was in Corrine Lake. An analysis of covariance indicated no difference in the length-weight relationship (see Gammon 1961).

TABLE 13. FREQUENCY OF OCCURRENCE OF FOOD ITEMS IN THE STOMACHS OF MUSKELLUNGE IN GEORGE AND CORRINE LAKES

	George Lake				Corrine Lake			
	1958		1959		1958		1959	
Number empty	27		13		75		31	
Number containing food	18		6		38		12	
Food Items	f	%	f	%	f	%	f	%
Perch								
yearlings and smaller	6	33.3	4	66.7	10	26.3	6	50.0
larger	2	11.1			13	34.2	4	33.3
Largemouth Bass								
yearlings and smaller	7	38.9			2	5.3		
larger								
Smallmouth Bass								
yearlings and smaller								
larger			1	14.3				
Unidentified fish	3	16.7	1	14.3	12	31.6	5	41.7
Coleoptera								
adult	1	5.6						
immature					1	2.6		

The growth rate of muskellunge (Figures 6 and 7) in George Lake decreased considerably from 1959 through 1960. A lack of appropriate food was probably responsible for this, since perch of all sizes were abundant only during the first year following the introduction of muskellunge. Many small perch were available after 1957, but few were larger than four inches, and the muskellunge probably could not capture enough of these to allow for normal growth. It is likely that the depression in growth rate would have occurred earlier except for the production of the extremely large 1958 year-class of largemouth bass. That year the muskellunge grew faster than they did either the previous or the succeeding year. The analysis of stomach contents shows that bass fry and fingerlings were prominent in the diet (Table 13). Growth of muskellunge in Corrine Lake was slow during the first summer, gradually increasing with each year. In the fourth year of life, fish from both populations were of the same length. The growth rate of both populations was below that of the average for muskellunge in Wisconsin (Schloemer, 1936) (Figure 8).

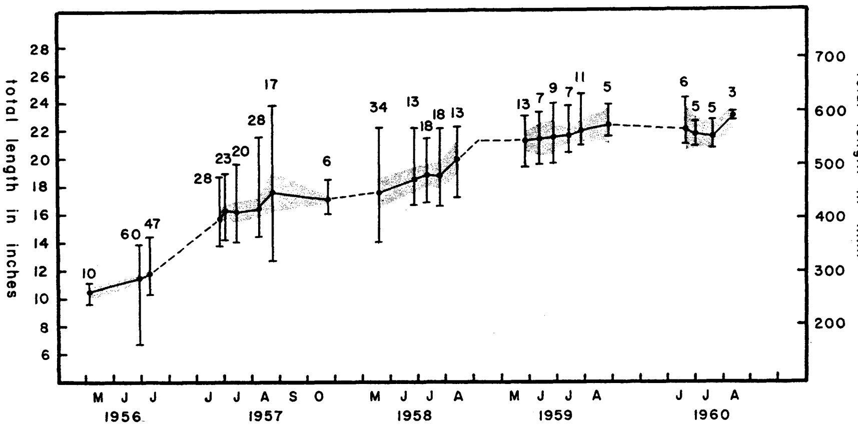

FIGURE 6. Growth of muskellunge in George Lake including the sample size, the range in length, and the mean length and its 95% confidence interval.

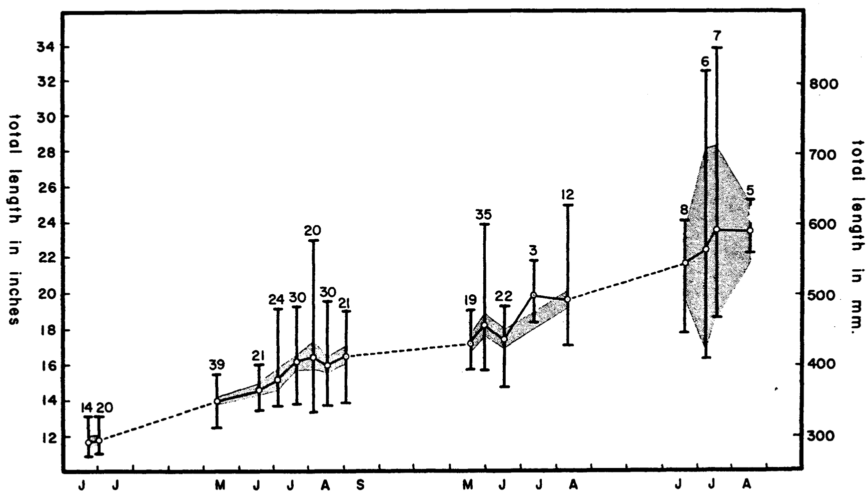

FIGURE 7. Growth of muskellunge in Corrine Lake including the sample size, the range in length, and the mean length and its 95% confidence interval.

DISCUSSION

The investigations of Alm (1946) have shown that cycles of population abundance occur regularly in bog lakes of Sweden which contain European perch, *Perca fluviatilis,* and few other fish. This cycle began with the production of a new, strong year class which proceeded to dominate the population for a number of years by preying heavily on their own young and preventing significant re-

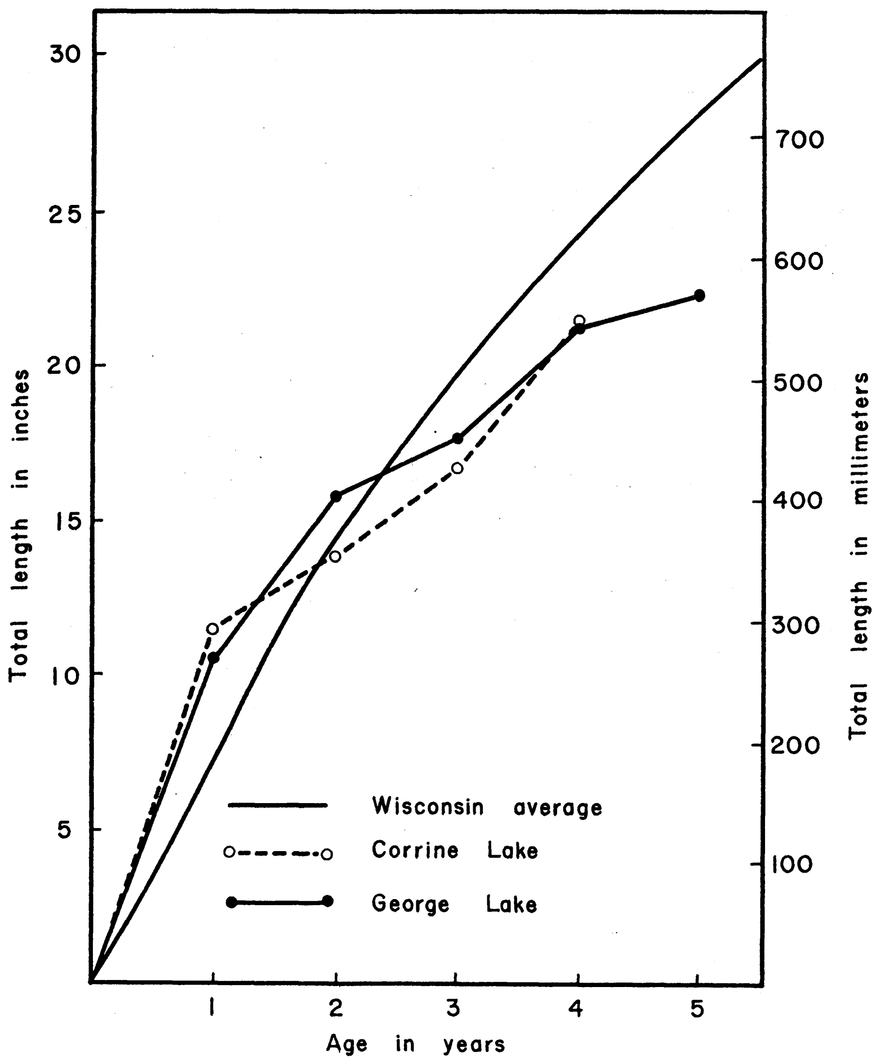

FIGURE 8. The growth rates of muskellunge in George and Corrine Lakes as compared to the average for muskellunge in Wisconsin.

cruitment. Only after this strong year class became greatly diminished in numbers toward the end of their life span was a new, strong year class produced. Although no similar research has been conducted in North America, it seems possible that abundance cycles might also be generated by *Perca flavescens* populations in lakes containing few other species. The two species are similar in many respects, including food habits, and differ primarily in life span. Shorter cycles would be expected in *P. flavescens* populations because of the shorter life span of this species.

The postulation of such a cycle of abundance is helpful in interpreting the events which followed the introduction of muskellunge into George and Corrine Lakes. The course of events following the introduction seem to have depended upon the timing of the introduction in relation to the abundance cycle of the perch.

In George Lake the total number of perch was being reduced by netting between 1953 and 1956. Yearling perch were very abundant in 1955, perhaps beginning a new cycle of abundance, and were probably the main source of food for the small muskellunge in 1956. The muskellunge grew rapidly and by the end of the first summer averaged more than 15 inches in length, long enough to eat any but the largest perch. The combination of predation on the strong 1954 year class and natural mortality of older perch could have led to a collapse of the population. The age distribution of perch changed greatly in 1958, two years after the introduction of muskellunge (Figure 4). The subsequent annual growth of the muskellunge depended greatly upon the success of the annual hatch of perch and bass which was inadequate to allow for normal growth even in the best years. All evidence available supports the view that the perch density remained low between 1957 and 1960 because of predation by muskellunge and bass. Few small perch were present when the muskellunge were introduced, and most of the population consisted of individuals too large to be eaten. Actually, these large perch were probably competing with the muskellunge for the same food items during the first year. The muskellunge grew slowly at first, but had grown sufficiently large by 1958 to prey upon some of the older perch. The number of small perch increased only when the number of old perch decreased (Figure 5). The age distribution of this population, as was the case with the George Lake fish, changed about two years after the introduction of the predator. Moreover, it has been demonstrated by Gammon (1961) and by laboratory studies (Gammon, 1963) that, in this study the prey consumed bears a theoretically feasible relation to the calculated production of predator flesh.

Another aspect of this study that bears discussion is the differential change in the large and smallmouth bass populations following the muskellunge introduction. The largemouth bass populations of both lakes declined steadily in spite of strong year classes produced in 1957 and 1958. The population of adult smallmouth bass actually increased during the same period, although no exceptional year classes were produced in any year. Indeed, consistently fewer young smallmouth bass were observed annually than young largemouth bass.

The difference in the relative abilities of these two species to survive the extensive predatory activity of muskellunge appears to be explainable from different early behavior and habitat preference. Young largemouth bass formed and maintained dense schools from hatching, well into the second summer. Moreover, these schools, as determined by netting and underwater observation, were closely associated with cover of some kind, usually beds of vegetation and brush piles. Smallmouth bass were also found in schools shortly after hatching, but these became more and more diffuse and by mid- or late July disappeared. After this time the individuals were found scattered singly or in small groups in the shallow water near shore, often in rocky or sandy areas. These behavioral patterns have also been noticed by Rodeheffer (1939, 1944), Bennett and Childers (1957) and Ridenhour (1958).

In George and Corrine Lakes the largemouth bass congregate in the very same scattered areas that are preferred by the muskellunge. If the density of muskellunge had been lower or if a greater number of individuals of other species had been available, much better survival of the young largemouth bass might have been expected.

Smallmouth bass, on the other hand, increased in numbers even though no exceptionally large year classes were produced. It seems likely that here, too, the reduction in perch density aided the survival of fry and that the different habits of the smallmouth bass acted in such a manner as to reduce contact between themselves and the muskellunge.

SUMMARY

Two small northern Wisconsin lakes containing perch and bass were stocked with young muskellunge and the changes in population density, growth rate and length-weight relationship were measured. Within a year, perch in one lake decreased from 31,000 individuals to a density which was too low to estimate. Three years lapsed before a comparable reduction occurred in the other lake. Population levels of largemouth bass decreased because of the virtual absence of small bass surviving to the third summer of life, although several strong year classes were produced. Population levels of smallmouth bass increased significantly because of a net increase in recruitment, although no strong year classes were observed. The different responses of these two species appear to be related to differences in the schooling tendencies and habitat preferences of the young. The growth rate of one- and two-year-old perch increased after the reduction in the number of perch. The length-weight relationship of all species remained unchanged. About 25% of the muskellunge stocked in the spring was unaccounted for after

one and a half months, but there was no evidence of a similar high mortality of those stocked in the fall. After the initial loss, a relatively constant annual mortality rate of 20% to 25% was observed in both populations.

ABSTRACT

Two small northern Wisconsin lakes containing perch and bass were stocked with young muskellunge and the changes in population density, growth rate and length-weight relationship were measured. Within a year, perch in one lake decreased from 31,000 individuals to a density which was too low to estimate. Three years lapsed before a comparable reduction occurred in the other lake. Population levèls of largemouth bass decreased because of the virtual absence of small bass surviving to the third summer of life, although several strong year classes were produced. Population levels of smallmouth bass increased significantly because of a net increase in recruitment, although no strong year classes were observed. The different responses of these two species appear to be related to differences in the schooling tendencies and habitat preferences of the young. The growth rate of one- and two-year old perch increased after the reduction in the number of perch. The length-weight relationship of all species remained unchanged. About 25% of the muskellunge stocked in the spring was unaccounted for after one and a half months, but there was no evidence of a similar high mortality of those stocked in the fall. After the initial loss, a relatively constant annual mortality rate of 20% to 25% was observed in both populations. The course of events which followed the introduction of the predator is discussed in relation to a postulated cycle of perch abundance.

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PREDATION BY INTRODUCED MUSKELLUNGE ON PERCH AND BASS, II: YEARS 8–9

*William R. Schmitz and Roland E. Hetfeld**

INTRODUCTION

The changes in the population density, growth rate, and length-weight relationships of the resident fish populations following the introduction of muskellunge into two Wisconsin bog lakes have been described by Gammon and Hasler (1965). During the five years following the introduction: the perch virtually disappeared; the largemouth bass decreased in number; the smallmouth bass, in the lake containing this species, increased in number; increases in the rate of growth of the perch accompanied the reduction of the adult perch population; little change in the rate of growth of the basses occurred, and no changes in the length-weight relationship of any resident species occurred; the annual rate of mortality of the muskellunge was 20–25%, and the growth of this species was exceptionally slow.

This paper describes the results of continued observations on the same lakes during the eighth and ninth years after the introduction of young-of-the-year muskellunge. The objectives of this study are to determine the effect of the decreased stock of muskellunge on the resident fish; to determine changes in the rate of growth of the resident fish; and finally to verify the annual rate of mortality of the predator.

METHODS

The lakes employed in this study are George Lake (17.3 ha) and Corrine Lake (14.6 ha), both in Vilas County. They are described briefly by Gammon and Hasler (1965) and in detail by Gammon (1961).

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*Contribution from the Laboratory of Limnology, Department of Zoology, University of Wisconsin–Madison. We are indebted to Mr. Guido Rahr, Rainbo Lodge, the Notre Dame University, and the Wisconsin Conservation Department for the use of their facilities and lands in this work. The financial support of Rainbo Lodge and the National Science Foundation Research Participation Program are gratefully acknowledged. Dr. Schmitz is Assistant Professor of Zoology and Botany at the University of Wisconsin, Marathon County Center, and Mr. Hetfeld is instructor in biology at Merrill High School, Merrill, Wisconsin.

Except for measurements of the survival of the predator which was estimated in both lakes, most observations were confined to Corrine Lake.

Fish were captured by means of fyke nets. There were two distinct periods of netting in each of two years. Muskellunge were netted in May. In 1963, muskellunge captured were measured, weighed and removed from the lake. In 1964 they were measured, weighed and marked by means of fin clipping and returned to the lake. Population estimates were of the Petersen type (Bailey modification) based on subsequent recaptures later in May and in June. The perch was the only species caught during this May period. The catch of perch during May of 1963 contained disproportionately high numbers of small males and fishing for this species was thereafter relegated to the second netting period in June and early July.

During the June–July period of netting, all species were captured by means of small-mesh fyke nets (approximately 10 mm bar mesh). All perch age II and older were measured, fin clipped and returned to the lake. A Schnabel estimate was made of the perch during this period in each of the two years. It is assumed that marked fish and unmarked fish were equally vulnerable to natural mortality and subsequent fishing by the nets. No adjustment was considered necessary for recruitment into the fishable population because of the brief duration of netting i.e. 21 days in 1963 and 16 days in 1964. Muskellunge captured were removed from the lake. Largemouth bass were measured, weighed and returned. Insufficient numbers of this latter species were caught for purposes of estimating the population. Scale samples were taken from perch. Scales were collected and processed, in the standard manner. The back-calculated lengths obtained for the perch were used to determine the average rates of growth for statistical comparison with the pre-treatment control i.e. the period prior to the introduction of the muskellunge in 1956.

No estimates of the size of the populations of largemouth bass were made. The adult part of the bass population remained so low in Corrine Lake that an estimate of its size was impossible. Seven adults were captured in 1963 and eight in 1964. In 1963, in addition to the seven adults, 80 bass of age I were captured. None of these fish exceeded 140 mm in total length (range = 83 to 132 mm, $\bar{x} = 106.6$ mm, $s_{\bar{x}} = 1.18$, $n = 80$).

The percent catch of the various size classes of the 1963 catch is presented in Fig. 1 and the significance of the distribution is discussed below.

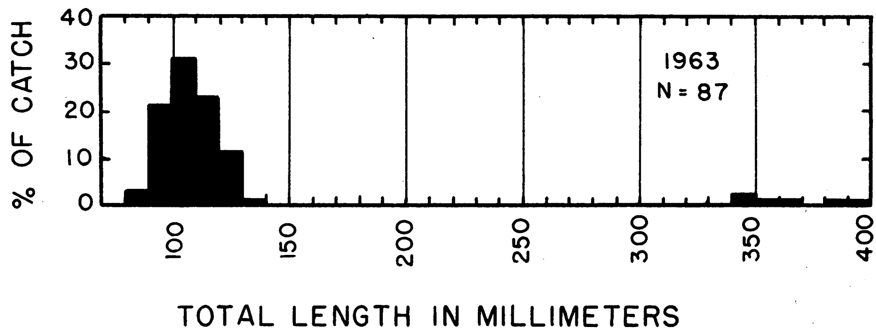

FIGURE 1. Catch of largemouth bass in Corrine Lake in 1963.

Perch

Gammon and Hasler (1965) reported that the part of the perch population age II and older in Corrine Lake was too small to census by 1960. The population estimates of 1963 and 1964 (Table 1), show a recovery in numbers. However, the size-distribution of the 1963–64 fish was not unlike that of 1960 in that few fish exceeded 150 mm in length. By contrast, the population of 1959 included individuals to 240 mm in total length (Figure 2).

The mean size of the individual perch captured in 1964 was greater than that of those captured in 1963 (see Table 2).

Scale samples from the four year classes represented in the perch catches of 1963 and 1964 were used to back calculate the length of these fish during the years since 1959. That these fish grew at a significantly greater rate as compared with the pre-

TABLE 1. POPULATION ESTIMATES OF PERCH IN CORRINE LAKE IN 1963 AND 1964

DATE	AGE GROUP	SAMPLE SIZE	NO. RECAPS.	ESTIMATED POPULATION (THOUSANDS)	95% CONFIDENCE INTERVAL (THOUSANDS)	TYPE OF ESTIMATE
1963	I	12				none possible
1963	II and older	940	38	12.1	8.8–19.1	Schnabel
1964	I					*
1964	II and older	752	158	2.2	1.9– 2.5	Schnabel

*No estimate was made, however exceedingly high catches e.g. as many as 2500 per single net, were counted.

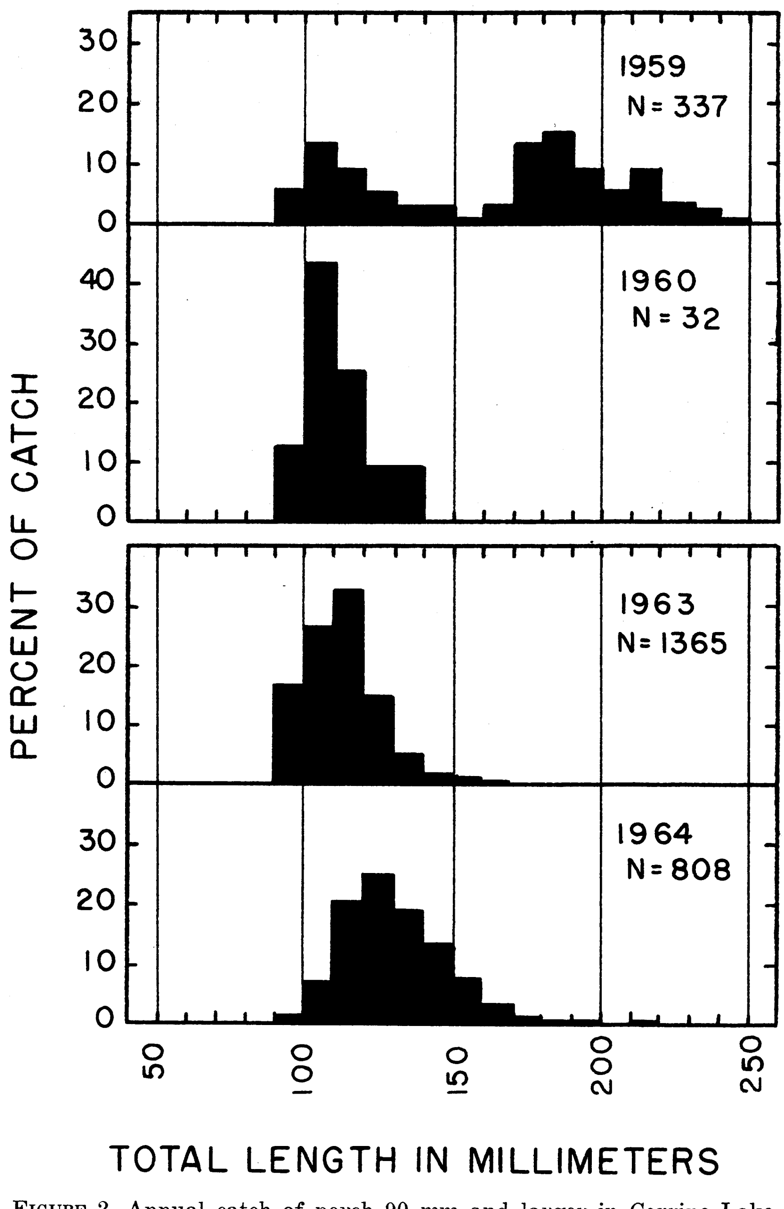

FIGURE 2. Annual catch of perch 90 mm and larger in Corrine Lake 1959–1964.

TABLE 2. MEAN SIZE OF PERCH AGE II AND OLDER IN CORRINE LAKE

YEAR	TOTAL LENGTH				WEIGHT			
	No.	range (mm)	mean (mm)	$s_{\bar{x}}$	No.	range (gm)	mean (gm)	$s_{\bar{x}}$
1963	874	77–168	112.0	0.382	268	3–36	12.1	0.959
1964	342	76–198	128.3	0.948	415	3–80	19.1	0.142

treatment rate of growth is shown in Table 3. Gammon and Hasler found significant increases in the growth of perch in George Lake, only after the decline of the perch population (1965). Likewise, no significant increases in rate of growth were detected in Corrine until after the reduction of the perch that occurred during 1959 and 1960.

Although the analysis is not shown here, still greater increases can be demonstrated by comparison of the rate of growth of only those year classes living after the near demise of the perch in 1960 i.e. the 1960, 1961 and 1962 year classes, with the pretreatment rate of growth.

The 38 muskellunge trapped in Corrine Lake during 1963 were removed from the lake. Petersen (Bailey modification) estimates of the muskellunge populations were made only during 1964. In

TABLE 3. SUMMARY OF STATISTICS FOR THE COMPARISON OF THE GROWTH OF THE PRETREATMENT[1] AND THE 1959–62 YEAR CLASSES[2] OF PERCH IN CORRINE LAKE

AGE	PERIOD OF OBSERVATION								t
	Pretreatment				1959–62 year classes				
	No	s^2	mean length (mm)	$t_{05}s_{\bar{x}}$	No.	s^2	mean length (mm)	$t_{05}s_{\bar{x}}$	
1	50	46.8	67.6	1.95	117	121.7	82.6	2.02	5.88**
2	41	130.2	103.6	3.60	117	224.2	113.7	2.73	2.46*
3	34	132.9	129.7	4.04	51	563.8	130.6	6.66	0.136
4	30	194.3	145.8	5.21	20	172.8	149.0	6.15	0.310
5	20	197.4	163.4	6.58	3	240.5	184	38.5	0.763

*Acceptance probability <0.05.
**Acceptance probability <0.01.
[1]From the data of Gammon and Hasler (1965).
[2]From the 1963–64 collections of this study.

George Lake the best estimate (16 May) was 23 individuals (95% confidence interval = 19–58). The best estimate for Corrine Lake (15 May) was 35 individuals (95% confidence interval = 24–133).

An annual survival rate of 0.76, applied to the last population estimate made by Gammon and Hasler (1965) for this species, in both George and Corrine Lakes, yields approximately the populations estimated for May of 1964, provided the removals are taken into consideration.

The size of the muskellunge is shown in Table 4. Gammon and Hasler (1965) found a marked decrease in the rate of growth of this species only in George Lake (see Fig. 3). The curve of the mean weights indicates that the change in rate must have occurred during 1960 and that this lower rate persisted in the absence of sufficient numbers of forage fish.

TABLE 4. MEAN SIZE OF MUSKELLUNGE IN CORRINE AND GEORGE LAKES

DATE	TOTAL LENGTH				WEIGHT			
	No.	range (mm)	mean (mm)	$s_{\bar{x}}$	No.	range (gm)	mean (gm)	$s_{\bar{x}}$
Corrine Lake								
7 June 63.........	38	510–727	621	6.3	38	737–2098	1316	38.5
5 June 64.........	23	505–930	660	15.5	23	652–5330	1586	183
George Lake								
7 May 63.........	14	595–685	636	7.2	6	879–1474	1124	80.4
1 June 64.........	3	640–744	708	34	2	1474–2183	1828	

DISCUSSION

Cycles of abundance such as those described by Alm (1946), or synchronous variation in strength of year-class observed by LeCren (1955) would complicate the interpretation of the results of any introduction of predator species. However, certain observations made during these eighth and ninth years and in the earlier years as well, can be related directly to the action of the introduced predator, i.e. the continued elimination of nearly all perch and largemouth bass in excess of 150 mm in length (Figs. 1 and 2). That these missing size-classes are not merely the result of reduced reproductive success, is attested to by the failure of strong year classes to enter the larger size classes e.g. 1957, 1958 and 1959 year classes of bass and the 1960 year class of perch (Gammon and Hasler 1965).

The elimination of the larger resident fish and the continued reproductive success of the perch and bass during 1963 and 1964

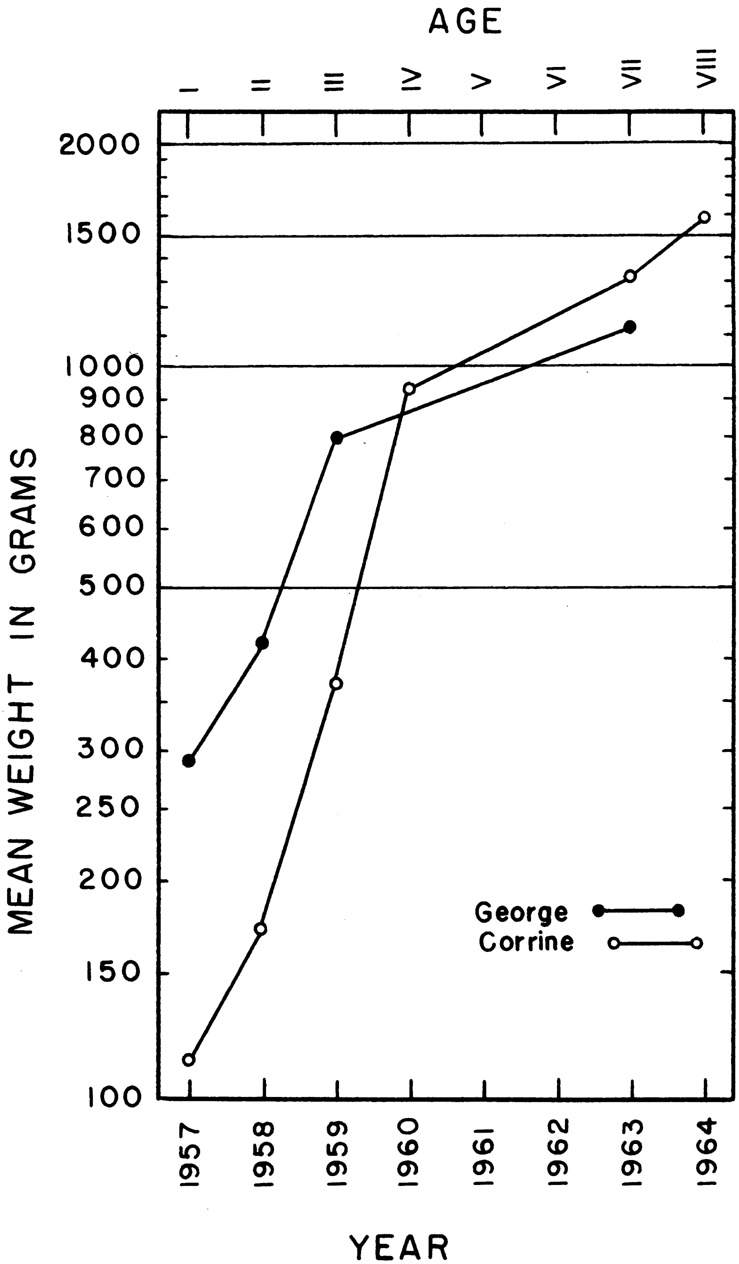

FIGURE 3. The growth in weight of muskellunge in George and Corrine Lakes, ages I through VIII.

suggest that Ricker's (1952) type C predator-prey relationship prevails, where predators take all of the individuals of a prey species that are present, in excess of a certain minimum number. The minimum, in this case, dictated by both minimum size and probably "safe" density of numbers of prey. As the number of predators decrease, the type B predation can be anticipated, where "Predators at any given abundance take a fixed fraction of prey species present, as though there were captures at random encounters" (Ricker 1952). Under these conditions it would further be expected that some survival of prey to the older year classes would prevail. In Corrine Lake, between the years 1959 and 1964, the predators were reduced from 245 individuals having an aggregate weight of 90 kg, to 23 individuals having an aggregate weight of 36 kg. During the same period the catches of perch indicate a trend toward an increased size-range (Fig. 2) and a corresponding increase in mean length and weight (Table 2).

Other events recorded during the eighth and ninth years are manifestations of intraspecific competition. Significant increases in the rate of growth of age I and age II perch were demonstrated for fish living during and after the reduction in the adult population that occurred in 1959–60 (Table 3). No corresponding increase was demonstrated for any age classes of perch during the years of muskellunge activity prior to the decline of prey. Nor would such an increase be expected, since, as Gammon and Hasler (1965) point out, little change occurred in the adult population during the first five years in Corrine Lake. Further, changes in growth rate due to changes in population density would not be expected among age 0 perch because of their food habits eg. they are primarily plankton feeders (Pycha and Smith 1955). It is generally observed that effects of mortality are less likely to be manifested in increased rate of growth in fish stocks that depend upon abundant food sources such as plankton.

Many studies, such as those cited by Larkin (1956), demonstrate the changes of food habits with age in fish. For the pikes, the observations of Frost (1954), Hourston (1952), Ivanova (1959) and others, show that prey-size corresponds with the size of the predator. Examples of the failure of the predator to secure prey of appropriate size resulting in marked reductions in growth of young pike are depicted by Karsinkin (1939), and of older muskellunge by Muir (1960). The effects of competition among the predators in this study is best illustrated by the growth curve for muskellunge in the two lakes (Fig. 3). The abrupt change in rate of growth in Corrine Lake is concomitant with the virtual disappearance of the age II and older perch. The corresponding change in George Lake is described by Hasler and Gammon (1965). Similar changes in the third and fourth summers of growth are reported by Muir (1960) for the Nogies Creek muskellunge and attributed to the lack of large forage species. The muskellunge in Corrine and George Lakes are growing at a rate comparable to the slowest group reported by Muir (1960) and less than the slowest reported by Schloemer (1936) for Wisconsin.

SUMMARY

Measurements of population changes were made eight and nine years after the introduction of muskellunge into lakes containing perch and bass. There was a recovery in numbers of age II perch and older. However, little recruitment into size-classes of either prey fish over 150 mm in total length occurred. The growth rate of age I and II perch was significantly greater after the severe reduction of perch that occurred in 1960. The annual survival rate for the predator in two lakes was 0.8. Marked decreases in the growth rate of the muskellunge bore a temporal relation to the reduction in numbers of the prey species.

ABSTRACT

Measurements of population changes were made eight and nine years after the introduction of age 0 muskellunge into lakes containing perch and bass. There was a recovery in numbers of age II perch and older. However little recruitment into size-classes of either prey fish over 150 mm in total length occurred. The growth rate of age I and II perch was significantly greater after the severe reduction of perch that occurred in the fifth year. The annual survival rate for the predator in two lakes was 0.8. Marked decreases in the growth rate of the muskellunge bore a temporal relation to the reduction in numbers of the prey species. The type of predation and intraspecific competition manifested are discussed.

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HYBRIDIZATION IN *GENTIANA (GENTIANACEAE)*: A RESUME OF J. T. CURTIS' STUDIES[1]

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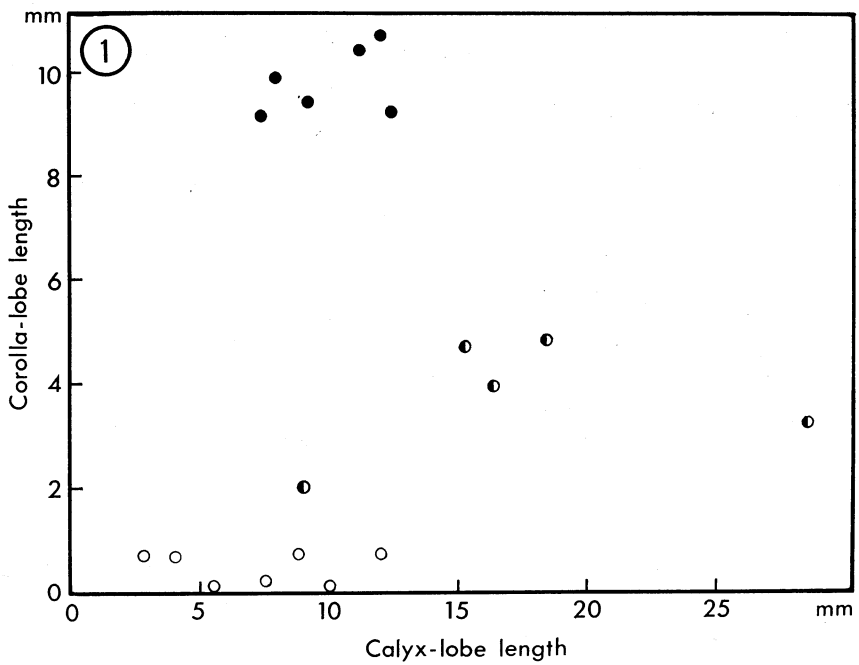
Royal Botanical Gardens, Hamilton, Ontario

The perennial gentians (*Gentiana* L. sensu stricto) were of especial interest to Dr. J. T. Curtis, late professor of botany at the University of Wisconsin. During his lifetime he made many crosses involving various species in this genus, as well as studies of natural hybridization. Although Dr. Curtis did not live to see his studies reach the degree of completion he considered desirable before publication, his meticulously recorded data and carefully preserved specimens appear to be of great potential value to future students of this group. Despite the recent publication of several papers on the taxonomy of *Gentiana,* many questions pertaining to phylogeny within this large genus remain unanswered. Dr. Curtis's records of hybridization, involving both North American and Eurasian species, may provide valuable clues when employed in conjunction with data from additional studies. Illustrations of his specimens should be useful in the interpretation of problematic natural populations. In addition, his data could be useful to plant breeders, as gentians are among the favorites of connoisseurs of hardy perennials.

I am very grateful to Mrs. Curtis for permission to borrow Dr. Curtis's records and specimens, which eventually will be deposited in the University of Wisconsin Herbarium, and to prepare this compilation. In addition, voucher specimens for some of the hybrid swarms are deposited in the University of Wisconsin Herbarium in Madison. I should also like to acknowledge the excellent photographs of the specimens by Mr. Max A. Gratzl of the University of Wisconsin. All photographs are of Dr. Curtis's specimens, and all graphs have been adapted from his graphs.

Three species of *Gentiana* are frequent in southern Wisconsin. All apparently are involved in natural hybridization (see Pringle, 1964). Figure 1 shows certain measurements from a natural hybrid swarm north of Swan Lake, in Columbia County, Wisconsin, on

[1]Contribution no. 4 from the Royal Botanical Gardens, Hamilton, Canada.


1
mm
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Corolla-lobe length
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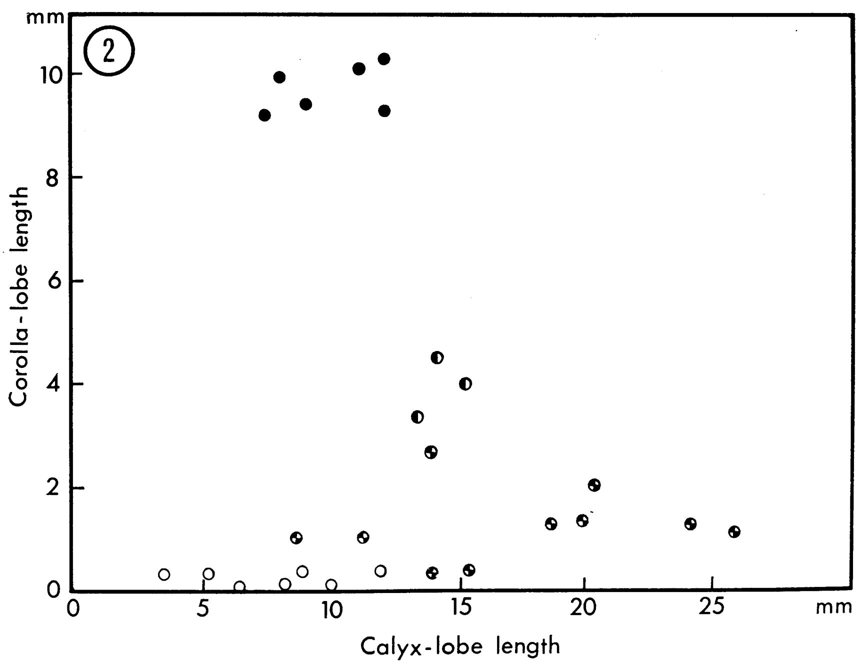
Calyx-lobe length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Calyx-lobe length

the edge of a sedge meadow and adjoining the local country club, which appeared to involve only two of these species, namely *G. andrewsii* Griseb. and *G. puberula* Michx. Specimens from this population have been shown in a previous publication (Pringle, 1964). In Figure 1, plants from this population are contrasted with plants from several pure populations of *G. andrewsii* var. *andrewsii* (the native variety in Wisconsin) and *G. puberula.* To be compared with this representation of a natural hybrid swarm is Figure 2, which shows measurements of two generations of progeny from an experimental cross involving the same species. Figure 3 shows additional measurements from F_1 and F_2 generations from a simi-

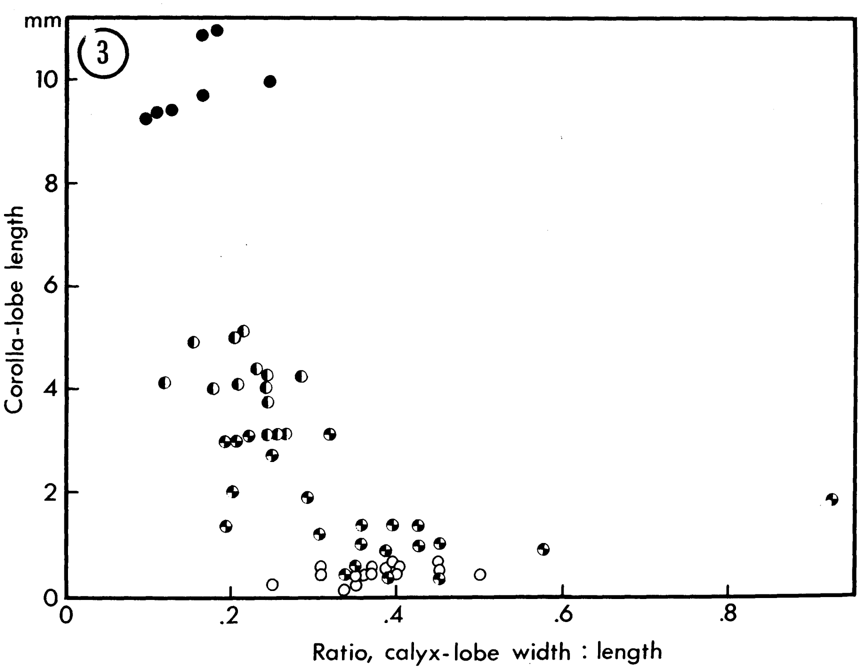
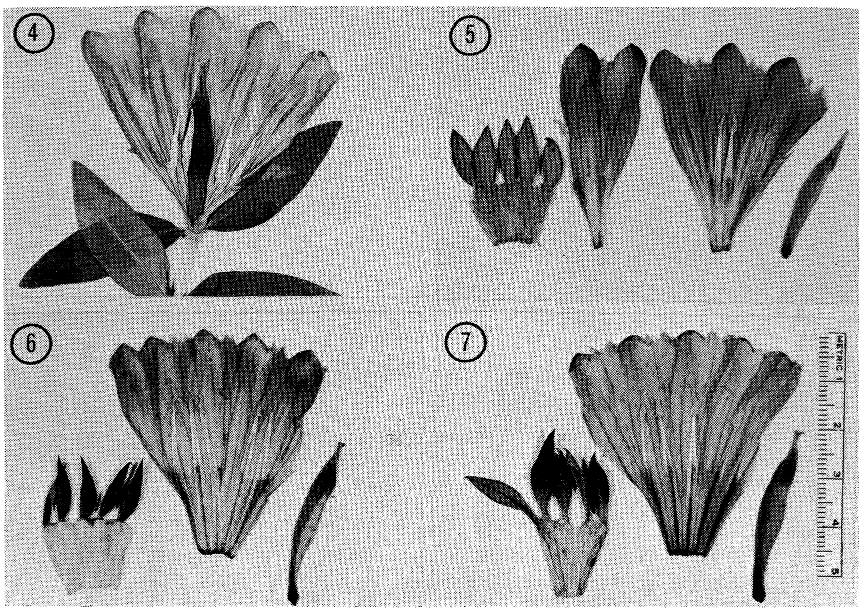


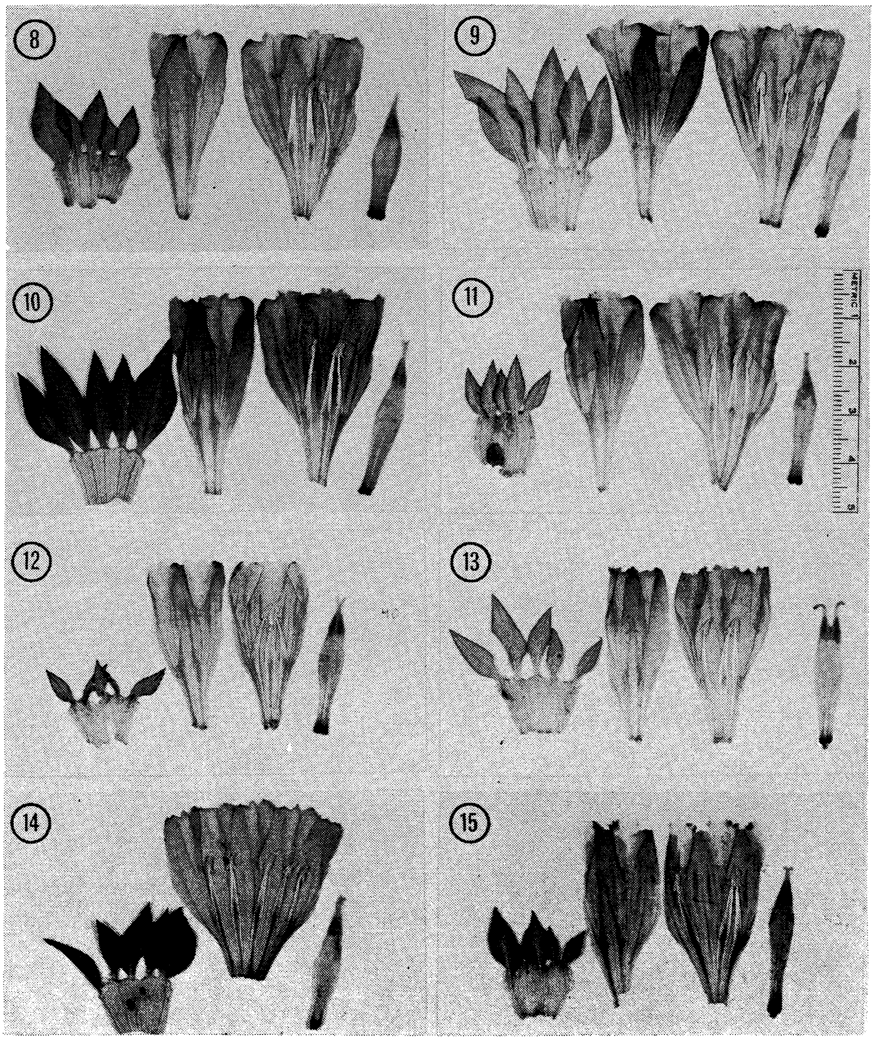
FIGURE 3. Additional measurements from F_1 and F_2 generations from an experimental cross of *G. andrewsii* X *G. puberula,* compared with the parental species. Symbols as in Figure 2.

FIGURES 1 AND 2. *Gentiana puberula* (black dots), *G. andrewsii* (open circles), and their hybrids. Figure 1. A natural hybrid swarm at Swan Lake, Wisconsin (halved circles), compared with pure populations of the parental species. Figure 2. F_1 (halved circles) and F_2 (quartered circles) from an experimental cross compared with populations of the parent species.

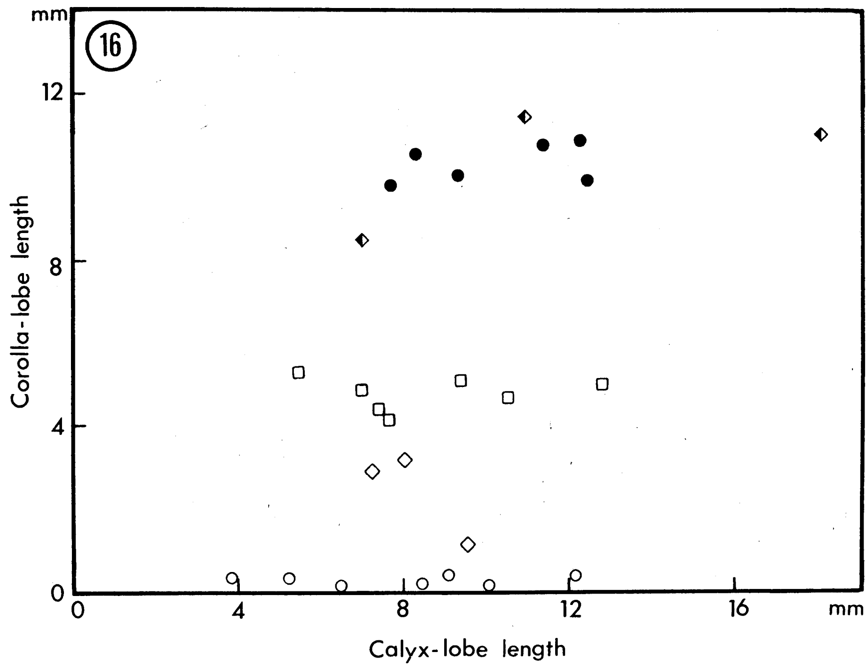
lar cross. Specimens from the F_1 and F_2 generations are shown in Figures 4 to 15. The corolla lobes of the F_2 plants varied widely in size. The corolla shown in Figure 15 is essentially indistinguishable from those of typical *G. andrewsii* in this respect. The hybrid plants tended to have larger calyx lobes than plants of either of the parental species. In the traits measured, the entire F_2 generation was more like the "control" population of *G. andrewsii* than like that of *G. puberula*. The natural hybrid population also appears to have retained a greater similarity in these characteristics to *G. andrewsii*.

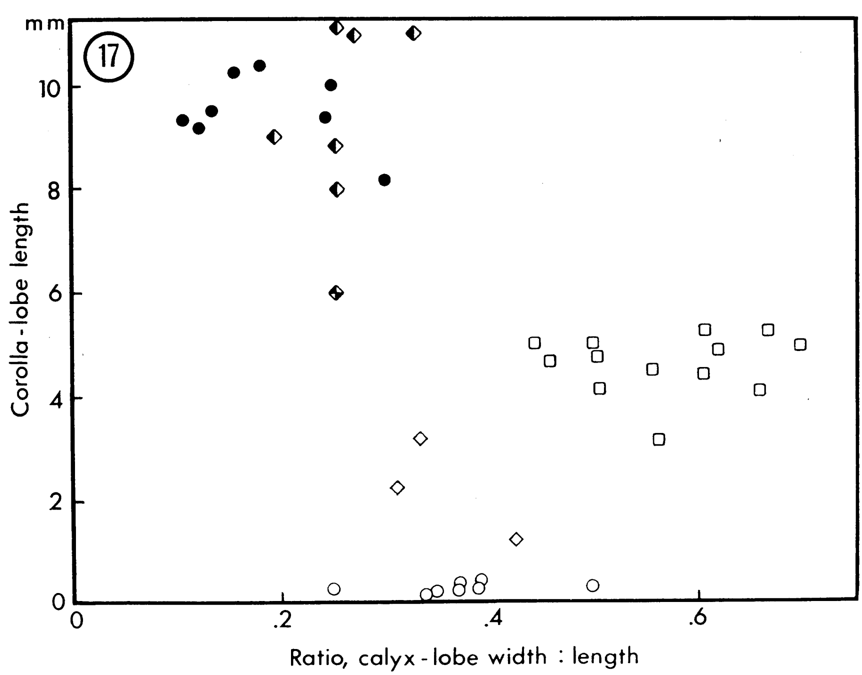
Figures 16 and 17 represent graphically the results obtained by crossing both of the species mentioned above (*G. andrewsii* and *G. puberula*) with *G. alba* Muhl. (*G. flavida* Gray). No specimens of these experimental plants were encountered. However, Figures 18 to 27 are of Dr. Curtis's specimens presumed to be derived from the natural crossing of *G. puberula* with *G. alba*, although *G.*





FIGURES 4–15. Corollas, calyces, and pistils of hybrids produced by crossing *G. andrewsii* X *G. puberula*, X 4/7. Figure 4. F_1. Figures 5–15. F_2.


16
mm
12
8
4
0
Corolla-lobe length
0
4
8
12
16
mm
Calyx-lobe length


17
mm
10
8
6
4
2
0
Corolla-lobe length
0
.2
.4
.6
Ratio, calyx-lobe width : length

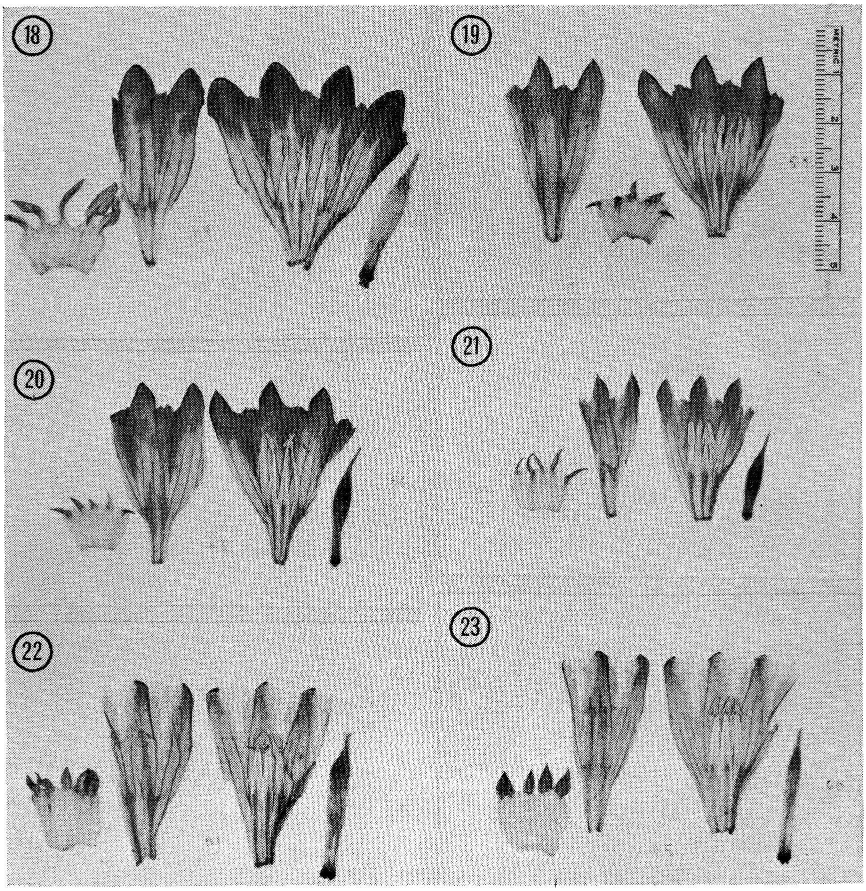
andrewsii may also have been involved to some extent. These specimens were collected in another area also near Swan Lake. Calyx lobes ranged from ovate, as in *G. alba,* to linear, as in *G. puberula* and from strongly keeled, as in *G. alba,* to keelless, as in *G. puberula.* The influence of *G. alba* is manifested in these specimens by low, obliquely triangular free portions of the corolla appendages. (In *G. andrewsii, G. puberula,* and hybrids of these two species these structures are more nearly symmetrical, and bifid.) The color remains well preserved in many of the corollas. In addition, Dr. Curtis recorded the colors of some. The corollas shown in Figures 18–20 were deep blue; in Figure 21, reddish purple; in Figures 22 and 23, white, suffused with light blue on the upper parts of the petals (excluding appendages); in Figure 24, pink; in Figures 25 and 26, white, suffused with pink on the petals; in Figure 27, whitish, as in *G. alba.* The flowers also varied in the degree of closure of their corollas and fusion of their anthers.

In certain areas near Swan Lake, all three of these species grew in close proximity to each other and evidently hybridized. In Figure 28, measurements obtained by Dr. Curtis from this series of apparent polhybrid swarms are contrasted with comparable measurements from plants of each of the three species from pure populations elsewhere in Wisconsin.

Dr. Curtis's breeding experiments involved many additional species, including some in three of the sections into which the genus was divided by Kusnezow (1895). Species native to Wisconsin were obtained locally from the wild. *Gentiana clausa* was obtained from New Hampshire. The other species were raised from seed purchased from Rex D. Pearce, Moorestown, New Jersey. He kept detailed records on the set of seed and its subsequent germination. Table 1 indicates which crosses were attempted and which resulted in the production of germinable seed. In this table, the nomenclature of the Wisconsin species and their hybrids has been brought into conformity with Mason and Iltis (1965) and Pringle (1964).[2] Other names are retained as they appeared in Dr. Curtis's records. The hybrids *G.* X *billingtonii (G. andrewsii* X *G. puberula)* and *G.* X *curtisii (G. puberula* X *G. alba)* had previously been synthesized by Dr. Curtis. Two of the successful crosses

[2]Since it has been recently shown (Pringle 1966) the *G. puberula* type (in P) is a plant of an eastern species, the Prairie Gentian has been renamed *G. puberulenta* Pringle.

FIGURES 16 AND 17. Crosses involving *G. alba. G. alba,* squares; *G. andrewsii,* open circles; F_1 hybrids, *G. alba* X *G. andrewsii,* open diamonds; *G. puberula,* black dots; F_1 hybrids, *G. alba* X *G. puberula,* halved diamonds; F_2 hybrids, quartered diamonds.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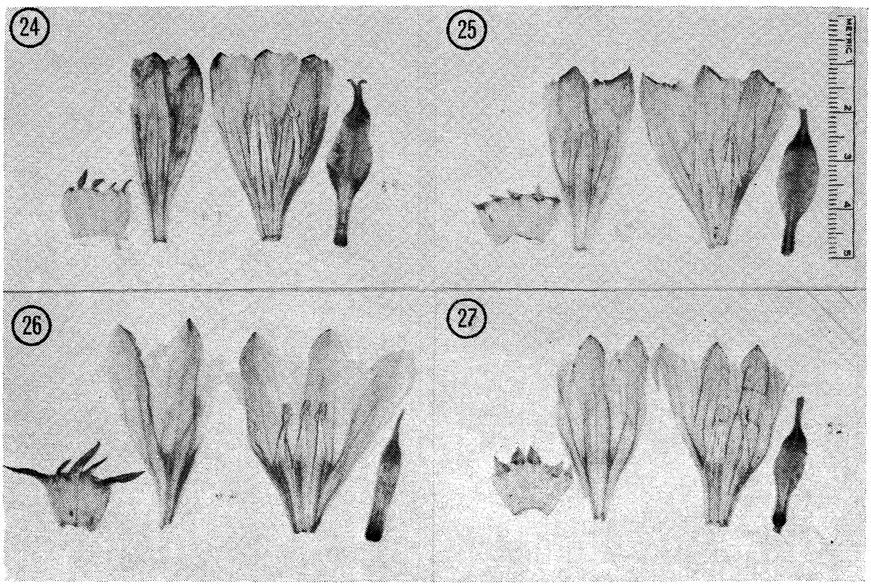
METRIC

were intersectional. In addition, some of those within section Pneumonanthae, such as those involving *G. lagodechiana,* were between species of conspicuously different morphology. Unfortunately, little information is available on the appearance of the hybrids derived from exotic species. According to Mrs. Curtis, many seedlings died in an exceptionally adverse winter. However, the F_1 progeny from the crosses *G. clausa* X *G. septemfida, G. alba* X *G. clausa,* and *G. alba* X *G. andrewsii* are described as having open corollas.



FIGURES 18–27. Corollas, calyces, and pistils from plants in a hybrid swarm at Swan Lake involving *G. alba* and *G. puberula,* X 4/7.

TABLE 1. RESULTS OF DR. CURTIS'S EXPERIMENTAL CROSSES

GENTIANA PISTILLATE PARENT	STAMINATE PARENT																	
	dahurica	*purdomi*	*farreri*	*sino-ornata*	*alba*	*andrewsii*	*asclepiadea*	X *billingtonii*	*clausa*	X *curtisii*	*lagodechiana*	*parryi*	*puberula*	*rubricaulis*	*scabra*	*septemfida*	*setigera*	(X *billingtonii*) X *andrewsii*
Sect. Aptera																		
dahurica Fisch.																		
purdomi Marquand	—	*														+		
Sect. Frigida																		
farreri I. B. Balf.																		
'Macauleyi' (*farreri* X *sino-ornata*)													—					
sino-ornata I. B. Balf.										—			—					
Sect. Pneumonanthae																		
alba Muhl.				*		*		*	*	*	*		*		*	+		
andrewsii Griseb.					*	*		*					*					
asclepiadea L.					*					*			*					
X *billingtonii* Farw.						+	*	*		*			*		*			
clausa Raf.					+				*							+		
X *curtisii* Pringle							*			*	*							
freyniana Bornm. ex Freyn												—						
lagodechiana (Kusn.) Grossheim ex Moellers					*		—			*	*				*			
parryi Gray																	*	
puberula Michx.					*	*	*	*		*	*		*		*	—		
rubricaulis Schwein.					*									*				
scabra Bunge															*			*
septemfida Pall.			—		*				*	*		—			—	*	—	
setigera Gray																		
(X *billingtonii*) X *andrewsii*																		*

* cross successful, seedlings numerous; +, cross successful but fewer than 10 seeds produced or fewer than 10% of seeds germinated; — cross attempted but unsuccessful.

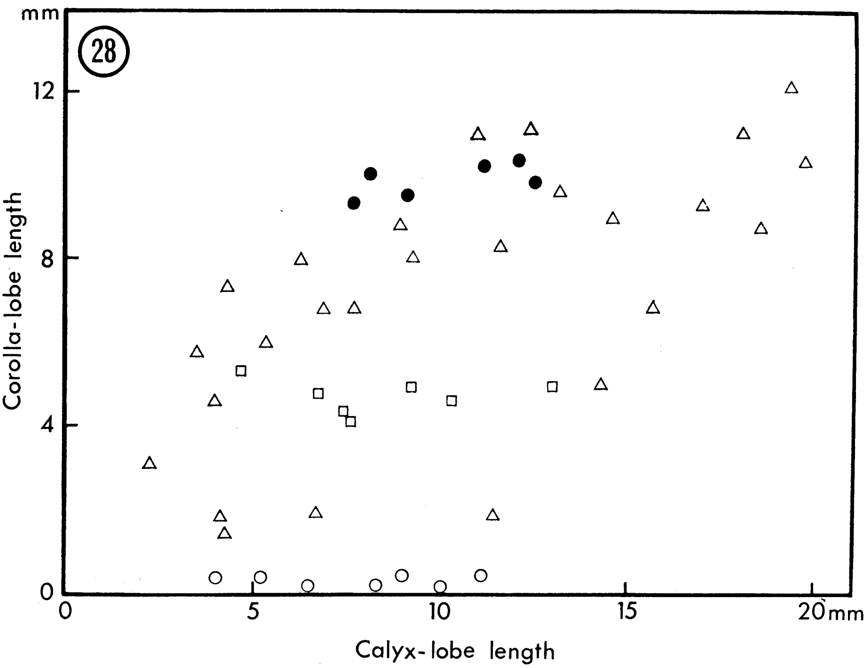


FIGURE 28. Plants from a hybrid swarm at Swan Lake (triangles) involving *G. puberula, G. andrewsii,* and *G. alba,* compared with plants of the parental species from pure populations (symbols as in Figures 16 and 17).

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PRELIMINARY REPORTS ON THE FLORA OF WISCONSIN NO. 53. *GENTIANACEAE AND MENYANTHACEAE*— GENTIAN AND BUCKBEAN FAMILIES

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Herbarium, University of Arizona, Tucson
and
Hugh H. Iltis[2]
Herbarium, University of Wisconsin, Madison

There are few flowers that have inspired nature lovers as much as the gentians. For the gardener, the large flowers, often of an unsurpassedly intense and brilliant blue, are among the most beautiful to grace a rock garden, while the species are among the "fussiest" ever to tax horticultural ingenuity (Wilkie 1950, Berry 1951). For the professional botanist, gentians are rewarding in different ways, and as a group have great promise in the solution of many an evolutionary puzzle. With highly specific ecological requirements (and consequent ecological, geographic, and often seasonal isolation); with intricate, as yet poorly understood, adaptations to insect pollination (such as glands, spurs, nectaries, in addition to various flower colors and shapes); with often minute seeds ideally suited to long-range dispersal (which can be related to geographic disjunctions and migrations of such groups as *Gentianopsis* or *Halenia*); with chromosomal homogeneity and nearly complete interfertility within some genera (e.g. *Gentiana*), and, in contrast, with sharp differences in chromosome number between genera;—with all this intrinsic biological appeal, as well as their beauty, it is not surprising that gentians are beloved by botanists wherever they occur. Let the joy that layman and biologist alike receive from these flowers be to them an admonition—(what with many of our Wisconsin species faced with extinction)—an admonition to exercise fully their social responsibilities: for without both self-restraint in picking and (more importantly) the preservation of samples of the diverse natural plant communities in which gentians live, these brilliant flowers will never gladden the eyes of future generations.

The present study discusses primarily the taxonomy and geography of the Wisconsin *Gentianaceae* and *Menyanthaceae,* while

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[1]University of Arizona, Agricultural Experiment Station, Department of Botany, Journal Article No. 839.

[2]Field work and preparation of manuscript supported in part by the Research Committee of the University of Wisconsin, on funds from the Wisconsin Alumni Research Foundation, the costs of illustrations in part by the Norman C. Fassett Memorial Fund.

other recent publications have dealt more specifically with hybridization in *Gentiana* (Mason 1959; Pringle 1964, 1965) and evolution and migrations of our species of *Gentianopsis* (Iltis 1965). Material from the following herbaria was intensively studied: University of Wisconsin–Madison (WIS), University of Wisconsin–Milwaukee (UWM), Milwaukee Public Museum (MIL), the private herbarium of Katherine Rill (RILL), Clintonville, Wis., and the University of Arizona (ARIZ). In addition a few indisputable records were taken from the studies of Hartley (1962) of the Driftless Area flora, of Gillett (1957) dealing with *Gentianella*, and from Pringle's as yet unpublished monograph of Eastern United States *Gentiana* subgenus *Pneumonanthae*. Each dot on the distribution map represents one or more collections from a particular location, each triangle a county record without specific location. Triangles in Illinois are based on Winterringer and Evers (1960) and Jones and Fuller (1955).

We wish to thank Dr. James Pringle, of the Royal Botanical Gardens, Hamilton, Ontario, for his elucidation of many critical aspects of the Genus *Gentiana* and for a careful reading of the manuscript; Drs. K. F. Parker and L. I. Nevling for checking the U.S. National Herbarium and the Gray Herbarium, respectively, for Wisconsin specimens of *Sabatia* and *Swertia;* Mrs. Katharine Snell, Miss Carol Mickelson and others from the Herbarium of the University of Wisconsin for help with manuscript and maps, and, finally, Mrs. Pat Mason for the meticulous habit drawings of the Wisconsin species.

KEY TO FAMILIES

1. Leaves simple, entire, opposite or subopposite, usually sessile; aestivation imbricate ____________________ *GENTIANACEAE.*
1. Leaves compound (trifoliolate), alternate, petioled; aestivation induplicate-valvate ____________________ *MENYANTHACEAE.*

GENTIANACEAE A. L. DE JUSSIEU GENTAIN FAMILY

[Gillett, J. M. 1963. *The Gentians of Canada, Alaska and Greenland.* Canada Dept. Agric. Publ. 1180. 1–19.]

Annual, biennial or perennial glabrous or minutely puberulous herbs (ours) to 1 m tall, with simple or branched stems. Leaves simple, opposite or subopposite, linear-lanceolate to ovate, or reduced to subulate scales, sessile, entire, exstipulate. Flowers regular, 4- or 5-merous. Corolla funnelform to campanulate. Stamens included, as many as the corolla lobes, inserted on the corolla tube. Pistil with 2 parietal placentae, 1-loculed, superior, the fruit a 2-valved, septicidal capsule. Seeds numerous, small to minute, variously shaped.

KEY TO GENERA

A. Leaves subulate scales 1–4 mm long; flowers minute, 2–5 mm long, 4-merous with free sepals and yellow-green corollas; stems usually unbranched; inconspicuous slender annuals --1. *BARTONIA*.

AA. Leaves linear-lanceolate to ovate; flowers 10–60 mm long, 4- or 5-merous, with sepal bases united into a tube, and often showy, variously colored corollas; stems simple or branched; annuals, biennials, or perennials.

B. Perennials with large, showy, 5-merous (or rarely abnormally 4-merous) sessile or subsessile flowers; corolla with conspicuous folded plaits between the lobes; seeds flattened and winged ------------------2. *GENTIANA*.

BB. Annuals or biennials with 4- or 5-merous pedicellate flowers; corolla without conspicuous plaits between the lobes; seeds variously shaped, not winged.

C. Corolla funnelform or campanulate; anthers straight after anthesis; flowers 4- or 5-merous, variously colored, not pink.

D. Corolla 4- or 5-merous, not spurred, 15–60 mm long, blue, lilac or purple, rarely white.

E. Flowers 5-merous, blue, lilac or purple, 15–25 mm long, clustered in 3- to 10-flowered cymes on short bracteate pedicels, the apiculate lobes entire; calyx lobes with green margins; seeds round, smooth -----------3. *GENTIANELLA*.

EE. Flowers 4-merous, blue or purplish-blue, rarely white, 25–60 mm long, solitary on slender 1–20 cm long ebracteate pedicels, the round lobes fringed; calyx lobes with hyaline margins; seeds oblong-angular, covered with rounded to elongated inflated papillae; ---4. *GENTIANOPSIS*.

DD. Corolla 4-merous, 8–15 mm long, the 4 slender divergent basal spurs 3–5 mm long, greenish, greenish-purple or greenish-yellow ----------5. *HALENIA*.

CC. Corolla salverform with a slender tube; anthers spirally twisted after anthesis; flowers 5-merous, bright pink; rare adventive ca. 8–16 cm tall --6. *CENTAURIUM*.

1. BARTONIA Muhl. ex Willd. Bartonia

[Gillett, J.M. 1959. Revision of *Bartonia* and *Obolaria*. *Rhodora* 61:42–62.]

1. BARTONIA VIRGINICA (L.) B.S.P. Screwstem, Virginia Bartonia
Map 1; Fig. 1.

Slender erect unbranched (rarely branched above or at base)[3] annuals 5–28 cm tall, hemi-saprophytic with reduced roots, chlorophyll content (i.e. plants pale green or yellowish) and leaves, these opposite to sub-opposite subulate scales 1–4 mm long. Inflorescence cymose or reduced to 2 flowers at a node or plants one-flowered. Sepals 4, free, 2–3 mm long, linear-lanceolate. Corolla 3–5 mm long, deeply parted into 4 oblong apiculate lobes; petals yellow-green at anthesis, sometimes fading pink with age. Stamens 4, epipetalous, 2.5 mm long. Anthers 0.8 mm long, with an apical appendage. Pistil about 4 mm long. Seeds very numerous, nearly microscopic (like dust and ca. 0.1 mm $\times$ 0.15 mm) ellipsoidal, rusty brown. $2n = 52$ (Rork 1949).

An "Atlantic Coastal Plain" element (the 3 species of this Eastern N. American endemic genus centering on the Coastal Plain), in Wisconsin rare, mostly in the sandy, acid, often boggy former beds of glacial lakes (esp. Glacial Lake Wisconsin) in the Central Wisconsin Sand Plains, in moist or boggy sedge or sphagnum peat, moist sandy meadows, sandy acid sedge flats, less often on sandy lake shores, sphagnous White Pine–Red Maple woods, wet open sands with scattered Jack Pines, openings or thickets, often associated with other Coastal Plain elements, e.g. in wet black sandy muck of sedge-sphagnum meadow, 7 mi. S of City Point, Wood County, with *Drosera intermedia, Rhynchospora alba, Xyris torta* and sp., *Lycopodium inundatum, Viola lanceolata, Aronia melanocarpa, Muhlenbergia uniflora, Gerardia paupercula,* etc. (*Iltis & Koeppen 12277,* WIS). Flowering from mid-July to early September; fruiting as late as mid-October.

Bartonia is probably much more common than the scanty herbarium material would indicate, since because of its small size and inconspicuous flowers it is easily overlooked.

2. GENTIANA L. GENTIANS

[Mason, C. T. Jr. 1959. A hybrid among the perennial gentians. *Brittonia* 10:40–43; Pringle, J.S. 1966. Taxonomy of *Gentiana,* section *Pneumonanthae* in Eastern North America. (in MS.); See also Pringle, J.S. 1964, 1965a, 1965b, 1966a, 1966b.]

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[3]Saprophytism in *Bartonia* is cited by Gillett (1959) and earlier by Gilg (1895), who includes a short discussion of saprophytism in *Gentianaceae* emphasizing mycorrhizae and low amount of chlorophyll. Neither stresses the minute seeds, which, generally characteristic of saprophvtes, allows them to be both easily dispersed and washed deep into the soil. The subject is in need of study and verification. With exception of Steyermark's (1963) Flora of Missouri, apparently no flora or manual, including Gleason (1952) or Fernald (1950), mentions saprophytism in this or the related American genus *Obolaria.*

Slender to robust perennial herbs. Flowers large, blue, purple, yellowish or white, clustered at the stem apex or axillary in one or several of the upper nodes, sessile or subsessile, subtended by paired bracts. Calyx with 5 linear-lanceolate to ovate lobes, commonly with conspicuous intra-calycine membranes. Corolla 5-lobed, with 5 folded plaits *(plicae)* between the lobes, convolute in bud. Stamens 5, often with connate anthers. Pistil often stipitate. Seeds numerous, winged.

The large, world-wide genus *Gentiana,* variously divided into subgenera and sections but here considered in a restricted form, is represented in Wisconsin by four species and four interspecific hybrids. All belong to Sect. PNEUMONANTHAE Bunge, and, because of their beauty, should be given more consideration both as garden subjects, and as wild plants in need of protection.

KEY TO SPECIES[4]

A. Corolla lobes obsolete or reduced to small points; corolla plaits (plicae) several times longer than the corolla lobes; flowers blue, rarely white, remaining closed at anthesis ---1. *G. andrewsii.*

AA. Corolla lobes prominent, equal to or several times as long as the plaits; flowers open at anthesis.

B. Corolla lobes erect; flowers white, yellow, or various shades of purple or blue; stems glabrous; leaves 1- to 5-veined.

C. Flowers yellowish or white, with greenish veins; calyx lobes ovate, keeled and divergent; leaves broadly lanceolate to ovate, 5-veined; prairies, mostly S. Wisconsin ------------------------------2. *G. alba (G. flavida).*

CC. Flowers blue to purple or grayish purple (rarely whitish or yellowish); calyx lobes lanceolate, ascending; leaves linear-lanceolate, 1- to 5-veined; mostly N. Wisconsin ------------------------3. *G. rubricaulis.*

BB. Corolla wide open (when in sun), the lobes spreading or reflexed; flowers a brilliant, deep blue; stems *minutely* puberulous all over; leaves linear-lanceolate, usually 1-veined; dry prairies, mostly S. Wisconsin --4. *G. puberula.*

1. GENTIANA ANDREWSII Griseb. Bottle Gentian Map 2; Fig. 2.

Stems 3–8(–10) dm tall, unbranched or rarely branched, glabrous. Leaves narrowly lanceolate to ovate-elliptic, *attenuate to base* and apex, 3- or 5-veined. Flowers ca. 3–15 in a tight, involu-

[4]Hybrids of species 1 x 2, 1 x 3, 1 x 4, and 2 x 4 are known and are discussed at the end of the genus (5a–d).

crated terminal cluster, and others often axillary in the 1–4 uppermost nodes. Calyx lobes lance-elliptic to lance-ovate, constricted at base, ciliolate, 5–15 mm long, erect to divergent. Buds rounded or subtruncate with vertical folds, to 30 mm long. Corolla 3–4.5 cm long, cylindric or barrel-shaped, *remaining closed at the anthesis, with laciniate plaits several times longer than the inconspicuous, highly reduced true corolla lobes, blue, becoming purple-tinged with age,* the apical fringe and inside folds often white, or flower wholly white (in f. ALBIFLORA Britton). Stamens united by their anthers. Mature capsule included or barely projecting from the marcescent corolla. 2n = 26 (Rork 1949).

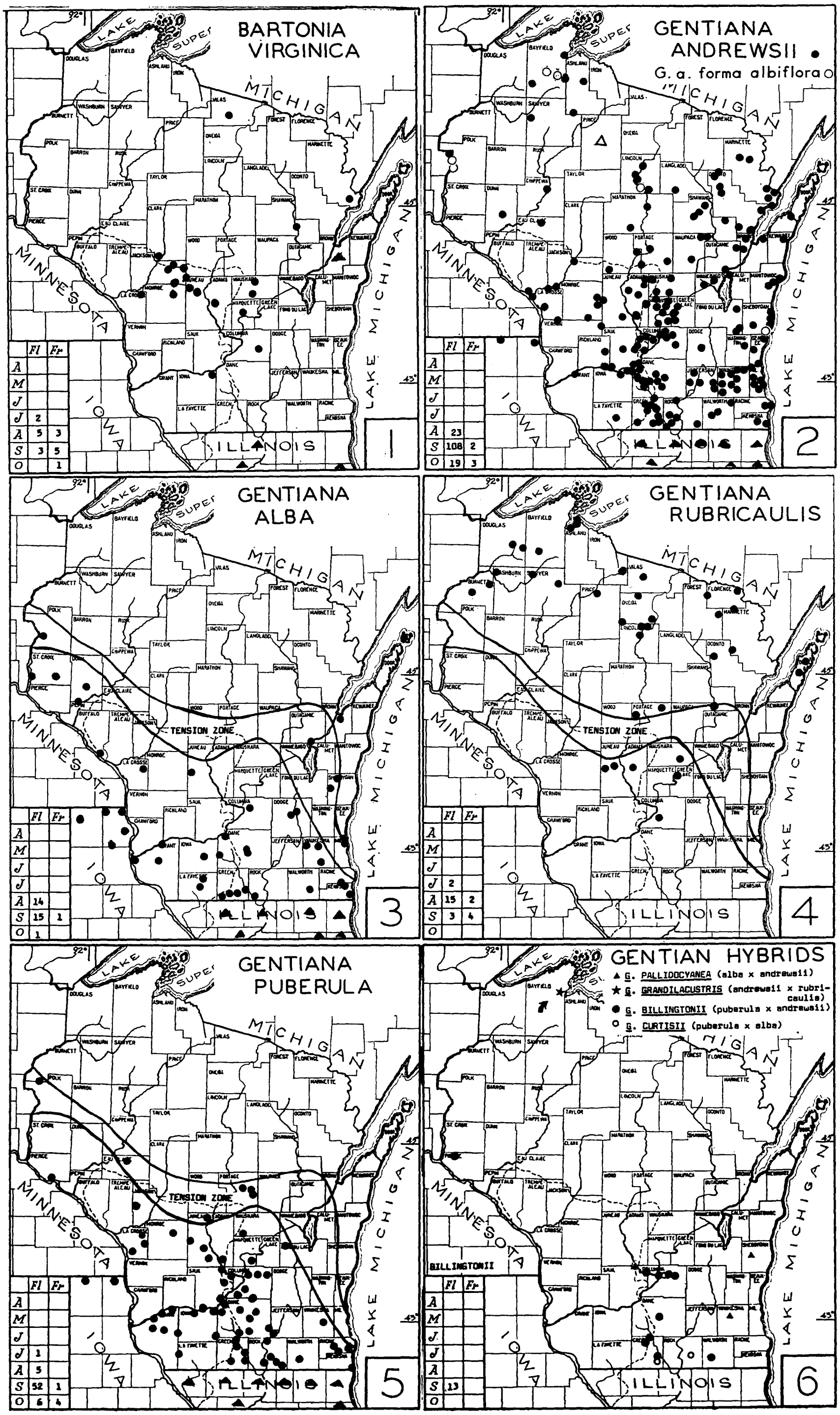
The most common Wisconsin gentian, in a variety of habitats, most often in low damp or wet soil of sedge meadows, prairies, streamsides, grassy lakeshores, swales, in the open or partial shade, sometimes in woods, roadsides and damp thickets. The white-flowered *G. andrewsii* f. *albiflora* is distinguished from the equally white *G. alba (G. flavida)* by the absence of corolla lobes and by closed flowers, occurs occasionally in northern Wisconsin, especially near St. Croix Falls (Polk Co.), and Bayfield County, where blue and white forms are reported as growing together. Flowering from (early) late August to mid-October, with a peak in the 2nd week of September, seasonally and/or ecologically isolated from the three other Wisconsin species, all of which may hybridize with it.

2. GENTIANA ALBA Muhl. White Prairie Gentian
Map 3; Fig. 4.

Gentiana flavida Gray (cf. Pringle 1964, 1965a).

Stems robust, 4–10 dm tall, glabrous. *Leaves lanceolate to ovate,* long-acuminate, *abruptly contracted to a clasping, subcordate base,* —fleshy, yellowish-green, 5-(7-)veined. Flowers 2–12 in a tight involucrated terminal cluster, or 1–3 occasionally axillary at the penultimate node, the large involucral bracts of the same size as cauline leaves. Calyx lobes broadly triangular-ovate, "with decurrent keels which causes them to spread horizontally" (Pringle 1965a), 3–10 mm long; tube ca. 1 cm long. Buds acute, contorted, the apex to 20 mm long. Corollas 3.6–4.5 cm long, *white or cream,* with a network of greenish veins, the lobes erect and not wide open when in flower, rounded to apiculate, about twice as long as the irregular-lobed to erose plaits. Anthers sometimes free (not connate). Capsules included or barely exserted from the persistent corolla.

In Wisconsin only within the region of limestones, on dry to moist, sometimes calcareous relic prairies along railroads or in old cemeteries, on calcareous morainal hills and roadsides, on the edges of dry oak woods or open wooded ridges or ravines, readily


BARTONIA VIRGINICA
1
GENTIANA ANDREWSII ●
G. a. forma albiflora ○
2
GENTIANA ALBA
TENSION ZONE
3
GENTIANA RUBRICAULIS
TENSION ZONE
4
GENTIANA PUBERULA
TENSION ZONE
5
GENTIAN HYBRIDS
▲ G. PALLIDOCYANEA (alba x andrewsii)
★ G. GRANDILACUSTRIS (andrewsii x rubricaulis)
● G. BILLINGTONII (puberula x andrewsii)
○ G. CURTISII (puberula x alba)
BILLINGTONII
6
LAKE SUPERIOR
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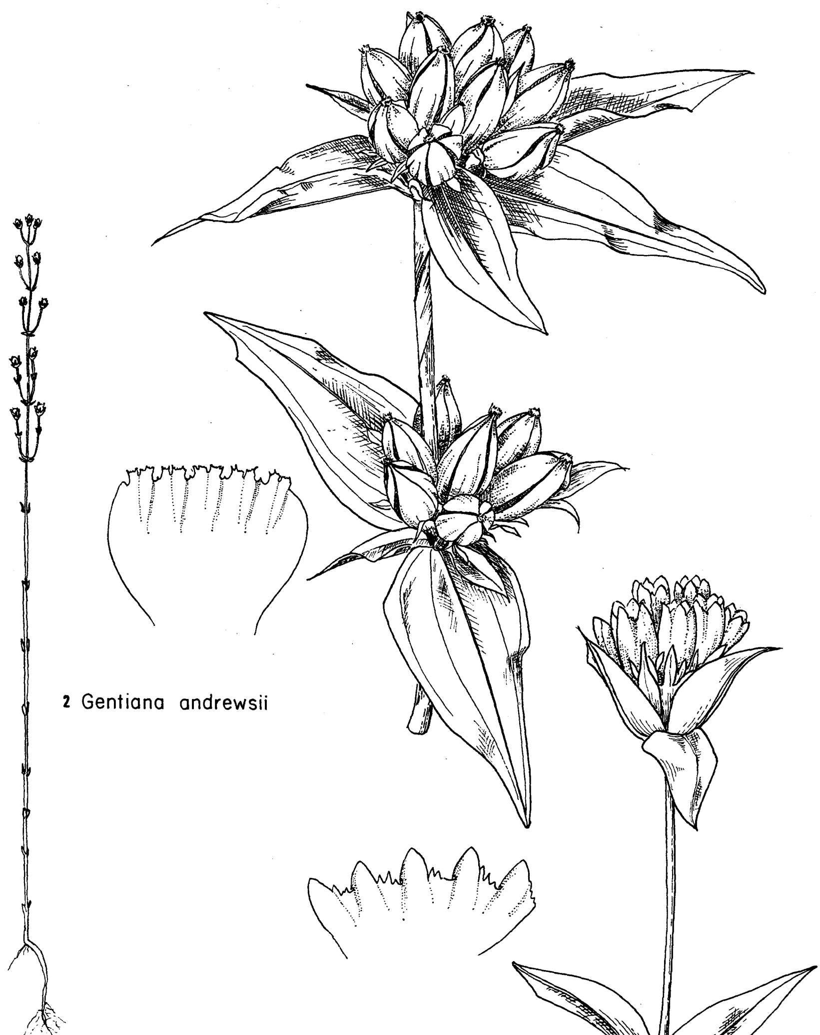
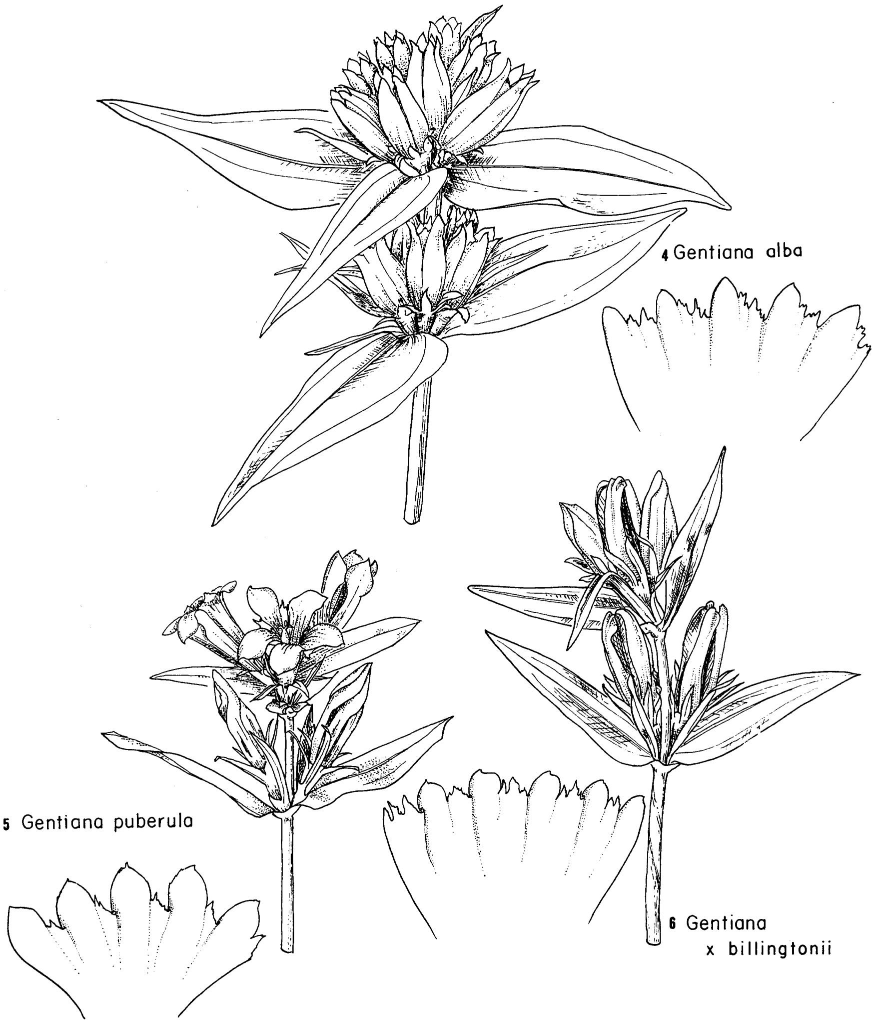


1 Bartonia virginica 3 Gentiana rubricaulis

distinguished from the white *G. andrewsii* f. *albiflora* by larger corolla lobes and open flowers, and generally earlier flowering, i.e. from early August to late September, with a peak in the last week of August. Though three of our gentians occur mostly in prairies, *G. alba* in oak openings and mesic prairies, *G. puberula* in xeric or sand prairies, and *G. andrewsii* often in wet prairies, the latter two species seem to be isolated primarily seasonally from *G. alba,* which generally blooms 2 to 3 weeks earlier. According to Asa



Gray (1874:388) "[*G. alba* in the NE U.S.] begins to flower in July, far earlier than the next two" [species, i.e., *G. andrewsii* and *G. saponaria*].

Several collections of *G. alba* from areas where it grows together with *G. puberula,* and *G. andrewsii,* suggest hybridization. In his garden in Madison, J. T. Curtis crossed *G. alba* and *G. puberula,* producing an F_1 hybrid with characters approaching those of *G. andrewsii.* Field material from the moist prairie north of Swan Lake, Columbia County, is similar (Pringle 1964, 1965b).

3. GENTIANA RUBRICAULIS Schwein. Red-stemmed Gentian
Map 4; Fig. 3.

G. linearis var. *rubricaulis* (Schwein.) MacMillan.
G. linearis var. *latifolia* Gray of ed. 7, Gray's Manual.

Stems (2-)3–6(-8) dm tall, glabrous or minutely puberulous below each node, the upper internode frequently conspicuously elongated. Leaves long-acuminate, ± clasping or abruptly contracted at base, the *lower linear to linear-lanceolate,* the upper lance-ovate to ovate, 1-, 3-(or 5-)veined, frequently conduplicate in pressed specimens, the margins minutely puberulous. Flowers 1–6 in a tight terminal cluster *closely subtended by keeled, lanceolate to ovate-cordate outer bracts,* occasionally 1–3 flowers also at the penultimate node. Calyx tube 9–11 mm long, the lobes linear-lanceolate or elliptic, 3–16 mm long, ascending, separated by rectangular sinuses, the intra-calycine membrane conspicuous. Corolla 3–4 cm long, *blue, purple or grayish-lavender,* rarely white tinged with purple, or yellowish, cylindric with erect, broadly acute to obtuse or rounded lobes, the *irregular plaits ⅓ to ½ the length of the corolla lobes.* Anthers connate. Mature fruits long-stipitate (gynophore to 18 mm long!), sometimes greatly exceeding the persistent marcescent corolla.

Mostly in northern Wisconsin north of the "Tension Zone", in moist or wet areas as shores of lakes, swamps, moist woods, sedge meadows with *Carex, Solidago, Eupatorium, Pedicularis lanceolata,* etc., in open, acidic habitats, such as edges of bogs near roads, included by Curtis (1959) as a species characteristic of the Northern Sedge Meadows; in central Wisconsin rare, in moist prairie relics along railroad, (growing there with *G. andrewsii*), and in rather alkaline sedge meadows with *Solidago patula, S. gigantea, S. uliginosa* and *Aster junciformis (sub Iltis 15240,* near Rosholt, Portage Co.) Flowering from early August to early September, with a peak in the last week of August, apparently seasonally isolated from the later-blooming *G. andrewsii,* with which it may hybridize.

4. GENTIANA PUBERULA Michx.[5] Prairie Gentian, Downy Gentian
Map 5; Fig. 5.

Stems slender, (1–)2–5 dm tall, several to many from a deep root, with dense minute puberulous projections. *Leaves small,*

[5]In his forthcoming monograph of *Gentiana* sect. Pneumonanthe in Eastern North America (Pringle 1966a) and another study (Pringle 1966b), Pringle shows that the type of *Gentiana puberula* Michx. in the Paris Herbarium is actually an eastern species different from the prairie species discussed here, and assigns to the latter the new name *G. puberulenta* Pringle.

mostly 2–5 cm long, 1 cm or less wide, linear-lanceolate, abruptly contracted at base, usually 1-, (rarely 3-) veined, the margins *minutely* puberulous. Flowers 1–5 in an open terminal cluster, or occasionally a few others axillary at the 1 or 2 (3) uppermost nodes, 5-merous (very rarely 4-merous, e.g. Kenosha Prairie, *D. Levin,* in Sept., 1964). Calyx tube 8–15 mm long; lobes linear to linear-lanceolate, 7–18 mm long and equalling the tube, with minutely puberulous margins. *Corollas 3.5–5 cm long, deep dark blue,* funnelform to campanulate, when in full sun *wide open with spreading to pronouncedly recurved lobes;* plaits variously lobed and cut, usually bifid ½ to ⅓ the length of the 10–15 mm long corolla lobes; anthers separate. Mature capsules often long-exserted beyond the persistent corolla (gynophore to 25 mm long), the winged seeds sometimes persisting into the following spring. 2n = 26 (Rork 1949).

Characteristic of prairies, hence "prairie gentian" (or "downy gentian", a translation of *puberula* which is a misnomer the plant being essentially glabrous), especially common in dry sandy prairies, rich dry-mesic prairie relics along railroads, in very dry steep calcareous "goat prairies", there with *Anemone patens, Dodecatheon meadia, Castilleja sessiliflora,* etc., less often in damp but then strongly calcareous prairies (e.g. the Kenosha Prairie underlain by dolomite, there with *Aster ptarmicoides, Parnassia glauca, Gentianopsis procera, G. crinita,* etc.; cf. Illtis 1965), on prairies at Swan Lake, Columbia Co., with *Gentianella quinquefolia, Gentiana andrewsii* and its *G. puberula* hybrids (*Mason 1457,* WIS; cf. Pringle 1964), rarely in open woods (e.g. dry oak woods, top of Observatory Hill, Marquette Co., a quartzite monadnock). Flowering from (mid-August) early September to mid-October, with a peak in the third week of September, the last-blooming of our perennial gentians.

Of this gorgeous species, which deserves protection, as well as cultivation in the sunny limestone rock garden, Curtis (1959) writes admiringly in his discussion of the prairie:

> "Many of the xeric prairies support large populations of the downy gentian which is by all odds the most beautiful member of this famed genus in Wisconsin, and which at its best compares favorably with the species from the high Himalayas that are so prized by rock gardeners."

5. GENTIANA HYBRIDS IN WISCONSIN.

Hybridization in perennial *Gentiana* is well-known from field, garden and herbarium studies. Mason (1959) demonstrated in the greenhouse that some Wisconsin species, e.g. *G. andrewsii* and *G. puberula,* hybridize freely, producing plants strongly resembling *G. saponaria* of the Southeastern United States. The extensive notes and population samples of hybrids gathered over many years by

J. T. Curtis from the wild and from his garden were recently studied by Dr. James Pringle (1964, 1965b), to which the reader is referred.

As *Gentiana* hybrids are as a rule morphologically intermediate between their parents, it is often very difficult to assign a hybrid specimen to one species or another. Since hybrids often occur in areas where two or three *Gentiana* species occur together it is therefore important to carefully study in the field many plants of such a population to determine parentage and putative hybrids (but without pulling up stems and roots!). The following list of specific morphological traits of our *Gentiana* species will be useful in determining probable parentage of hybrids (from Pringle 1964: 274).

TRAIT	SPECIES
Stems minutely puberulent	*G. puberula*
Upper internodes long	*G. rubricaulis*
Leaves glaucous, pale bluish- or grayish-green	*G. rubricaulis*
Leaves yellowish-green, relatively large	*G. alba*
Involucral leaves ascending, folded, enveloping calyces	*G. rubricaulis*
Lower leaves linear-oblong	*G. rubricaulis*
Calyx tubes hyaline	*G. rubricaulis*
Calyx lobes keeled, pushed to one side in pressing	*G. alba*
Corolla pale, whitish or yellowish	*G. alba* (albinos of *G. andrewsii*)
Corolla banded or suffused externally with green	*G. puberula*
Corolla spreading (open), the lobes large, ovate	*G. puberula*
Corolla closed, the lobes very small	*G. andrewsii*
Corolla appendages (plaits) bifid	*G. puberula* and *G. andrewsii*
Corolla appendages with attenuate divisions	*G. puberula*
Corolla appendages symmetrical, broad, truncate	*G. andrewsii*
Corolla appendages low, asymmetrically triangular	*G. alba* and *G. rubricaulis*
Anthers separate	*G. puberula* (sometimes *G. alba*)

The following four *Gentiana* hybrids have been recognized to occur in Wisconsin (cf. Pringle 1964 and 1965b, for complete specimen citations, illustrations, and a taxonomic key to hybrids):

5a. GENTIANA X BILLINGTONII Farwell, *pro species*. Map 6; Fig. 6.

Gentiana puberula Michx. x *G. andrewsii* Griseb.

The commonest hybrid, illustrated here (Fig. 6), as well as by Mason (1959) and by Pringle (1964), has more rounded, broader and more abruptly constricted leaf-bases than *G. andrewsii*, and deep blue flowers with ± erect corolla lobes (2–7 mm long) that are well-developed and equal to, to somewhat longer than, the bifid-laciniate plaits (but shorter than in *G. puberula*) (cf. also Pringle 1965, this volume, pp. 284–287, figs. 1–15).

Wisconsin hybrid swarms show the whole range of intermediates (cf. Figs. 1–6 in Pringle 1964). The type collection, from Ontario, Canada, is apparently an F_1. The seasonal isolation of the parents (q.v.) is evidently reinforced by sharp ecological isolation. Thus, in Springvale Township, Columbia Co., Curtis collected "within 10 feet of one another, *G. puberula* on dry sand, *G. andrewsii* in wet peat, and the hybrid in between . . ." (herbarium label, WIS). Our collections come mostly from prairie relics on railroad rights-of-way, the disturbance and ecological "openness" of this habitat possibly an important factor in the production and establishment of this and other *Gentiana* hybrids (cf. 5c). Steyermark (1963: 1188) reports a spontaneous hybrid in his wildflower garden near Barrington, Illinois.

5b. GENTIANA X CURTISII Pringle, Transact. Wisc. Acad. Sci. Arts and Letters 53:277–8. 1964. [Type: Along Chicago & Northwestern Railroad, 34, T. 2N, R. 13E, Rock Co., Wisc., 20 Sept. 1951, *Mason 1470* (WIS)]. Map 6.

Gentiana puberula Michx. x *G. alba* Muhl. (*G. flavida* Gray)

Intermediate between the parents; stem essentially glabrous; leaves broader and much longer than in *G. puberula;* flowers a pale blue, sometimes very large, in the type to 6 cm, the narrowly lanceolate calyx lobes 9–27 mm long, in other Wisconsin specimens smaller; corolla lobes suberect, triangular, conspicuously reticulate-veined as in *G. alba,* 5–10 mm long; corolla appendages obliquely triangular, much shorter than lobes.

Pressed corollas from hybrid swarms involving such parents (as well as *G. andrewsii* ?) are illustrated by Pringle (1964. Figs. 7–12); their whole plant vouchers are in WIS. The parental species show strong seasonal isolation (*G. alba,* the earliest, *G. puberula* the last gentian to bloom in Wisconsin), moderate ecological isolation (mesic vs. dry prairies), as well as probably floral isolation, the white *G. alba* vs. deep blue *G. puberula* corollas very likely attracting somewhat different pollinators (Suggestion of Dr. Pringle, in correspondence).

5c. GENTIANA X PALLIDOCYANEA Pringle, Transact. Wisc. Acad. Sci. Arts and Letters, 53:279. 1964. [Type: Waukesha Co.: In black sandy loam and cinders, growing with *G. flavida, Celastrus scandens* and grasses, along railroad, SE¼, SE¼, Sec. 1, T. 7N, R. 18E, between Hartland and Pewaukee, Sept. 23, 1945, *Irene Cull s. n.* (WIS)]. Map 6.

Gentiana andrewsii Griseb. x *G. alba* Muhl.

Intermediate between the parents; leaves basally rounded and wide, almost clasping, similar to those of *G. alba;* corollas pale blue, barely open, with white plaits suggesting *G. andrewsii;* lobes 2–3 mm long, the appendages sub-equal or shorter; sepals eciliate.

In addition to the type, the following are known from Wisconsin (fide Pringle 1964): Vic. of Kilbourn [Wisconsin Dells] on Wisconsin River, 25 Aug. 1909, *Steele 19* (US). Sheboygan Co.: Plymouth, 29 Aug. 1930, *Goessl s.n.* (MIN).

Dr. James Zimmermann, Arboretum Botanist, University of Wisconsin—Madison, recognized the correct parentage and hybrid nature of the holotype, as indicated by an annotation dated 1950. The nearby presence of the much rarer of the two parents *(G. alba)* and the open, evidently disturbed and recent habitat of the type locality should be noted.

5d. GENTIANA X GRANDILACUSTRIS Pringle, *loc. cit.* 53:279. 1964. Map 6.

Gentiana andrewsii Griseb. x *G. rubricaulis* Schwein.

Intermediate between the parents; stems dark reddish-purple, the uppermost internode relatively long; upper leaves and outer involucral bracts broadly lance-ovate, abruptly constricted and broadest near the base; bracts enveloping the lower portion of the flowers, these purple or purplish-blue, somewhat barrel-shaped but open; corolla lobes 1–2 mm long, slightly longer than plaits; calyx tubes hyaline.

Aside from the type (Clearwater Co., Minn., in MIN) a Wisconsin collection of 7 specimens represents a hybrid swarm of *G. rubricaulis* back-crossing to *G. andrewsii.* One of these plants appears to be an F_1 and is described above, 4 appear to be (almost ?) pure *G. andrewsii,* and 2 seem to be backcrosses very close to *G. andrewsii.* Bayfield County: Popple-White Cedar and sandy beach of Lake Superior, along Boyd Creek E. of Wisc. Hgw. 13, S. of Barksdale (T 48N, R. 5W, S.25), Sept 3, 1959, *Zimmerman, Weber, & Ugent s.n.* (WIS).

3. GENTIANELLA MOENCH. GENTIANS

Gentiana L. Sp. Pl. ed. 1. 1753, *pro parte.*

[Gillett, J.M. 1957. A revision of the North American species of *Gentianella* Moench., Ann. Missouri Bot. Gard. 44:195–269; cf. Iltis 1965].

Annual or biennial herbs, often with square angle-winged stems. Flowers 5-merous, lilac or blue, small, short-pedicelled. Calyx lobes contorted, with green margins, the sinuses without inner membranes. Corolla lobes entire, each with a solitary interstaminal gland at very base; plaits lacking. Ovary sessile, the placentae confined to the sutures; seeds smooth, round.

One of the largest genera in *Gentianaceae,* common in the arctic, montane Western North America, and particularly the Andes of South America, related to *Gentianopsis* (but not to *Gentiana, sensu stricto*), our species the only truly Eastern North American taxon.

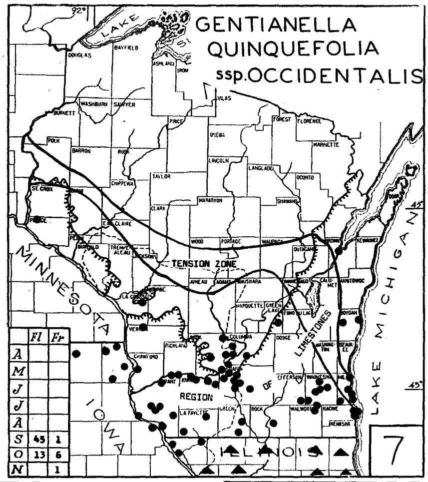
1. GENTIANELLA QUINQUEFOLIA (L.) Small ssp. OCCIDENTALIS (Gray) Gillett. Ague-weed, Five-flowered Gentian.
Map 7; Fig. 7.

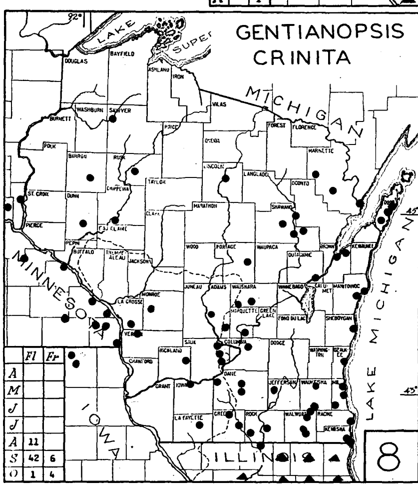
Gentiana quinquefolia L. var. *occidentalis* A. Gray

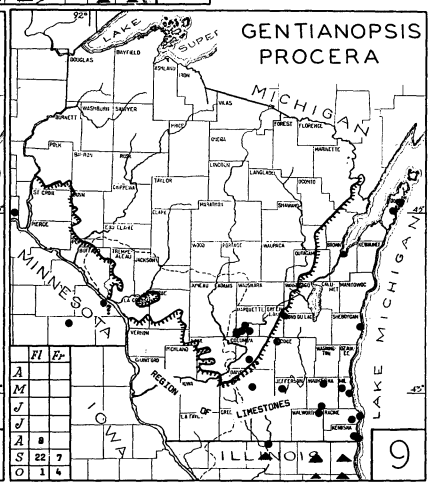
Biennial or annual (?) 1–9 dm tall, commonly much-branched above, simple at base and throughout when slender; stems square, winged. Basal leaves spatulate, withering and seldom collected, the median ovate, 5-veined, at base cordate to rounded, clasping, 1–4(–6) cm long. Flowers few to several hundred, 1–6(–10) in each compact umbelliform cymose terminal cluster, the bracteate pedicels short (3–25 mm). Calyx 5-parted, (6–)8–15 mm long, the lobes lanceolate, 4–9 mm, longer than tube. Corolla 15–25 mm long, "lake blue" (J. T. Curtis) to a deep lilac, narrowly funnelform, the 5 triangular acuminate-caudate lobes ½ to ⅓ as long as the tube, the orifice naked without any fimbriae or plaits. Seeds round, 0.6 mm diam., smooth, wingless, light brown. $2n = 36$ (Rork 1949).

In Wisconsin in the limestone regions, in a variety of habitats, from dry, S-facing, steep, rocky, calcareous "goat prairies" and bluffs (reported as characteristic of xeric prairies; Curtis 1959), mesic lime prairies and even well-drained ridges in deep-soil prairies (e.g. Faville Prairie Sci. Area, Jefferson Co. or Juda Prairie, Green Co.), to moist calcareous prairies and marshy, gravelly places (e.g. near L. Michigan, Kenosha Co.), in moist clay soil and seepage on the L. Michigan Bluffs, edges of oak-hickory woods, in oak openings, rocky wooded ridges and hillsides, and rarely on damp calcareous sandstone cliffs (e.g. across from Lone Rock, Iowa Co.) or shaded earth banks along roads, the species apparently requiring calcareous soil, and an "ecologically open" or slightly disturbed, unstable local habitat without too much competition. Flowering from early September to late October, one of the very last species to bloom in our flora.

Gentianella q. ssp. *quinquefolia* is an Appalachian element, while ssp. *occidentalis* is an element of the Ozark and Cumberland Plateaus. whence our plants must have come post-glacially. Is it an annual or a biennial? Some 200 plants were observed on Oct. 16, 1960 in full flower (the melancholic last flowers of the season!) on a steep, dry, SW-facing, high lime prairie and adjoining dense *Juniperus virginiana* glade near the top of Lodde's Mill Bluff Nature Preserve,







Sauk Co. (*Iltis 17087*, WIS). Interspersed among the flowering plants were sterile green rosettes ca. 3–5 cm in diam., these with rounder leaves than flowering *G. quinquefolia,* yet unquestionably that species. The nearly full grown tap roots and large size of the rosettes suggested at least a good season's growth. Here the species thus appears to be a biennial.

4. GENTIANOPSIS MA FRINGED GENTIANS

Gentiana L. Sp. Pl. ed. 1, 1753, *pro parte.*
Anthopogon Neck. ex Raf. Fl. Tellur. 3:25. 1837, *pro parte.*
Gentianella Moench, Meth. Pl. 487, 1794, *pro parte.*
Gentiana **** *Crossopetalae* Froel., Gent. Diss. 109. 1796.

7 Gentianella quinquefolia 8 Gentianopsis crinita 9 Gentianopsis procera

Crossopetalum Roth, Enum. Pl. Phaen. Germ. 1:516. 109, 1827, *non* P. Br. 1756.

Gentianella subg. *Eublephis* (Raf.) Gillett, Ann. Missouri Bot. Gard. 44:210. 1957.

[Gillett, J. M. 1957. A revision of the North American species of *Gentianella* Moench. *Ann. Missouri Bot. Gard.* 44:195–259; Iltis,

H. H. 1965. The genus *Gentianopsis* (Gentianaceae): transfers and phytogeographic comments. *Sida* 2:129–154.]

Small annual or biennial herbs unbranched at base, often above, with slender roots (ours). Flowers 4-merous, blue, fading to purple, large and showy, solitary on long pedicels. Calyx 4-angled, compressed, the lobes large, keeled, distichously imbricate, their margins, thin, transparent, the outer pair narrower, each sinus with a minute ciliated inner membrane. Corolla campanulate to funnelform, the ciliate to fimbriate lobes without plaits or epipetalous nectaries except for a gland at the very base of each petal. Ovary stipitate, the stigma large, the parietal placentae extending over most of inner surface. Seeds oblongoid-angular, papillose.

A small Northern Hemisphere boreal and montane genus of ca. 26 taxa, originally placed into *Gentiana,* later *Gentianella* (or considered as *Crossopetalum* or *Anthopogon,* invalid or unavailable names), but on morphologic and cytologic grounds (Löve 1953) best considered as a distinct genus most closely related to the scandent E. Asiatic *Pterygocalyx* Maxim. (cf. Toyokuni 1963; Iltis 1965). Their annual or biennial habit and ecological specificity, their celebrated beauty and man's desire to pick the flowers (and thus in this genus generally whole plants) and, for other reasons, man's draining of their habitats, all conspire to their present rarity and local extinction.

KEY TO SPECIES (cf. Fig. 12)

A. Upper or median leaves lanceolate to ovate, rounded to subcordate at base, (5–)10–30 mm wide, 10–60 mm long; flowers few to many, 1–40 or more, the longest pedicels 2–12 cm long. Throughout Wisconsin .... 1. *G. crinita.*

AA. Upper or median leaves linear or less often linear-lanceolate, 2–8(–10) mm wide, 10–110 mm long; flowers few, 1–10(–20), the pedicels (2–)10–20 cm long. S. and Eastern Wisconsin .... 2. *G. procera.*

1. GENTIANOPSIS CRINITA (Froel.) Ma, Acta Phytotax. Sinica 1:19. 1951. Eastern Fringed Gentian. Maps 8, 10, 12; Figs. 8, 10–14.

Gentiana crinita Froel.
Gentianella crinita (Froel) G. Don

Slender annuals or biennials 1–7 dm tall, often much branched above, the base and small plants unbranched. *Median leaves ovate to ovate-lanceolate* (cf. Figs. 12, 14), 10–60 mm long, (3–)*7–30 mm wide, with a broad clasping base.* Flowers usually several to many, 1–40(–125, fide Fernald), very showy, 28–56 mm long, deep blue (or rarely white in forma ALBINA (Fern.) Iltis), the 4 petal-lobes prominently fringed; *pedicels relatively short, the longest 2–10(–12) cm long.* 2n = 78 (Rork 1949).

Widely distributed, and locally common to rare throughout Wisconsin, both in the region of limestones as well as of acidic rocks, in sunny or shady moist habitats, especially those that are flooded in spring, in marshes or sandy sedge meadows, along Lake Michigan in swales behind dunes, on moist dunes, seepage slopes, and on low, wet sandy or gravelly flats or rock pavements, rarely in damp open woods and shaded dolomitic sandstone cliffs (e.g. cliff across from Lone Rock, Iowa Co., with *Sullivantia* and *Gentianella quinquefolia*), apparently not requiring, but tolerating, as calcareous a habitat as *Gentianopsis procera* [with which it rarely grows, as on calcareous sedge meadows (fens) on Lake Wingra, U.W. Arboretum, Madison, and Ennis (Muir) Lake, Marquette Co. (cf. Iltis 1957); and on calcareous low prairies, Kenosha Co. on Lake Michigan]; flowering from mid-August into October, peaking in the 2nd and 3rd week of September, a little later than *G. procera.*

2. GENTIANOPSIS PROCERA (Th. Holm) Ma, Acta Phytotax. Sinica 1:19. 1951. Great Plains Fringed Gentian.
Maps 9, 11, 12; Figs. 9–14.

Gentiana procera Th. Holm.
Gentianella procera (Th. Holm) Hiit.
Gentianella crinita (Froel.) G. Donn, ssp. *procera* (Th. Holm) Gillett.

Similar to *G. crinita:* slender annuals or biennials, 1–4 (–5) dm tall, unbranched at base and in small plants. *Median leaves linear to linear-lanceolate,* 10–112 mm long, 2–8 mm wide (or in robust plants of certain SE Wisc. populations, narrowly lanceolate and to 12 mm wide; cf. fig. 12b), attenuate to abruptly contracted at base, ascending and ± arched outward. Flowers relatively few, 1–7 (–20), very showy, 30–70 mm long, deep blue, rarely white, the 4 (in one plant abnormally 8) petals prominently fringed, solitary *on very long pedicels, and longest* in depauperate plants (2–)*5–19 cm long.* 2n = 78 (Rork 1949).

Restricted to the region of limestones and more locally distributed in Wisconsin than *G. crinita,* in full sun in generally more distinctly alkaline habitats (judging from associated calcophiles), as marly, often springy sedge meadows, low prairies, or fens, moist calcareous gravels, sands, or limestone pavement on L. Michigan (Bailey's Harbor, Door Co., with *Gentianella quinquefolia,* pH 8, fide Fuller), spring seepage on the L. Michigan bluffs (pH 7, fide Pohl), often on bare sands, black soil, or clays without much competition, as well as on grassy shores, rarely growing with *Gentianopsis crinita* (q.v., if so, then like in Indiana (Deam 1940) probably in moister microhabitats). Flowering from (mid-) late August into early October, with a peak in the 2nd week of September, though their blooming dates do overlap, a little earlier than *G. crinita,* this also noticed for Indiana by Deam (1940) and for the N.E. U.S. by Fernald (1950).

These, usually wet calcareous sedge prairies or fens occur on drift derived from E. Wisconsin's Niagara Dolomite, on the dolomite itself, or around calcareous springs, and are characterized by a distinctive assembledge of calcophiles whose distribution pattern often very closely match that of *G. procera,* incl. *Solidago ohioensis, S. ridellii,* and perhaps *S. patula* (Salamun 1963), *Salix candida* (Argus 1964), *Lysimachia quadriflora* (Iltis and Shaughnessy 1960:133), *Lobelia kalmii, Aster junciformis, Parnassia glauca, Potentilla fruticosa* (Mason & Iltis 1958; Map 16), *Valeriana ciliata (V. edulis),* the rare *Scleria verticillata* (cf. Iltis 1957) and others. All these, together with *G. procera,* are rare or absent from the "Driftless Area" of SW. Wisconsin, not because of historical factors or absence of calcareous rocks, but of deficiency in appropriate moisture (i.e. flat marly springs, calcareous seepage and glacial till).

The Fringed Gentians East of the Rocky Mountains

The Eastern and Middle-western Fringed Gentians, *Gentianopsis crinita, G. procera, G. victorinii* and *G. macounii* (incl. *G. tonsa* and *G. gaspensis*) have recently been treated in several fashions. Fernald (1950) recognized all as valid species of *Gentiana,* while Gleason (1952), in listing *G. crinita, G. procera, G. victorinii* and *G. tonsa* (incl. *G. gaspensis*), comments (3:62) that ". . . [*procera*] and the next two species [*victorinii, tonsa*] are so closely similar that they might well be reduced to varieties of a single widely varying species." Gillett (1957, 1963) visualized an all-inclusive *Gentianella crinita,* composed of 4 *equivalent* subspecies, with *G. gaspensis* and *G. tonsa* synonymized under *G. macounii.* The morphological patterns of these gentians make it evident, however, that neither such "splitting", nor such "lumping", properly reflect the natural relationships of these taxa. On the other hand, a reconsideration of ecology, geography and morphology suggests a synthesis of the above viewpoints into a taxonomy closely resembling that of Gleason, one that is more compatible with evolutionary and historical factors, in which but two species are recognized: namely, the uniform *G. crinita,* and the variable *G. procera.* The latter species includes all other taxa mentioned above, some as clinal geographic subspecies, others as discrete local populations here recognized as weak varieties.

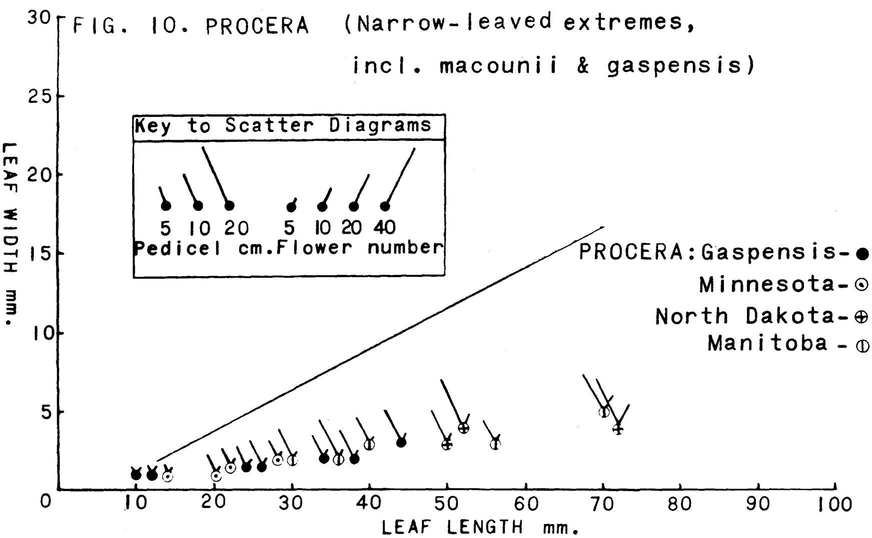


FIGURE 10. *G. procera* ssp. *macounii.* Solid dots are the very local, geographically isolated, morphologically only slightly differentiated var. *gaspensis* (*Victorin et al. 4008*), the hollow dots collections of var. *macounii,* one each from Minnesota, North Dakota, and Manitoba. The Gaspé plants (star on Map 11) tend to be smaller, to branch from the base and have narrower, shorter leaves. However, the variation pattern is continuous with that of plants from Minnesota and further west (cf. Fig. 14). All plants have very few flowers, and most, except some very slender, depauperate ones, have long pedicels. These are the narrow-leaved extremes of the *G. procera* complex. *G. p.* var. *victorinii,* from the St. Lawrence River estuary, not graphed here (cf. Iltis 1965:Fig. 5a), has glyphs distributed much like those from Manitoba and Minnesota. All plants in Figs. 10–14 are from the University of Wisconsin Herbarium, the largest median leaf of each being used for measuring.

Thus, though Iltis (1965) recently transferred all of these taxa to *Gentianopsis* as full species, it seems on further consideration better to treat them as follows:

1. GENTIANOPSIS CRINITA (L.) Ma.

2A. GENTIANOPSIS PROCERA (Th. Holm) Ma, ssp. PROCERA.

2B. GENTIANOPSIS PROCERA (Th. Holm) Ma, ssp. **macounii** (Th. Holm) Iltis, **comb. nov.**
Gentiana macounii Th. Holm, Ottawa Naturalist 15:110. 1901.

a. var. *macounii*
b. var. **victorinii** (Fern.) Iltis, **comb. & stat. nov.** *Gentiana victorinii* Fern. Rhodora 25:87. 1923.

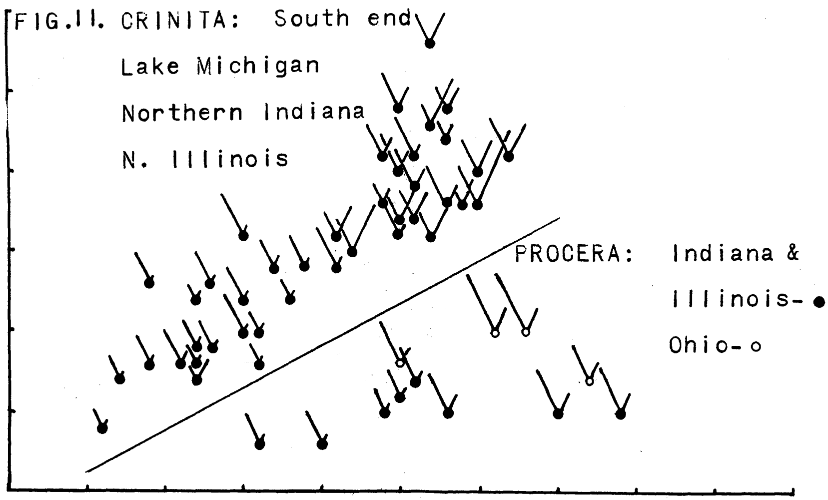


FIGURE 11a. *G. crinita* from the south end of Lake Michigan (mostly Northern Indiana collections of L. M. Umbach). The distribution of glyphs is nearly identical to those from Wisconsin or New England.

FIGURE 11b. *G. procera* ssp. *procera* from Indiana, Illinois (black glyphs) and Ohio (hollow circle glyphs). Note the often larger leaf-width of the *G. procera* collections as compared with those from further west (Fig. 10). The Ohio specimens, especially, are very robust (collections of C. W. Short, "Columbus" 1835, "Prairies of Ohio" 1836). The glyph position on the diagram should be related to the robustness of these plants (flowers to 8 cm long! pedicels to 19 cm long!).

c. var. **gaspensis** (Vict.) Iltis, **comb. & stat. nov.** *Gentiana gaspensis* Vict. Contr. Lab. Bot. Univ. Montreal 20:10. 1932.

The morphological relationships of these taxa are well shown by scatter diagrams (Figs. 10–14) based on specimens in the University of Wisconsin Herbarium and representing dimensions for the largest median leaf of each plant, as well as for certain characters of pedicel length and flower number (cf. Iltis 1965, for detailed discussion of these and other diagrams). *Gentianopsis crinita has lanceolate to ovate leaves* and shows great *uniformity* throughout its range. Thus the glyphs are distributed in roughly the same pattern, whether the plants come from Wisconsin (Fig. 12a), Northern Indiana (Fig. 11a), or New England (Fig. 14, dot-dash-dot-line) *Gentianopsis procera typically has linear to linear-lanceolate leaves* as shown by the solid black glyphs in Figs. 11b and 12b, the hollow circle glyphs in both representing particularly robust plants (these perhaps introgressants with genes from *G. crinita,* or simply plants growing in a more favorable environ-

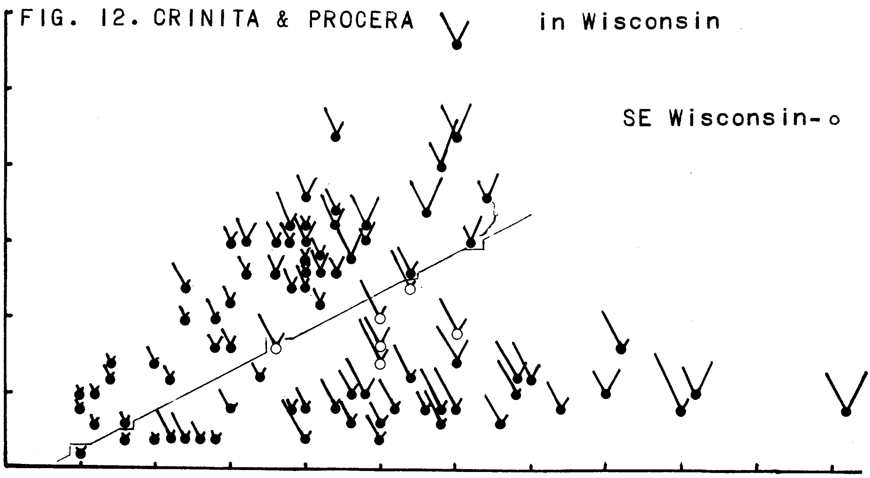


FIGURE 12a. *G. crinita* in Wisconsin follows the same distribution as in other parts of Eastern North America (see Fig. 14), and shows no perceptible influence (either climatic or genetic) of *G. procera* on its phenotypic expression. The glyphs in the far left-hand corner belong to the particularly depauperate "Lone Rock" cliff population of Fig. 13.

FIGURE 12b. *G. procera* in Wisconsin is complex. While there are many plants that are nearly as narrow-leaved and few-flowered as some of the ssp. *macounii* specimens plotted in Fig. 10, most plants have much wider leaves and are similar to those shown in Fig. 11b. A few very robust plants, all from Milwaukee, Racine and Kenosha Counties are plotted as hollow circles (see text).

ment, e.g. wet prairies in S.E. Wisconsin near Lake Michigan, and at the very southeastern edge of its range in Ohio). In Minnesota, North Dakota and northwestward into Canada, as well as in three highly local populations, two in eastern Quebec and one on the south end of Hudson Bay (Map 11), occur linear-leaved plants of ssp.*macounii* (Fig. 14, dots-dash-dots-line), the var. *gaspensis* (Fig. 10) and var. *victorinii* distinguished from var. *macounii* on but very minor morphological grounds, as well as by geographic isolation (Map 12) and ecological peculiarities (cf. Rousseau 1932; Raymond 1951). It is clear that while the subspecies of *G. procera* grade into each other, and its varieties are weak and mostly taxonomic conveniences maintained for purposes of discussion, *the two species are quite distinct morphologically,* with clearly different modes of variation (Fig. 14), the three or four robust plants in S.E. Wisconsin (Fig. 12b, hollow glyphs) notwithstanding. Distinctions between the two species seem to break down only in the smallest depauperate plants (Figs. 12 & 13, glyphs in lower left-hand corner), whose identification is often only possible in conjunction with more normal plants of the same population.

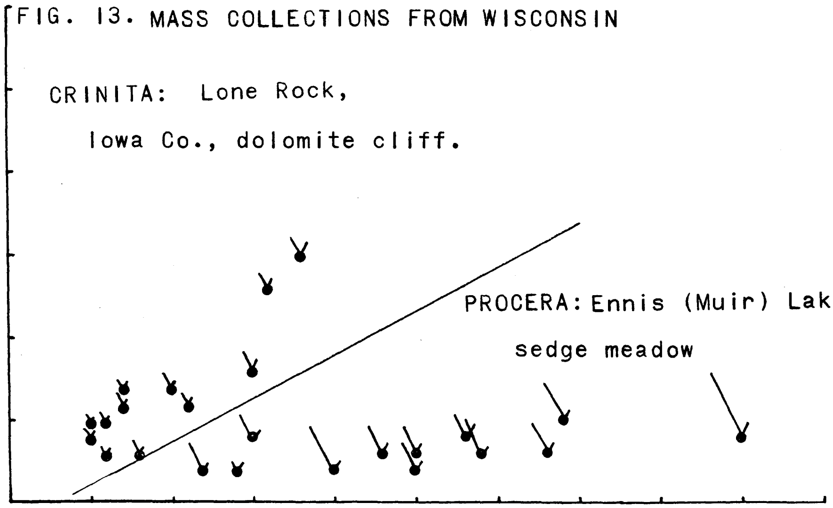


FIGURE 13. *G. crinita* and *G. procera* in Wisconsin: Mass collections to show variability within single populations. Fig. 13a. *G. crinita* from Iowa Co., across the Wisconsin River from Lone Rock, Wisc., is peculiar in that these mostly depauperate plants grow on a vertical north-facing dolomitic sandstone cliff. Collections in 1925 by N. C. Fassett and in 1958 by Brian McNab show precisely the same morphological distribution.

FIGURE 13b. *G. procera* population from an alkaline sedge meadow ("fen") on Muir (Ennis) Lake, Marquette County: note large spread of glyphs within this local population.

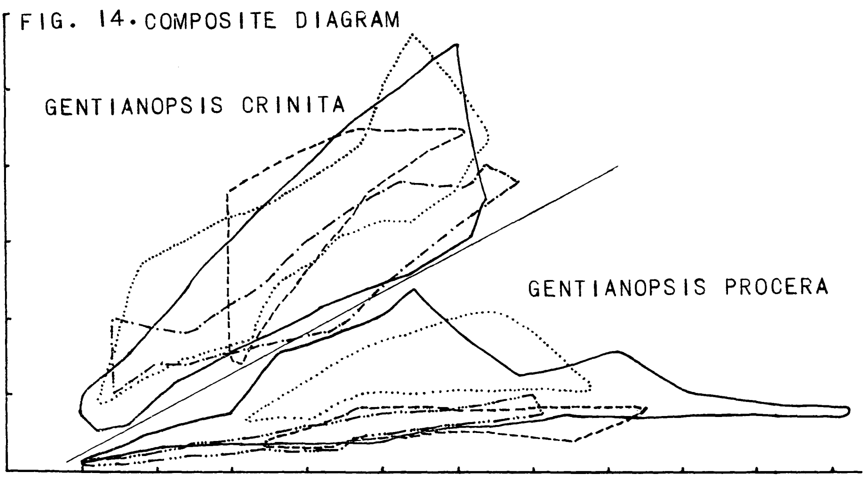
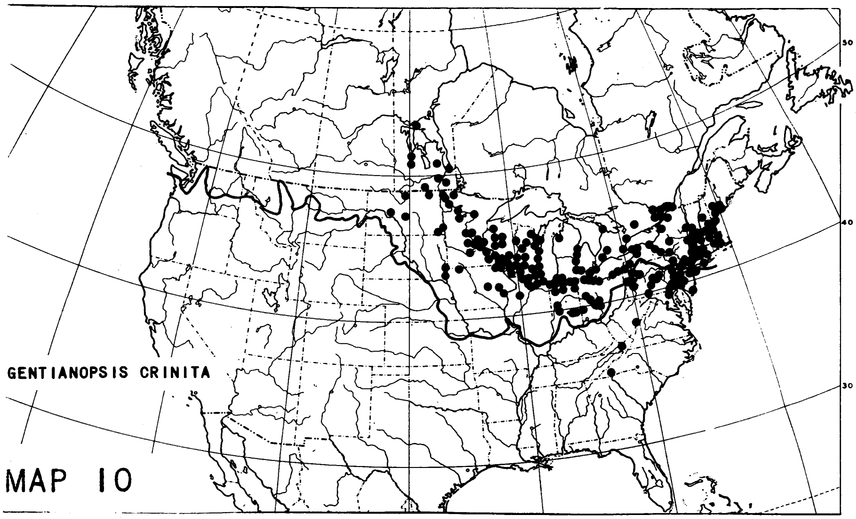


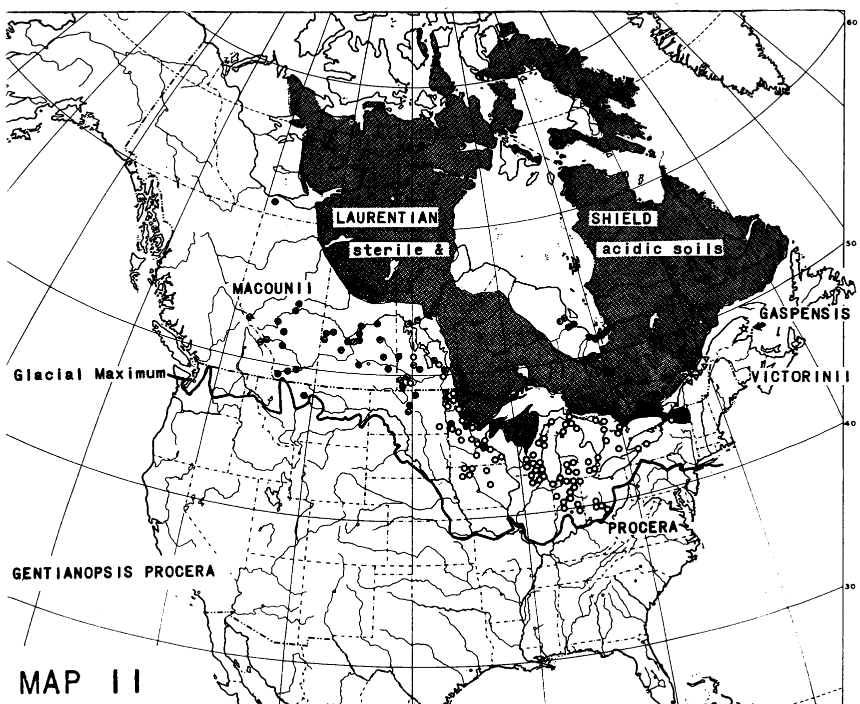
FIGURE 14. Composite of all graphs of *G. crinita* and *G. procera.* See discussion especially of Figs. 11 and 12. Var. *victorinii* is not shown since its limits are essentially congruent with those of the western plants of *G. procera* (dashes).

Probable History of Gentianopsis in the Eastern United States

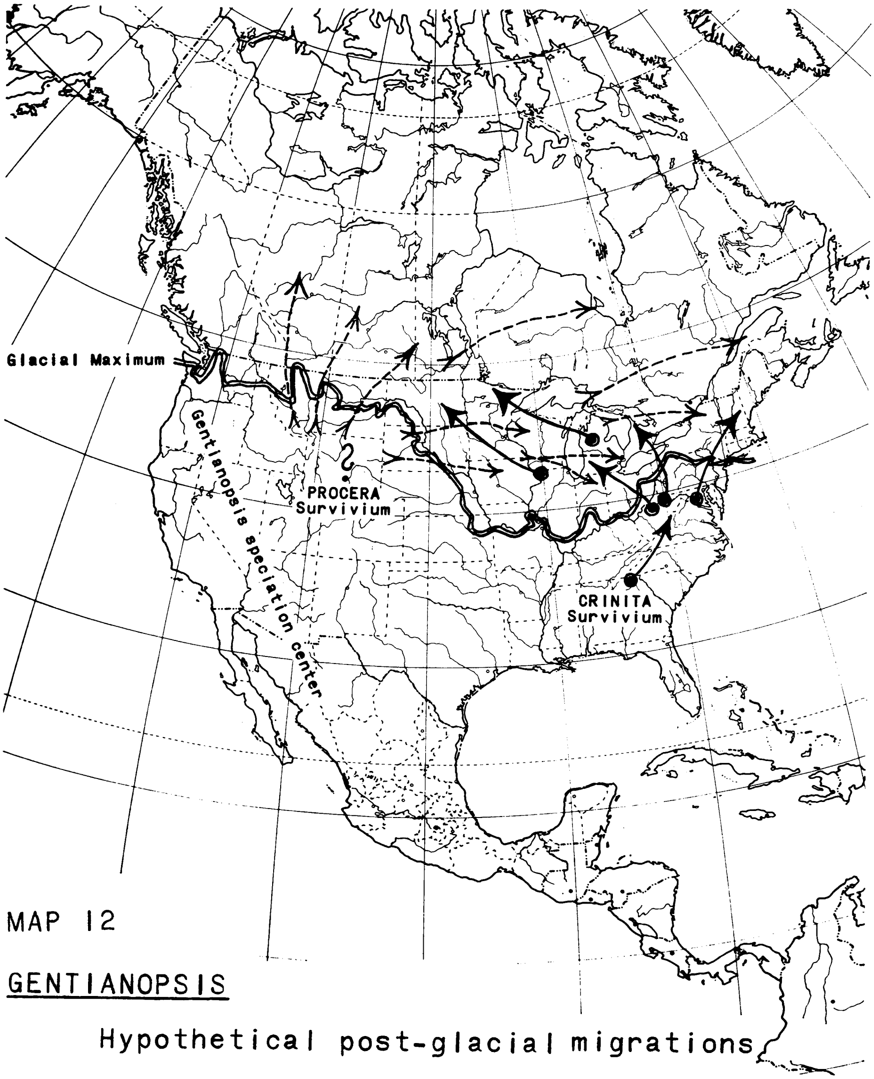
Since the modern ranges of *Gentianopsis crinita* (Map 10) and *G. procera* (Map 11) must be related to Pleistocene glaciation, we can visualize their post-glacial emigrations from glacial refuges or *"refugia"* or, better, survival centers which we may call *"survivia"*, and attempt to reconstruct their post-glacial history (Map 12). All factors of geographic distribution, ecology, phenology and even morphology, suggest that these two taxa are the result of separation by the Pleistocene glaciers of a once widespread ancestral species into two populations whose subsequent history we may postulate to have been as follows: One population survived in the moister, more acidic, wooded, Appalachian region of the southeastern United States, a region with a mild long growing season, eventually evolving into a broad-leaved, many-flowered, late-blooming, shade tolerating, circum-neutral to somewhat calcophilic *G. crinita.* The other population survived in the dry, treeless, more calcareous (alkaline) upper Great Plains (and Northern Rocky Mountains?) in the West, a region with a severe climate and short growing season, eventually evolving into a narrow-leaved, early-blooming, few-flowered, heliophilic, distinctly calcophilic *G. procera.* Upon retreat of the glaciers, the eastern *G. crinita* spread into the glaciated region of the "White Pine—Hemlock—Northern Hardwoods" and beyond, while the western taxon (or were there several, morphologically slightly differentiated, geographically isolated surviving populations?), which, in its more depauperate, xeromorphic Northern Great Plains phase is known as ssp. *macounii,* migrated eastward, especially on damp, but physiologically dry, calcareous habitats, to eventually invade and overlap the range of *G. crinita.* In Wisconsin and Michigan, perhaps as a consequence of the higher precipitation, there evolved, through selection or phenotypic responses, generally larger, bigger-leaved plants which have been distinguished from ssp. *macounii* as ssp. *procera.* Some of these resemble *G. crinita,* suggesting the possibility of introgression from that species. While scatter diagrams (Fig. 12) reflect this similarity, it seems equally or more reasonable to suppose increased leaf size to be a phenotypic response to moister habitat, less alkaline soil, and/or longer growing season.

The Wisconsin and Indiana *G. procera* populations are variable, suggesting "broad dispersal" migration and many genotypes. The Eastern Canadian populations, in contrast, are highly uniform. As is characteristic of many other Western elements, *G. procera* ssp. *macounii* spread as far east as the Gaspé Peninsula and Hudson Bay, very probably by sporadic, single-seed "long range" dispersal,





since the intervening acidic rocks (cf. Map 11; Wynne-Edwards 1937, 1939) would make establishment all but impossible. These isolated and highly local, ecologically specialized, genetically evi-



MAP 12

GENTIANOPSIS

Hypothetical post-glacial migrations

dently impoverished, homogenic populations have been taxonomically recognized as var. *gaspensis* and var. *victorinii,* two neoendemics perhaps best considered simply as local populations of *G. procera* ssp. *macounii.*

There are, of course, examples of quite distinctive species or subspecies evolving in as short a time as 10,000 years or less in the Northeastern United States. One need only examine some of the

Great Lakes endemics, e.g. *Iris cristata* ssp. *lacustris*,[6] *Hypericum kalmianum*, *Cirsium pitcheri* (cf. Johnson and Iltis 1963: 290–292), *Calamovilfa longifolia* var. *magna* (Thieret 1960), or *Agropyron psammophilum* (Senn and Gillett 1961). However, by comparison, especially to some of the beach and dune endemics, the fringed gentian populations are not nearly as clearly differentiated. Thus, in the formation of these post-glacial neo-endemics, evolutionary rates appear to have differed greatly, depending on the nature of the plants themselves, the type of habitat, the kind of selection and the original variability and size of the population.

The great taxonomic-phytogeographic difficulties which the *G. macounii—G. procera* pheno-cline engendered, and its relationship to the Gaspe endemics and to *G. crinita*, can thus be resolved by realizing that *the two major taxa fall into the standard pattern of Eastern North American–Western North American vicarious species pairs*, their post-glacialy produced modern ranges *overlapping only in glaciated Northeastern North America. This pattern is much more prevalent than is generally appreciated,* and is exemplified by the ranges of many of our commonest as well as rarest, by some of the most distinct as well as taxonomically most difficult species in the Northeastern United States.

The difficulties that one encounters in distinguishing the components of poorly differentiated, post-glacially confluent species

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[6]*Iris cristata* Ait. ssp. **lacustris** (Nutt.) Iltis, **stat. nov.**
Iris lacustris Nutt. Gen. Am. Plants 1:123. 1818.
Iris cristata Ait. var. *lacustris* (Nutt.) Dykes, The Genus Iris 106. 1913.

This attractive Great Lakes Endemic (cf. Guire & Voss, Mich. Botanist 2: 100–101, 1963 for an excellent discussion of its range) is distinguished from some plants of the southern paternal species *I. cristata* by the shorter perianth tube (short due to selection by strong Great Lakes shore winds, which would knock a long tube like that found in typical *I. cristata* to the ground??) and by such minor quantitative characters as petal, sepal, and capsule shape, laxness of leaves, smaller size, and supposed lack of flower odor. Foster (Contrib. Gray Herb. 119: 10–13. 1937), who carefully reviewed much information, places emphasis on previously reported, apparently erroneous chromosomal differences (2n = 42, *fide* Simonet; cf. Foster, *loc. cit.;* probably based on a plant of *I. verna*). Material from near Baileys Harbor, Door Co. (*H. H. Iltis 17675,* 1961) counted by Dr. Shoichi Kawano (MS) showed the chromosome number to be 2n = 32, the same as reported for *I. cristata* by Foster (*loc. cit.* 119:11), Foster also emphasized Fernaldian ideas of pre-Wisconsin glacial survival, citing many associated supposed "glacial relics" that also grow on the alkaline sands and gravels of the Niagara dolomite. However, a) its restriction to glaciated territory, b) its allopatric distribution in respect to *I. cristata* (cf. Guire & Voss, *loc. cit.*), c) its ecological restriction to shore habitats that are alkaline, often unstable and ecologically "open", and rich in many disjunct southern and western taxa like *G. procera,* d) its great morphological uniformity as compared with the quite variable *I. cristata,* noticed by Anderson (cf. Foster, *loc. cit.* and personal observation), and e) its truly minor morphological differentiation from *I. cristata*—all speak for *I. lacustris* as a post-glacially evolved "founder population" (E. Mayr) of much the same character as the isolates of *G. procera* ssp. *macounii* in Eastern Quebec discussed above, which, due to both limited original variability (being "founded" as it were by one seed?) as well as rather rigorous selection by the Great Lakes shore environment, had undergone slight morphological divergence. The lesser size of many morphological characters in *I. lacustris* could well be understood as the effect of climate on this population which, after all, represents the southern *I. cristata* at the very limit of its range as a northern, poorly differentiated geographic subspecies. (H.H.I.)

pairs were well known to Hultén (1937), who was among the first to appreciate the dynamics of such a situation: . . . "As long as those races are separated from one another geographically, they may be distinguishable, but when migration has proceeded so far that the radiants from two elementary areas meet, hybridization and thereby an intergradation of the differences must be expected to occur." The taxonomic-phytogeographic significance of this pattern, which is enormous in the Upper Middle Western flora, has been preliminarily discussed elsewhere. (Iltis 1965)

5. HALENIA Borkh. Spurred Gentian

[Allen, Caroline K. 1933. A Monograph of the American species of the genus *Halenia*. Ann. Missouri Bot. Gard. 20: 119–222.]

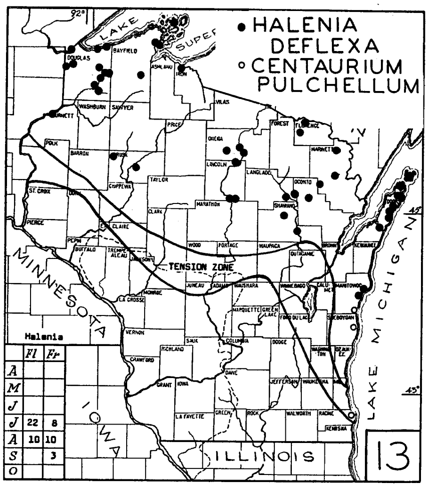
1. Halenia deflexa (Sm.) Griseb. Spurred Gentian

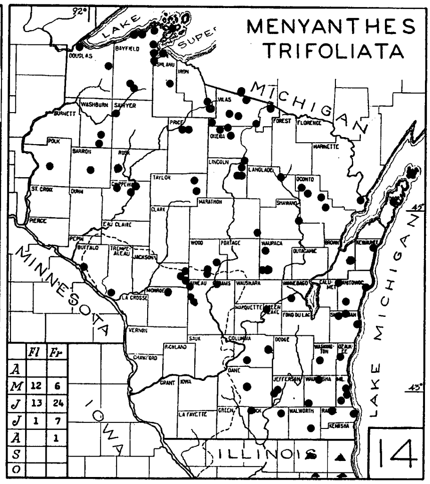
Map 13; Fig. 15.

Biennial (?) or winter annual (?) 1–4(–9) dm high. Stems simple or branched above, slender with 6–8 cm. long internodes. Leaves 3- or 5-nerved. Basal leaves suborbicular- to oblong-spatulate, petiolate, 1–2 cm long, cauline oblong-lanceolate to ovate, acuminate, 1–5 cm long. Flowers 4-merous in terminal or axillary, loose umbelliform cymes. Calyx 4–8 mm long, the segments ovate-lanceolate, acuminate. Corolla 8–15 mm long, yellowish or greenish to greenish-purple, often pronouncedly reddish purple when in bud, marcescent, the lobes lanceolate to ovate acute, erect, each prolonged at base into a divergent slender 3–5 mm long spur (in forma heterantha (Griseb.) Fern. these spurs occasionally lacking in lower flowers or in flowers developing late in the season). Capsule lancoblongoid, falcately curved upward, septicidal, thin-papyraceous the seeds oblong-ovoid, greenish-brown.

In Wisconsin North of the "Tension Zone", locally abundant in cool moist shady or open forests, especially in wet and mossy coniferous *Picea glauca-Abies balsamea-Thuja occidentalis* woods, in open sphagnum or *Thuja* bogs, on black organic "muck", gravelly or clayey shores of lakes, mesic lumber-roadsides and old clearings, but rarely on dry sites. Flowering from early July to the 3rd week of August; fruiting from end of July to mid-September.

Halenia includes few Asiatic, and only two northern North American taxa, the remainder all western hemisphere species [highly fragmented into 69 taxa by Allen (1933)] local in the montane or alpine zone from Arizona and Mexico to Peru and Chile. With a very wide range characteristic of invaders to glaciated territory, *Halenia deflexa* occurs from Alberta to Hudson





Bay, Quebec, and New York, with its only non-glaciated stations in western Nebraska [unless one should care to accept the two incongruously disjunct central Mexican stations cited by Allen (1933)]. Generically it is thus a "Neotropical Alpine Element", but specifically a western "Northern Great Plains" element, its range, and probably its migratory history, very similar to that of *Gentianopsis procera* (cf. Map 12).

Allen (1933) notes that some very early or late flowers of *H. deflexa* may be spurless. In addition, some plants may produce almost nothing but spurless flowers, recognized as *H. deflexa* f. *heterantha* (Fernald 1899, 1938). Of the sixty collections studied from Wisconsin, none could be definitely assigned to forma *heterantha*.

6. CENTAURIUM Hill CENTAURY

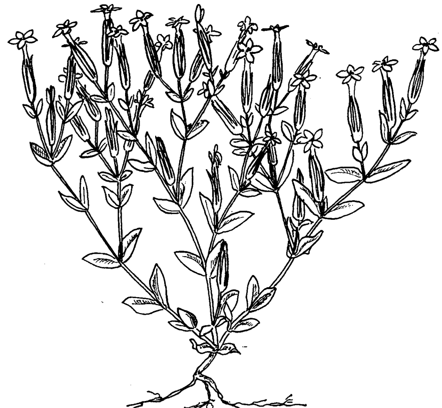
1. CENTAURIUM PULCHELLUM (SW.) DRUCE. Centaury

Map 13; Fig. 16.

Slender annuals with simple or usually much-branched stems (2–)8–16 cm tall. Leaves opposite, sessile, lanceolate to ovate, 9–15 mm long. Inflorescence cymose; calyx (2–)4–8 mm long, with 5 narrow lobes about 3 times as long as the tube. Corolla salverform, the tube exceeding the calyx, the 5 *pink lobes* 3–4 mm long. Capsule elongate, exceeding the calyx, and invested by a marcescent corolla. Seeds minute, irregularly spherical with a rough brown surface. 2n = ca. 38 (Rork 1949).

Naturalized from Europe, so far collected from only two localities: SHEBOYGAN CO.: On limestone [Niagara Dolomite] at level

15 Halenia deflexa



16 Centaurium pulchellum

17 Menyanthes trifoliata

of Lake Michigan, E. end of Lincoln Ave., Sheboygan, 1935, *Fuller & Reeder 4532* (MIL); Sheboygan, 1930, *Goessl s.n.* (WIS); Sheboygan, Beach, 1935, *Goessl s.n.* (WIS). MANITOWOC CO.: Cleveland, 1907, *Goessl s.n.* (MIL). RACINE CO.: Weed in railroad track, vic. Modine Company, Racine, July 24, 1965 (fl), *Swink 228* (WIS).

Flowering as early as August, with all stages of development from buds to mature capsules found on the same plant throughout September and into October.

Excluded Genera

Fernald (1950) records *Swertia caroliniensis,* the American Columbo, and *Sabatia angularis,* the Rose Gentian, for Wisconsin; however, no known herbarium specimen of the former is available, the species being way out of range (north to Central Illinois with one record from Cook Co. Ill.; cf. Card 1931; Winterringer and Evers 1960). The only Wisconsin specimen of *Sabatia,* a showy pink-flowered relative of *Centaurium,* is deposited in the Gray Herbarium: "WIS. J.J. Hale", without specific locality. Wilbur (1955) annotated Hale's specimen [collected ca. 1860], but did not recognize Wisconsin within the species range (i.e. did not cite it in his monograph). There are other, reputedly Wisconsin records based on *Hale* collections, as *Filipendula rubra,* (cf. Mason & Iltis 1958: 80) in 1865 at Mazomanie. These low sandy flats still house many plants that are rare or occur nowhere else in Wisconsin (e.g. *Krigia virginica, Diodia teres*), and it is possible that the species might have occurred locally in southern Wisconsin. Its closest stations are in North-central Illinois to Gary, Indiana, less than 100 miles from the Wisconsin border.

MENYANTHACEAE Moench. Buckbean Family

[Lindsey, A. A. 1938. Anatomical Evidence for the Menyanthaceae. Am. Jour. Bot. 25:480–485]

The relationship and position of *Menyanthes* has been discussed by Lindsey (1938), who showed that *Menyanthes* is anatomically distinct from Gentianaceae and should be considered, together with *Nymphoides,* in the separate family Menyanthaceae.

The Menyanthaceae, a small but widely distributed family of aquatics and marsh plants is represented in Wisconsin by the single circumpolar genus and species *Menyanthes trifoliata* L. The description of the family, therefore, is also the description of the genus and species.

1. MENYANTHES L. Buckbean

1. Menyanthes trifoliata L. Buckbean Map 14; Fig. 17.
Menyanthes trifoliata var. *minor* Michx. ex Raf. (cf. Fernald 1929).

Perennial succulent semi-aquatic marsh or bog herbs with alternate 3-foliolate leaves from a creeping rootstock; petioles 5–20 cm long with enlarged sheathing bases; leaflets oval or oblong, 2–8 cm long, entire, with acute to obtuse apices. Inflorescences erect racemes ca. 10–20 cm long with elongated naked peduncles. Flowers on slender pedicels, dimorphic, in Wisc. 43% of the plants with flowers that have long styles (10–16 mm) and short stamens (7–11 mm), and 57% very short styles (7–11 mm) and long stamens (9–16 mm). Calyx lobes 5, 3–5 mm long. Corolla white, 10–15 mm wide, 7–11 mm long, the tube exceeding the calyx to twice as long, the 5 lobes about 5–8 mm long, the *inner surface bearded with many slender clavate hairs*. Stamens 5; anthers sagittate. Ovary 1-celled; stigma 2-lobed. Capsule 2-valved, ovoid, 6–10 mm long. Seeds 9–30, shiny (varnished), light brown, ovoid to subglobose, 2.2–2.9 x 1.7–2.4 x 1.1–1.4 mm. $2n = 54$ in both Eurasian and American plants (Rork 1949).

A characteristic circumboreal species of sphagnum bogs and wet coniferous forests, not uncommon in Wisconsin north of the "Tension Zone", lacking due to absence of bogs from most of the "Driftless Area", in wet portions of acid sphagnum bogs (with *Smilacina trifolia, Chamaedaphne, Kalmia, Andromeda*), in boggy sphagnous *Larix* woods (with *Picea mariana, Sarracenia purpurea, Trientalis*), in the far north in various wet cold habitats of woods or shores of streams and acid lakes. Flowering from the 2nd week in May (S. Wisc.) to late June (rarely into July); fruiting from June to August.

Fernald (1929) referred the specimens from Eastern North America, including Wisconsin, to var. *minor* Michx. ex Raf., with smaller, more nearly white and not as conspicuously bearded flowers compared with European material. These supposed differences are hard to see, and some careful analysis is needed here to verify Fernald's suppositions. Ronald Liesner, a student at the University of Wisconsin, made preliminary measurements of our collections, which in no way seem to differ from the European or Japanese collections here available, except for a rare Old World plant that is more robust and larger-flowered. Stamen and style length measurement are exactly alike. One may say that Old World *Menyanthes* appears somewhat more variable, that of the New World well within the flower size distribution of the former, but more uniform.

NYMPHOIDES PELTATA (Gmel.) Kuntze, the Yellow Floating Heart, a rooted aquatic introduced from Europe, is an additional representative of Menyanthaceae to be looked for in Wisconsin. Reported just south of Wisconsin in Winnebago County, Illinois (Fuller, Fell and Fell 1949), it has alternate suborbicular floating leaves nearly identical to those of the waterlilies *(Nymphaea* and *Nuphar)* and 1 or more umbels of 5-merous fringed-petaled yellow flowers.

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PRELIMINARY REPORTS ON THE FLORA OF WISCONSIN. NO. 54. *EQUISETACEAE*—HORSETAIL FAMILY

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The monogeneric family Equisetaceae, one of the so-called "Fern Allies", is well-represented in the flora of Wisconsin. Five species and one hybrid of the subgenus *Equisetum,* and four species and three hybrids of the subgenus *Hippochaete* have been collected in the state. Although the genus is unmistakable, and several of the species are readily recognizable, the species of *Equisetum* are frequently subject to misidentification. A study of the subgenus *Hippochaete* (Hauke 1960, 1961, 1962a, b, c, 1963) has shown that several factors contribute to this. First is an extreme morphological plasticity under environmental stress. Thus, a single rhizome system of, for example, *Equisetum arvense* can bear aerial stems of radically diverse appearance. Second is the occurrence of hybridization, obscuring species boundaries. Third is the subtlety of those characters which are reliable for taxonomic determination.

The practice, an unfortunate one, of giving formal taxonomic recognition to essentially descriptive names has arisen in the nomenclature of *Equisetum.* Since the taxonomic categories of *subspecies, varietas,* and *forma* are intended for use with genetic variants from a species type, their use to describe environmental variation is misleading. In the treatment which follows, the plethora of forms usually listed for several of the species (Tryon *et al.,* 1953) are not accorded taxonomic status.

This treatment is based upon specimens in the herbarium of the University of Wisconsin–Milwaukee (WIS), University of Minnesota (MINN), and the Milwaukee Public Museum (MIL), for the loan of which I thank the curators. A few specimens from other herbaria [Missouri Botanical Garden (MO), University of Michigan (MICH), Ohio State University (OS), University of California (UC), New York Botanical Garden (NY), and the United States National Herbarium (US)] are included. The assistance of Dr. Hugh Iltis and Miss Carol Michelson in preparing this paper is particularly appreciated. Dots on the maps indicate specific localities and triangles county records only.

EQUISETUM L.

Rhizomatous perennials with stems characterized by a jointed appearance with leaves small, whorled, and fused into a nodal sheath. A series of ridges and grooves traverse the internodes and continue up into the nodal sheaths. These ridges and grooves alternate in each successive internode. Stem in cross-section usually with a prominent central canal (centrum) and smaller vallecular (under the grooves) and carinal (under the ridges) canals. Reproduction by spores borne in a cone terminal on the vegetative stem or in some species on a specialized fertile stem.

Key to Species

A. Stems with regular whorls of branches.
- B. First internode of branch shorter than or about equal to subtending stem sheath, at least in lower portion of plant.
  - C. First internode always shorter than stem sheath.
    - D. Sheath teeth few, large. Stem prominently angled ---------------------------------- 3. *E. palustre.*
    - DD. Sheath teeth numerous, small. Stem nearly smooth ---------------------------------- 1. *E. fluviatile.*
  - CC. First internode of upper whorls longer than stem sheath.
    - E. Stem teeth long and narrow. Branches 3-sided, with deltoid teeth ---------------------- 4. *E. pratense.*
    - EE. Stem teeth short and wide. Branches 4–5 sided, with pointed teeth -------------------- 2. *E. X litorale.*
- BB. First internode of branch longer than subtending stem sheath.
  - F. Teeth dark, coarse, separate. Branches usually simple. Stem ridges lacking conspicuous ornamentation ------ -- 6. *E. arvense.*
  - FF. Teeth red, membranous, coherent. Branches with 3–5 pairs of lateral branches. Stem ridges with prominent silica spicules ---------------------- 5. *E. sylvaticum.*

AA. Stems normally unbranched, occasionally with a few branches.
- G. Stems soft, deciduous (occasionally forms of *E. palustre, E. X litorale* will fit here).
  - H. Sheaths as long as wide, retaining teeth. Plants of wet places ------------------------------ 1. *E. fluviatile.*
  - HH. Sheaths about twice as long as wide, usually shedding teeth (except species 12). Plants of grassy, sandy places.

I. Plants with many ridges, the teeth deciduous. Rhizome dull.
J. Cones blunt, with green, plump spores. Sheaths green ______________________7. *E. laevigatum.*
JJ. Cones apiculate, with aborted spores. Sheaths often black-girdled ___________8. *E. X ferrissii.*
II. Plants with few ridges, teeth retained. Rhizome shiny __________________________12. *E. X nelsonii.*
GG. Stems firm, evergreen. Cones apiculate.
K. Large plants with numerous ridges.
L. Sheaths about as long as wide. Spores green ______ _______________________9. *E. hyemale* var. *affine.*
LL. Sheaths about 1½ times as long as wide. Spores aborted _______________________8. *E. X ferrissii.*
KK. Small plants with 14 or fewer ridges.
M. Stem with six angles but only three teeth ________ ____________________________13. *E. scirpoides.*
MM. Stem with angles and teeth of same number, more than 3.
N. Ridges in cross-section deeply furrowed. Spores green _____________________11. *E. variegatum.*
NN. Ridges in cross-section mostly biangulate. Spores aborted __________10. *E.* X *trachyodon.*

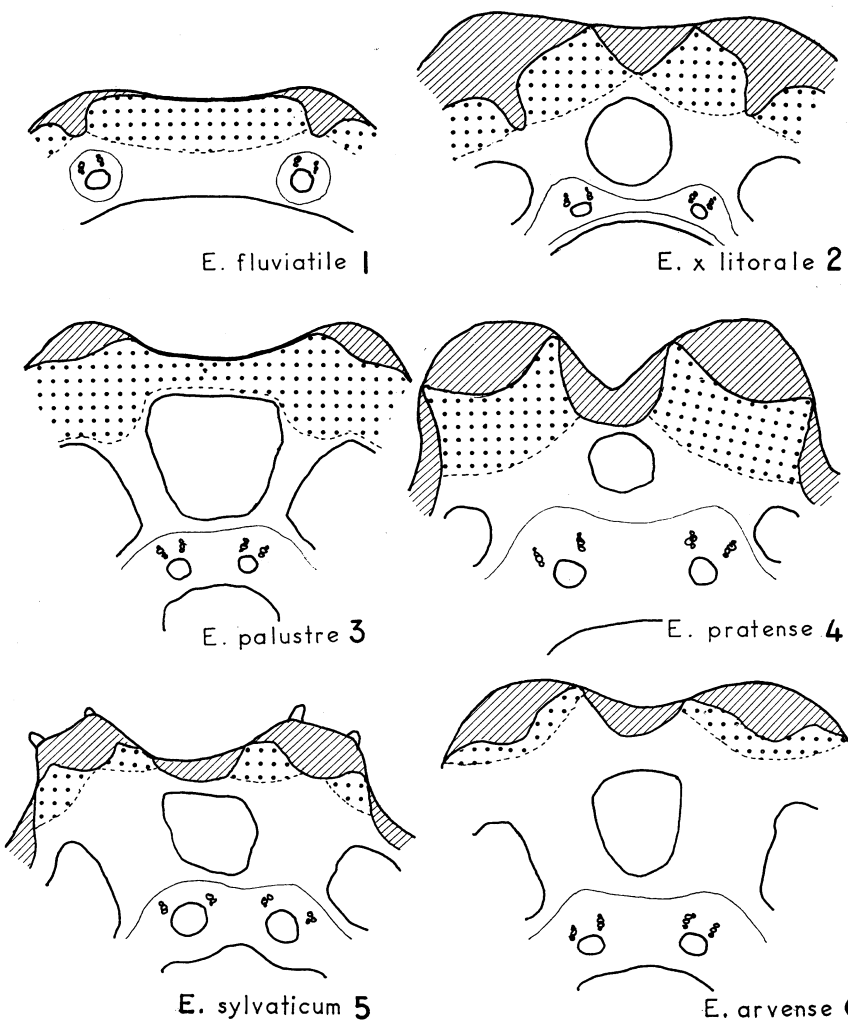
I. SUBGENUS EQUISETUM

Plants usually with regularly branched deciduous stems and blunt cones. Stomata superficial, in bands.

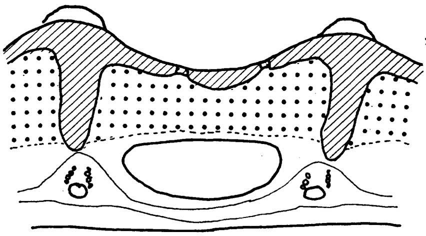
1. EQUISETUM FLUVIATILE L. Water Horsetail, Pipes.
Map 1; Figs. 1, 14, 15.

Rhizome shiny, light brown, unfelted. Stem smooth, with thin wall and very large centrum, usually lacking vallecular canals. Sheaths about as long as wide, with 12–20 short (2–3 mm) narrow black teeth. Branches, when present, with first internode shorter than or equal to subtending stem sheath, 4- to 6-angled. Cones present. Late May to early July.

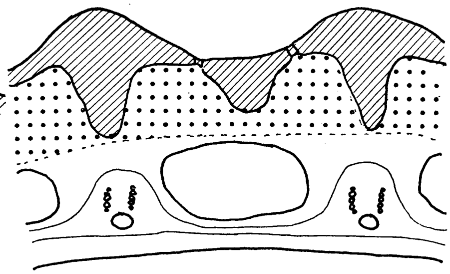
A common and widespread species in wet places, the Water Horsetail tends to come up in May as simple unbranched stems, and to become branched as the season progresses. Hence in May all collections tend to be of the unbranched form (f. *linnaeanum* (Döll) Broun. of Tryon *et al.*, p. 128, 1953), whereas by July most are of the forms with regular whorls of branches (typical form of Tryon *et al.*). Occasionally small or irregularly branched forms are found.



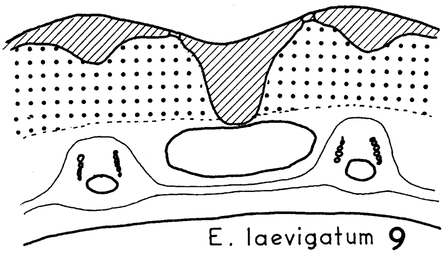
FIGURES 1–13. Diagrams of *Equisetum* stem cross-sections. Lined areas are supporting tissue, dotted areas chlorenchyma. Heavy lines mark canals—vallecular under the grooves, carinal under the ridges, and the centrum in the center. The light lines indicate the endodermis. 1. *E. fluviatile.*—2. *E. X litorale.*—3. *E. palustre.*—4. *E. pratense.*—5. *E. sylvaticum.*—6. *E. arvense.*—7. *E. hyemale* var. *affine.*—8. *E. X ferrissii.*—9. *E. laevigatum.*—10. *E. X trachyodon.*—11. *E. variegatum.*—12. *E. X nelsonii.*—13. *E. scirpoides.*



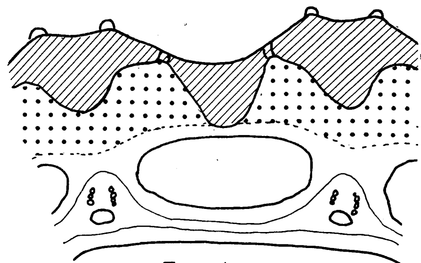
E. hyemale var. affine 7



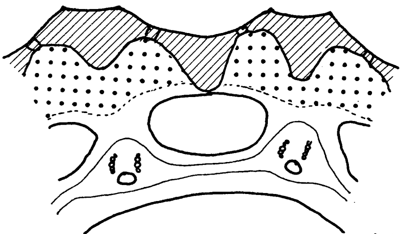
E. x ferrissii 8



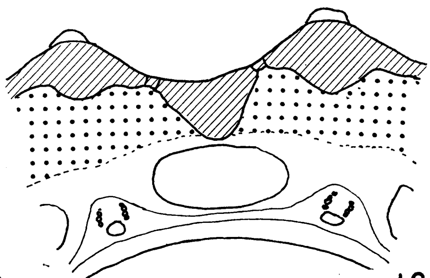
E. laevigatum 9



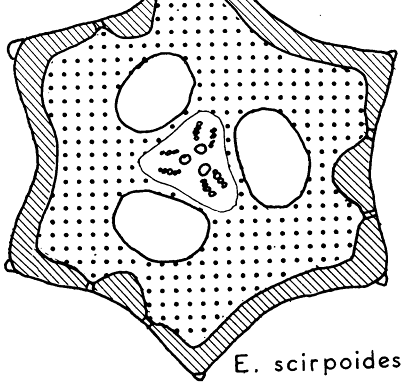
E. x trachyodon 10



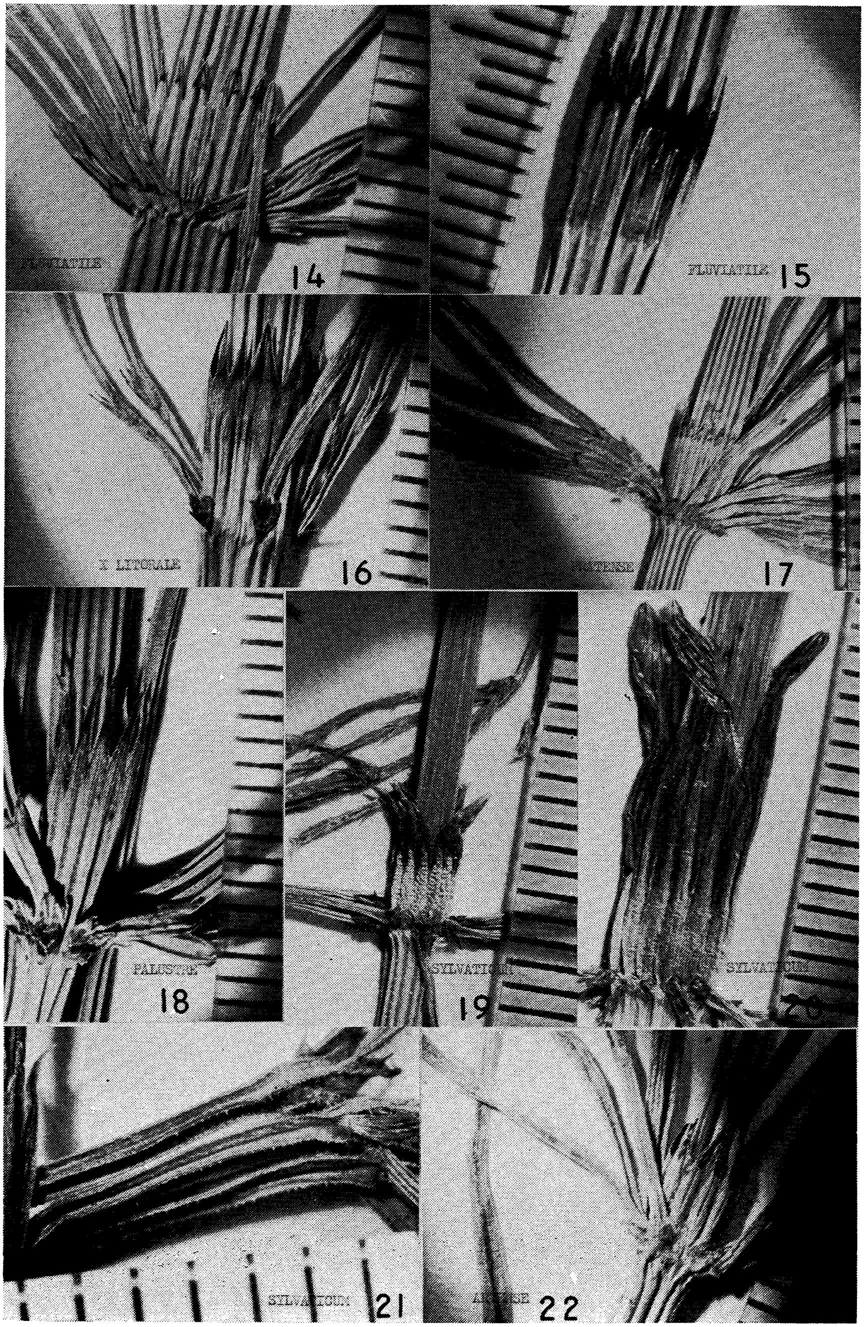
E. variegatum 11

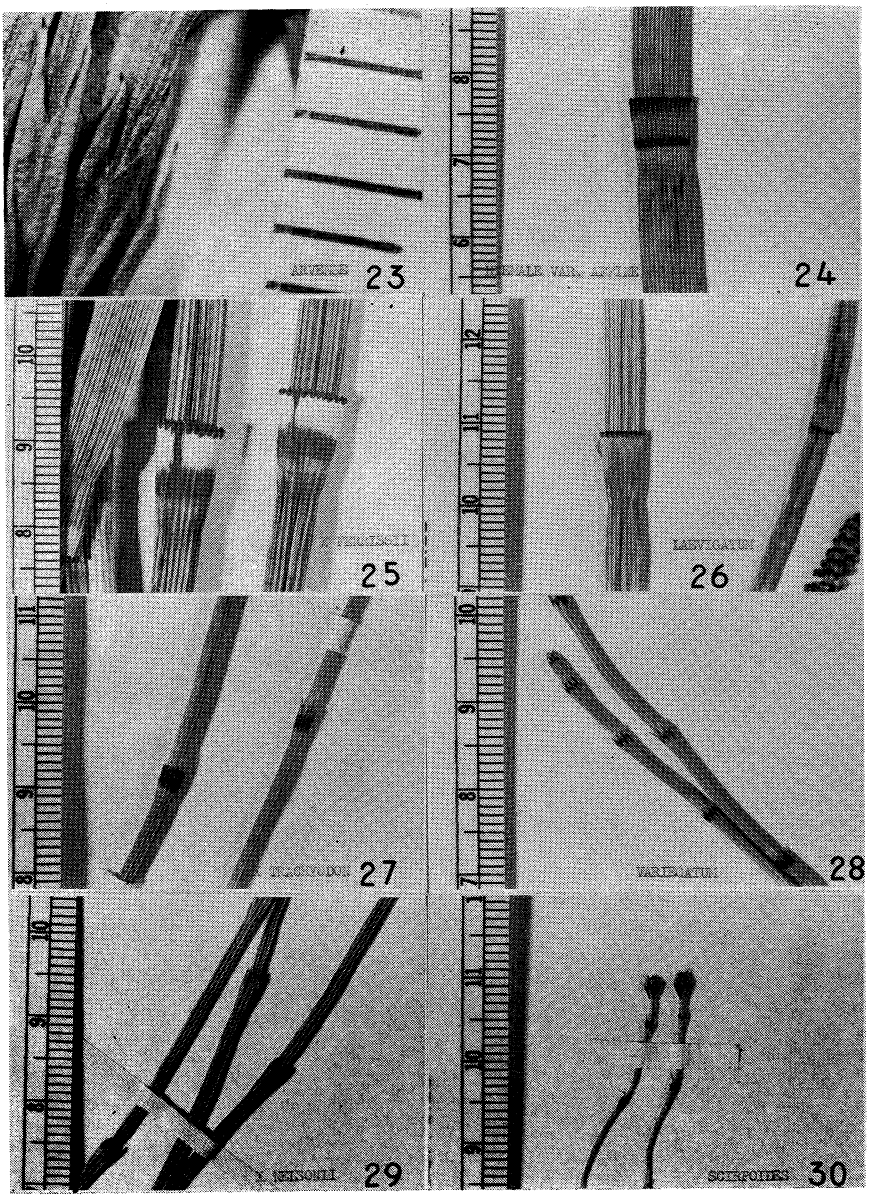


E. x nelsonii 12



E. scirpoides 13


FLUVIATILE
14
FLUVIATILE
15
X LITORALE
16
17
PALUSTRE
18
19
21
22



FIGURES 14–30. Photographs of nodal sheaths and branches of *Equisetum*. Scales are all millimeter rulers. 14. *E. fluviatile*, branched.—15. *E. fluviatile*, unbranched.—16. *E. X litorale*.—17. *E. pratense*.—18. *E. palustre*.—19. *E. sylvaticum*, vegetative.—20. *E. sylvaticum*, fertile.—21. *E. sylvaticum* branches with silica spicules.—22. *E. arvense*.—23. *E. arvense* branches with 3 angles. —24. *E. hyemale* var. *affine*.—25. *E.* X *ferrissii*.—26. *E. laevigatum*.—27. *E. X trachyodon*—28. *E. variegatum*.—29. *E. X nelsonii*.—30. *E. scirpoides*.

2. EQUISETUM X LITORALE Kuehl. Shore Horsetail. Map 2; Figs. 2, 16.

Equisetum fluviatile L. X *E. arvense* L.

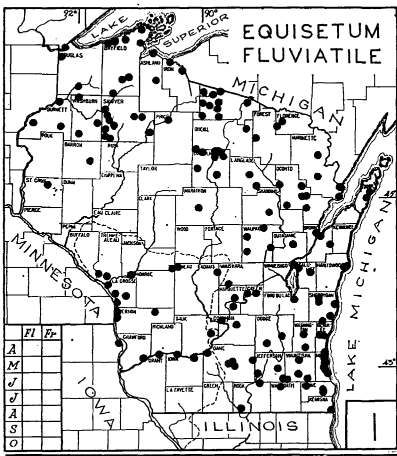
This hybrid is usually mistaken for *Equisetum fluviatile,* but differs in having definite vallecular canals, fewer (8–14) teeth, and 4- to 5-angled branches with the first internode shorter than the subtending sheath at the lower nodes, but definitely longer than the sheaths at the upper nodes. The cones contain aborted spores, which are readily recognizable because they are colorless, without elaters, and are never shed from the cone.

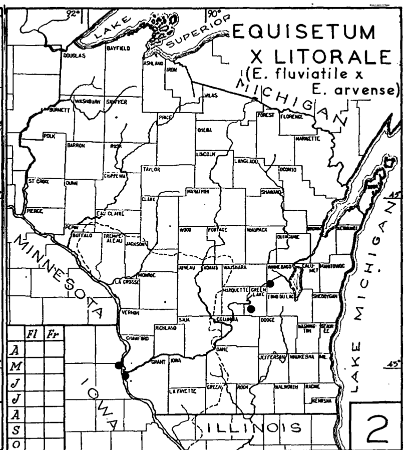
Milde first considered *E. X litorale* as a hybrid in 1851, but later (1867) decided it was a species becoming extinct. Only four localities are known for *E. X litorale* in Wisconsin, but it probably occurs elsewhere and has been bypassed as *E. fluviatile.* Grant Co.: Wyalusing State Park, 19 June 1959, *Patman s.n.* (WIS). Green Lake Co.: Marsh, north shore Lake Puckaway, Marquette, 18 Sept. 1929, *Fassett 8799* (WIS). Richland Co.: shallow water of springhole, Gotham, 11 Aug. 1958, *Hartley 5266* (WIS). Winnebago Co.: springy shore of Fox River, Eureka, 14 Sept. 1931, *Fassett 13243* (WIS).

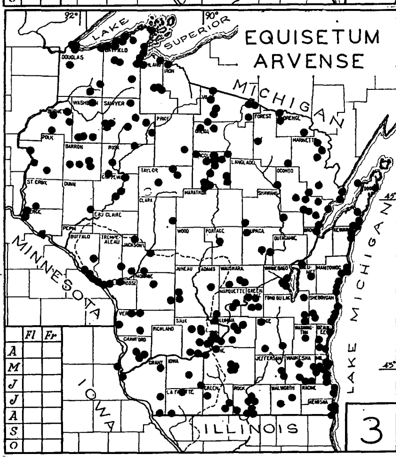
3. EQUISETUM PALUSTRE L. Marsh Horsetail. Map 4; Figs. 3, 18.

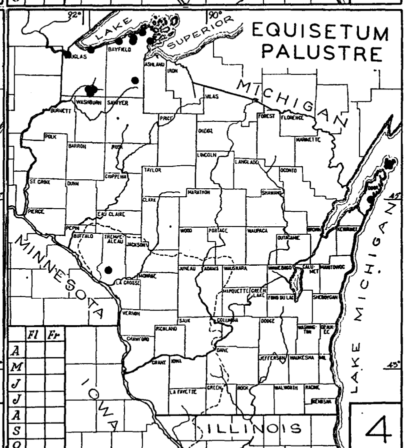
Rhizome shiny, dark brown, unfelted. Stem prominently angled, with a small centrum and vallecular canals as large as the centrum. Sheaths definitely longer than wide, with 8 to 12 long (3- to 6 mm) dark, white-margined teeth. Branches 6- to 7 angled, with the first internode only ½ as long as the stem sheath or shorter.

The Marsh Horsetail, a plant of wet places, is usually easily recognizable because of its few, large sheath teeth. Though normally a handsome plant with regular whorls of branches (f. *verticillatum* Milde of Tryon *et al.,* p. 127, 1953), it may occur in sparsely branched or unbranched forms. Tryon, *et al.* (1953) call this the typical form, following apparently Victorin (1927). (In the first edition they had used Victorin's names.) Typification of the name *E. palustre* L. is difficult since there is no specimen of this species in the Linnaean herbarium in London. (The sheet so labeled contains two specimens of *E. arvense,* one a robust, well-branched form, the other a rather depauperate specimen.) The Linnaean description is minimal *(Equisetum caule angulato, frondibus simplicibus,* i.e. Equisetum with angular stem, simple branches.), but Linnaeus would hardly have said *frondibus simplicibus* if he wished to indicate a plant with *caule nudo,* an expression he used in descriptions of unbranched species.


EQUISETUM FLUVIATILE
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
92°
90°
45°
Fl Fr
A
M
J
J
A
S
O
1


EQUISETUM X LITORALE
(E. fluviatile x E. arvense)
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
92°
90°
45°
Fl Fr
A
M
J
J
A
S
O
2


EQUISETUM ARVENSE
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
92°
90°
45°
Fl Fr
A
M
J
J
A
S
O
3


EQUISETUM PALUSTRE
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
92°
90°
45°
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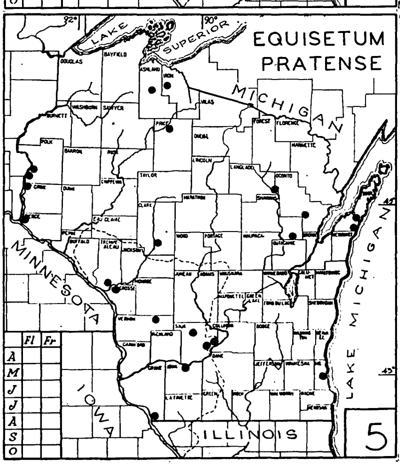
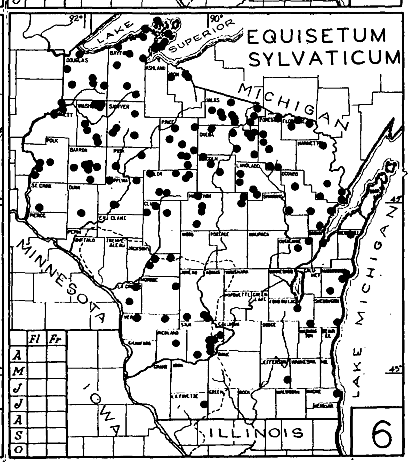
A
M
J
J
A
S
O
4


EQUISETUM PRATENSE
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
92°
90°
45°
Fl Fr
A
M
J
J
A
S
O
5


EQUISETUM SYLVATICUM
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
92°
90°
45°
Fl Fr
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S
O
6

The Marsh Horsetail is uncommon in Wisconsin, being found mostly in the northern part of the state. It bears cones in June and July.

4. EQUISETUM PRATENSE Ehrh. Meadow Horsetail.
Map 5; Figs. 4, 17.

Rhizome black, dull, with light brown felting on the nodal sheaths. Stems slender, roughened with silica dots along the ridges, with a relatively large centrum and well-developed vallecular canals. Sheaths of sterile stems slightly longer than wide, with a slight furrow in the middle of each segment, and with 8–16 thin-textured teeth having a dark center and colorless margins. Branches spreading or somewhat recurved, 3-angled, with deltoid teeth. First internode about equal to the subtending sheath on lower whorls, longer on upper whorls.

Fertile stems developing in May and June, with yellow or brown internodes and large, green, prominently flaring sheaths (2–3 times the diameter of the stem) with long (4–6 mm) teeth. At first unbranched, but persisting after the cone shrivels, becoming green and branched.

This species is found occasionally throughout the state in moist, wooded areas. It is often mistaken for *E. arvense,* but the roughened stems, furrowed sheaths, papery teeth, and deltoid branch teeth are all distinctive. It appears to be less variable than the other species of this subgenus.

5. EQUISETUM SYLVATICUM L. Wood Horsetail.
Map 6; Figs. 5, 19, 20, 21.

Rhizome dark brown, felted all over. Stems roughened with a double row of prominent silica spicules along the ridges; centrum large and vallecular canals prominent. Sheaths about as long as wide, with 8–16 long (to 1 cm) papery, reddish brown teeth, usually coherent into 3 or 4 lobes. Branches 3–4 angled, spreading, branched, giving the plant a delicate, lacy appearance. First internode longer than the subtending sheath. Fertile stem developing in May, at first lacking chlorophyll and unbranched, with very long (to 15 mm) papery teeth (Fig. 20), becoming green and branched as the cone shrivels.

The Wood Horsetail is the most beautiful species of *Equisetum.* It occurs throughout the state in moist, shaded areas, being quite common northward. Two forms of this species have received considerable attention. One has the first internode of the branches scabrous with silica spicules (typical *E. sylvaticum* in Europe) (Fig. 21), the other has the first internodes of the branches without silica spicules (var. *multiramosum* (Fernald) Wherry of Tryon *et al.*, p. 131, 1953). Fassett (1944) studied mass collections from various areas and showed that the scabrousity of the branches is a clinal character, occurring more frequently in plants from the western part of the range. It is also a variable character, some plants having completely smooth branches, others having branches scabrous only near the sheath, and others being completely scabrous. Fassett concluded that since this character shows geographic correlation, it merits varietal recognition. It is my belief, however, that a single, variable character with a gradual increase in frequency across a vast area and with no associated characters provides insufficient grounds for segregating the Wood Horsetail into two varieties.

6. EQUISETUM ARVENSE L. Field Horsetail.
Map 3; Figs. 6, 22, 23.

Rhizomes dark brown to black, felted along their length. Stems smooth, with a large centrum and well-formed vallecular canals. Sheaths about as long as wide, with slightly furrowed segments and 8–12 dark, often incurved teeth. Branches 3- to 4-angled, erect or ascending, the first internode definitely longer than the subtending sheath.

Fertile stems developing in April and early May, brown, thick, and fleshy, with large, flaring sheaths bearing long (to 15 mm) teeth and lacking branches. These die back as soon as the spores are shed, just when the young vegetative shoots are beginning to develop.

The Field Horsetail is by far the most common *Equisetum* throughout Wisconsin, growing in all sorts of disturbed places—cultivated fields, roadsides, railroad beds, sand dunes, river banks, lake shores, and even along the edge of woods. Perhaps this diversity of habitat and association with disturbed places account for its extreme variability. It occurs in depauperate forms and robust forms, in procumbent, decumbent, and erect forms, in forms with short, erect branches and forms with long, ascending to spreading branches. All of these have been named, but purely for descriptive purposes with no indication that any of them are genetically based. Plants with three-angled branches [var. *boreale* (Bong.) Rupr. of Tryon *et al.*, p. 123, 1953] (Fig. 23), are found throughout the range of *E. arvense*, but do seem to be more common in the northern part of the range, and there in shaded, quite undisturbed habitats. (See maps 55 and 56 in Tryon *et al.*, p. 124, 1953.) However, in the absence of a correlation with other characters, and considering its poorly defined geographic correlation, this character hardly merits varietal distinction. Even granting it *forma* status can, as far as I know, serve no useful purpose.

II. SUBGENUS HIPPOCHAETE (MILDE) BAKER

Plants usually with unbranched, evergreen stems bearing apiculate or acute cones. Stomata sunken.

7. EQUISETUM LAEVIGATUM A.Br. Smooth Scouring-Rush.

Map 7; Figs. 9, 26.

Equisetum kansanum Schaffner of Tryon *et al.*, p. 119, 1953.

Rhizome dull black, felted on sheaths. Stems medium to tall (to 8 dm) smooth, deciduous, with large centrum, prominent vallecular canals, and supporting tissue massed under the grooves. Sheaths twice as long as wide, slightly flaring upward, green with a black rim, with 18–24 segments, the teeth deciduous. Cones blunt to slightly apiculate, sporulating mostly in June.

This is a species of open fields, and occasionally of railroad beds, roadsides, and lake shores. It hybridizes with *E. hyemale* and because of this and a confusion of types, this species is commonly misnamed *E. kansanum* Schaffner (Tryon *et al.*, 1953; see Hauke, 1960). Plants may develop branches with age or following injury, and these sometimes grow from the base, producing a cluster of small stems mimicking *E. variegatum*. Occasionally forms are found with teeth retained, these being whitish. The smooth scouring rush is found mostly in the southeastern part of the state.

8. EQUISETUM X FERRISSII Clute. Map 8; Figs. 8, 25.

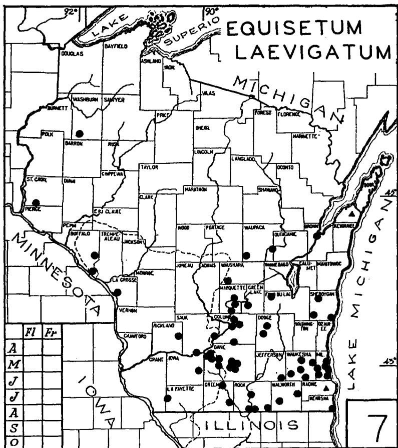
Equisetum laevigatum A. Br. X E. hyemale var. *affine* (Engelm.) A. A. Eat.
Equisetum laevigatum A. Br. of Tryon *et. al.*, p. 118, 1953.

This hybrid is intermediate between its parents *E. laevigatum* and *E. hyemale* in many characters, and is often called *E. hyemale* var. *intermedium* A. A. Eat. It has supporting tissue massed under both the grooves and the ridges, sheaths about 1½ times longer than wide, is half-evergreen, and develops a black girdle on the sheaths of the lower part of the stem. Cones appear mature in July, but contain aborted spores. This hybrid occurs mostly in the southeastern part of the state, but occasionally shows up in northern Wisconsin, where one parent is absent. Vegetative dispersal can account for this (see Hauke, 1960, 1963).

9. EQUISETUM HYEMALE var. AFFINE (Engelm.) A. A. Eat.

Scouring-Rush. Map 9; Figs. 7, 24.

Rhizome dull black, felted at the sheaths. Stem tall (to 12 dm)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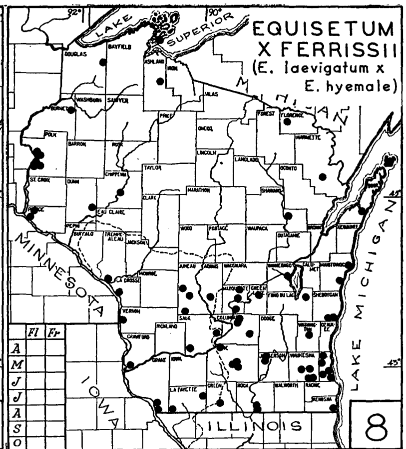
IOWA
ILLINOIS
LAKE MICHIGAN
7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X FERRISSII
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E. hyemale)
LAKE SUPERIOR
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IOWA
ILLINOIS
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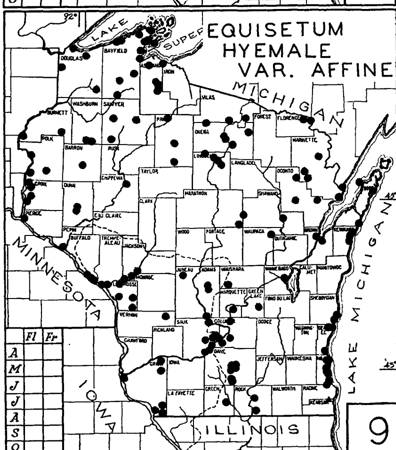
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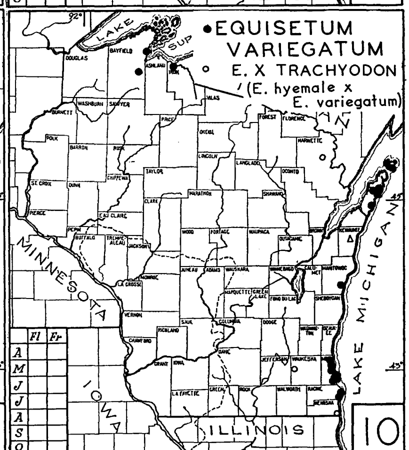
• EQUISETUM
VARIEGATUM
○ E. X TRACHYODON
(E. hyemale x
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IOWA
ILLINOIS
LAKE MICHIGAN
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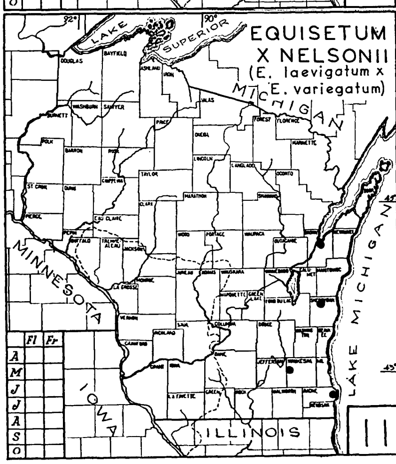
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LAKE MICHIGAN
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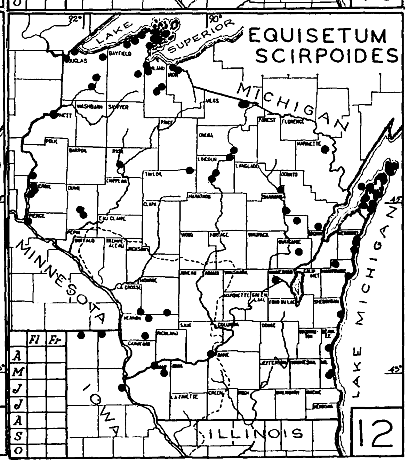
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LAKE MICHIGAN
12

rough, with a row of silica tubercles along the ridge, evergreen. Centrum and vallecular canals large, and supporting tissue massed under the ridges. Sheaths about as long as wide, dark-girdled around the middle and ashy white above, with 18–40 segments, the teeth usually shed. Cones sharply apiculate.

The Scouring-Rush is so called because its rough stems were used to scour pots and pans. They still are used by musicians to polish reeds for woodwinds. This species is common throughout the state and occurs in a variety of places—woods, fields, roadsides, railroad beds, lake and river margins. Branched forms result from injury, and often short, cone-bearing branches develop from the upper nodes of the previous year's stems. Occasionally it retains or tardily sheds the sheath teeth [var. *robustum* (A. Br.) A. A. Eat. of some authors]. Some apparent forms are actually hybrids with other species (see above and below).

10. EQUISETUM X TRACHYODON A. Br. Map 10; Figs. 10, 27.

Equisetum hyemale var. *affine* (Engelm.) A. A. Eat. *X E. variegatum* Schleich.

This hybrid is intermediate between the parents in size and ridge number. The ridges are biangulate, with a double row of silica tubercles. *Equisetum X trachyodon* frequently has the sheath coloration of *E. hyemale,* but the general low, clumped aspect and teeth structure of *E. variegatum.* Rare in Wisconsin, it is known from only four eastern counties: Kewaunee Co.: New Bay, on sawdust piles, borders of Lake Michigan, 15 Sept. 1925, *E. J. Palmer 28807* (MO). Kenosha Co.: flat prairie on banks of drainage ditch, Pleasant Prairie, 12 Aug. 1941, *Kruschke s.n.* (MIL). Marinette Co.: Pike River, Amberg, 14 Sept. 1937, *Tryon 3384* (WIS). Waukesha Co.: wet sandy shore, Golden Lake, 9 Oct. 1927, *Fassett 7563* (WIS).

11. EQUISETUM VARIEGATUM Schleich. Variegated Horsetail

Map 10; Figs. 11, 28.

Rhizome shiny black, unfelted. Stems small (to 3.5 dm) and clumped, with small centrum and vallecular canals, supporting tissue more prominent under the grooves, and ridges bearing two rows of silica tubercles with a well-developed furrow between them. Sheaths about 1½ times longer than wide, with segments having two ridges separated by a central furrow. Teeth persistent, obtuse, with a dark center and wide white margins, occasionally retaining also a filiform tip. Cones small, sporulation from July to September or overwintering and shedding the next spring.

This small, attractive species of wet sandy places, like river banks, lake shores, and ditches, is found in Wisconsin only near the shores of Lake Michigan and Lake Superior. It is very distinctive because of the variegated teeth and furrowed ridges, but the hybrids that occur with *E. hyemale* (see above) and *E. laevigatum* (see below) tend to obscure its distinctiveness.

12. EQUISETUM X NELSONII (A. A. Eat.) Schaffner

Map 11; Figs. 12, 29.

Equisetum laevigatum A. Br. *X* *E. variegatum* Schleich.

This hybrid has small, deciduous stems with sheaths much longer than wide. It is readily mistaken for small forms of *E. laevigatum,* but the shiny black rhizome, furrowed sheath segments, teeth coloration, and aborted spores reveal its hybrid nature. It is rare in Wisconsin, with specimens collected from only four southeastern counties. Brown Co.: Green Bay, 21 June 1881, *Schuette s.n.* (WIS). Racine Co.: Racine, 12 Sept. 1933, *Hicks s.n.* (OS). Sheboygan Co.: Elkhart Lake, 29 June 1879, *Schuette s.n.* (WIS). Waukesha Co.: Silver Lake, *Wilson, s.n.* (WIS).

13. EQUISETUM SCIRPOIDES Michx. Dwarf Scouring-Rush.

Map 12; Figs. 13, 30.

Rhizome rough, black, with felted sheaths. Stems very slender, wiry, and small (to 2 dm), flexuous, matted, with no centrum, 3 vallecular canals, and 6 ridges. Sheaths with 3 deeply furrowed segments and a black band around the base of 3 papery white teeth, which often bear a filiform tip. Cones small, sporulating in late summer, or overwintering and shedding the following spring.

The dwarf Scouring-Rush forms a loose turf of twisted wiry stems, generally in cold, moist, shaded places throughout N. Wisconsin, much rarer S. of the "Tension Zone", in cold wet muck of *Thuja* or *Abies balsamea-Betula papyrifera* woods, on and near rotten logs in *Tsuga-Acer saccharum-Fagus* forest, on the edges of rivers and lakes, less often in sandy, dry, ± open Oak–Hemlock–White Pine forests, or rocky canyons with *Taxus canadensis* or on sandstone cliffs, in S. Wisconsin in shaded edges of springs, limestone talus on N-facing bluffs, and on cold, mossy, moist, sandstone bluffs beneath white pines. With its curly stem and 6 ridges but only 3 teeth, it is an unmistakable species, easily overlooked because of its small size.

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