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## Aquatic Hydrophilidae and Hydraenidae of Wisconsin (Coleoptera). I. Introduction, Key to Genera of Adults, and Distribution, Habitat, Life Cycle, and Identification of Species of *Helophorus* Fabricius, *Hydrochus* Leach, and *Berosus* Leach (Hydrophilidae), and Hydraenidae

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AQUATIC HYDROPHILIDAE AND HYDRAENIDAE OF WISCONSIN  
(COLEOPTERA). I. INTRODUCTION, KEY TO GENERA OF ADULTS, AND  
DISTRIBUTION, HABITAT, LIFE CYCLE, AND IDENTIFICATION OF SPECIES  
OF *HELOPHORUS* FABRICIUS, *HYDROCHUS* LEACH, AND *BEROSUS*  
LEACH (HYDROPHILIDAE), AND HYDRAENIDAE<sup>1</sup>

William L. Hilsenhoff<sup>2</sup>

ABSTRACT

The 3,920 *Helophorus* (Helophorinae) adults collected in Wisconsin included 16 species, two of which were new species. *Helophorus orientalis* and *H. lacustris* predominated. Three types of univoltine life cycles occurred: (1) adults overwinter in terrestrial habitats and larvae complete development in riparian habitats from early summer to early autumn, depending on the species; (2) the same as type 1, except eggs and a few adults overwinter; (3) larvae, pupae, and/or recently emerged adults overwinter and teneral adults occur in aquatic habitats in early spring. Nine species of *Hydrochus* (Hydrochinae) were found among 6,278 adults, with *H. squamifer* predominating. All had a similar univoltine life cycle in which adults overwinter in terrestrial habitats and enter aquatic sites in spring; larvae complete development in riparian habitats from late spring to late summer, depending on the species. Eight species and 5,167 adults of *Berosus* (Hydrophilinae: Berosini) occurred, with *B. striatus* predominating; their univoltine life cycles varied greatly among species. Some species overwinter as diapausing eggs (*B. aculeatus*, *B. peregrinus*, *B. stylifer*), others as adults in terrestrial habitats (*B. pantherinus*, *B. striatus*), one as aquatic larvae (*B. hatchi*), and another as adults and larvae (*B. fraternus*). Only 35 Hydraenidae adults were collected; included were *Hydraena angulicollis*, *H. pennsylvanica*, and *Ochthebius lineatus*. A generic key to aquatic Hydrophilidae adults and keys to species of *Helophorus*, *Hydrochus*, *Berosus*, and Hydraenidae in Wisconsin are provided. Following each species key is information about species that includes distribution and abundance in Wisconsin, range in North America, habitat, life cycle, and notes on identification.

This study follows the higher classification of Staphyliniformia by Newton and Thayer (1992), and will be published in two parts. Part I covers Hydraenidae and three genera of Hydrophilidae, *Helophorus* (Helophorinae), *Hydrochus* (Hydrochinae), and *Berosus* (Hydrophilinae: Berosini).

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## MATERIALS AND METHODS

In 1962 I began collecting aquatic beetles from lotic and lentic habitats throughout Wisconsin, using a D-frame aquatic net. All are preserved in 70% ethanol with 3% glycerine and stored in 1- or 3-dram vials in the University of Wisconsin Aquatic Insect Collection. Initially, most beetles were collected from streams in conjunction with other research, but starting in 1970 an effort was made to sample ponds, marshes, and other shallow lentic habitats in all counties of the state. Beginning in 1976, traps made of window screen were also used. These traps and other collecting techniques were described earlier (Hilsenhoff 1985). After 1983, bottle traps were employed instead of screen traps (Hilsenhoff 1987). Although traps were most effective for collecting Dytiscidae, they efficiently collected adults and larvae of some Hydrophilidae (Hilsenhoff 1991). I tried to sample all areas of Wisconsin during all months when open water was present, and to collect from as many diverse habitats as possible. Blacklight traps were occasionally employed, especially in the south-central area and at McKenna Pond, and accounted for significant numbers of specimens in some genera.

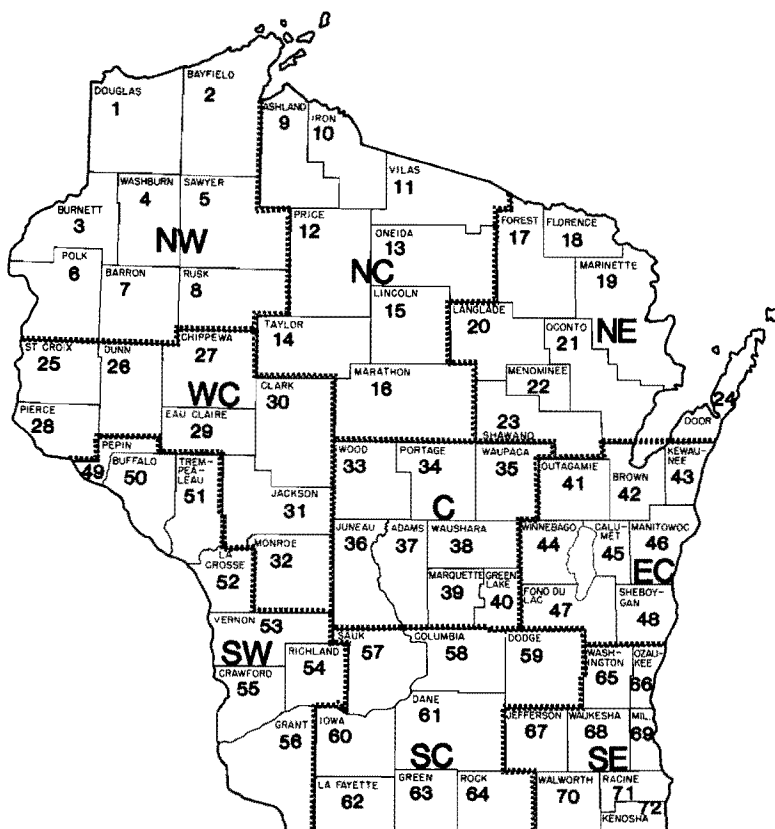
All specimens were re-examined to verify identifications and to record occurrence of teneral specimens. Adults were considered to be teneral if elytra were still soft. A range of lengths for each genus or species is provided in the keys. An ocular reticle in a Leitz dissecting microscope was used to measure the distance from the front of the head to the tip of the elytra when both were in the same plane with the head deflexed, but completely visible from above. If gaps occurred between the pronotum and head or elytra due to distortion, their width was subtracted from measurements. A micrometer was used to measure *Hydrophilus* adults. Reported size ranges are for at least 50 specimens from 25 Wisconsin counties, if available. If fewer than 4 specimens were collected, a size range from the literature was substituted. In all keys the sutural elytral interval is referred to as interval 1.

## HYDROPHILIDAE

Hydrophilidae is a rather large family in the suborder Polyphaga, with most species being aquatic as adults, and several also having aquatic larvae; all have terrestrial pupae. Five subfamilies occur in Wisconsin. In Hydrophilinae both adults and larvae are aquatic in Hydrophilini and Berosini; in Hydrobiini adults are aquatic and larvae are riparian, with larvae in some genera closely associated with the water. In Helophorinae and Hydrochinae adults are usually aquatic and larvae are riparian. A fourth subfamily, Sphaeridiinae, is terrestrial, and a fifth, Chaetarthriinae, is riparian.

Recent revisions of several hydrophilid genera in North America have made it possible to identify species of adults in all aquatic genera, except *Anacaena*, which has not been comprehensively studied in North America. Earlier studies by Wooldridge in Illinois (1967) and Willson in Michigan (1967) were helpful in determining which species of Hydrophilidae are likely to occur in Wisconsin; recent generic revisions provided much additional information. Smetana's study of the Hydrophilidae of Canada and Alaska (1988) included most species found in Wisconsin, adding significantly to our knowledge of the family in northern North America. A few species not collected in Wisconsin were included because above publications suggest they may occur. Larvae remain virtually unknown at the species level, although Richmond (1920) and others described larvae for some species.

Aquatic adults (64,745) of 73 species in 15 genera that were collected in Wisconsin over the past 33 years are the basis for this study. Collections from



Map 1. Location of nine 8-county areas in Wisconsin and number assigned to each county.

McKenna Pond in Dane County by Bryn Tracy from 1978–1981 and by me in other years accounted for 51% of the beetles used in this study, and collections from 16 ponds at the Leopold Memorial Reserve in Sauk County by Leonard Huebner from 1989–1992 accounted for 8%. Both sites are listed separately in tables. Records from 683 adults in the University of Wisconsin Insect Research Collection (UWIRC), most of which were from Bayfield, Florence, Wood, Sauk, and Dane counties, were also included in this study, but were not used to determine seasonal occurrence or general distribution (tables) because most were collected during the summer from only a few counties. Genera of Hydrophilidae that occur or may occur in Wisconsin are keyed below; a species name is included when only one species occurs in Wisconsin. Following this key, species of *Helophorus*, *Hydrochus*, and *Berosus* are keyed and discussed. Relative abundance and distribution are summarized in Table 1 for nine regions of Wisconsin depicted in Map 1 and for McKenna Pond and the Leopold Memorial Reserve. Information about species includes distribution and abundance in Wisconsin, range in North America, habitat, life cycle, and notes on identification. Each county in Map 1 is numbered; county records for each species refer to these numbers.

Table 1. Numbers of Hydrophilidae adults collected 1962-1994 from nine areas of Wisconsin (Map. 1), McKenna Pond (McK), and Leopold Memorial Reserve (LMR).

Species	NW	NC	NE	WC	C	EC	SW	SC	SE	McK	LMR	TOTAL
<i>Helophorus angusticollis</i>	55	34	15	7	19	0	10	7	2	6	3	158
<i>H. furius</i>	0	1	0	0	2	2	11	37	9	0	0	62
<i>H. grandis</i>	1	3	0	0	0	0	0	0	0	0	0	4
<i>H. inflectus</i>	3	1	12	0	0	13	0	2	1	0	0	32
<i>H. lacustris</i>	14	13	29	26	11	73	51	116	62	159	10	564
<i>H. latipennis</i>	1	0	2	0	7	0	0	0	0	0	0	10
<i>H. linearis</i>	0	0	2	9	3	1	5	27	2	16	2	67
<i>H. lineatus</i>	6	0	1	27	8	2	51	31	6	112	21	265
<i>H. marginicollis</i>	0	0	0	0	0	0	13	35	1	1	2	52
<i>H. nitiduloides</i> ♂	0	0	1	2	0	0	34	31	1	96	0	165
<i>H. nitidul. smetanai</i> ?	21	9	15	6	7	3	26	36	3	141	6	273
<i>H. oblongus</i>	1	2	120	0	0	0	0	0	0	0	0	123
<i>H. orchymonti</i>	0	0	1	0	0	0	5	1	0	0	0	7
<i>H. orientalis</i>	107	210	31	256	59	465	73	183	194	238	10	1826
<i>H. sempervarians</i>	61	97	21	8	0	0	7	0	0	0	0	194
<i>H. smetanai</i> ♂	43	5	21	6	6	4	5	6	0	19	2	117
<i>Hydrochus currani</i>	9	0	3	1	2	12	5	11	10	1	1	55
<i>H. granulatus</i>	4	0	0	0	1	0	0	0	1	3	0	9
<i>H. neosquamifer</i>	24	2	3	19	4	0	38	8	9	230	73	410
<i>H. pseudosquamifer</i>	1	0	7	0	5	29	15	17	104	655	0	833
<i>H. rufipes</i>	0	0	0	0	0	0	38	0	0	1	2	41
<i>H. scabratus</i>	0	1	0	0	0	0	0	0	0	0	0	1
<i>H. setosus</i>	0	0	0	0	0	1	0	1	0	0	0	2
<i>H. squamifer</i>	102	67	229	17	83	71	125	57	69	3880	142	4842
<i>H. subcupreus</i>	20	11	2	15	6	0	0	2	0	0	1	57
<i>Berosus aculeatus</i>	3	4	0	17	2	0	17	16	4	4	17	84
<i>B. fraternus</i>	8	3	5	34	10	29	15	117	86	51	65	427
<i>B. hatchi</i>	0	0	11	0	8	19	0	8	6	2	41	95
<i>B. infuscatus</i>	0	0	0	0	0	0	0	1	0	0	0	1
<i>B. pantherinus</i>	0	0	0	0	0	0	1	9	0	1	0	11
<i>B. peregrinus</i>	1	1	0	3	6	4	47	453	14	5	5	539
<i>B. striatus</i>	314	118	43	86	146	97	106	386	103	1138	1418	3955
<i>B. stylifer</i>	0	6	0	0	2	0	9	18	0	1	0	36

## Key to Genera of Adult Hydrophilidae

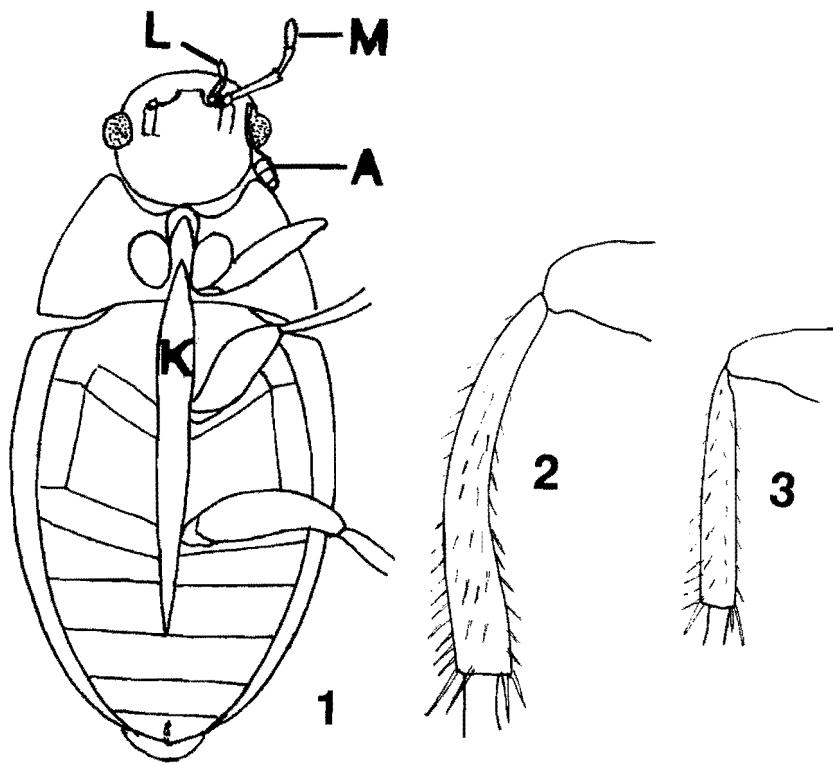
1. Pronotum with 7 longitudinal grooves, including marginal grooves; 2.0–7.1 mm long. . . . .HELOPHORINAE, *Helophorus*
- Pronotum without 7 longitudinal grooves . . . . .2
- 2(1). Pronotum much narrower than elytral base, and scutellum very small; pronotum granular or with very large punctures; 2.2–5.3 mm long. . . . .HYDROCHINAE, *Hydrochus*
- Pronotum not much narrower than base of elytra, or scutellum elongate; pronotum not granular, and lacking very large punctures. . . . .3
- 3(2). First 2 abdominal sterna excavated, usually containing a hyaline mass supported by a dense setal fringe on first abdominal sternum; small, < 2.0 mm long . . . . .CHAETARTHRIINAE, *Chaetarthria* (riparian)
- First 2 abdominal sterna not excavated . . . . .4
- 4(3). Metatarsus 5-segmented with segment 1 much longer than 2; antenna usually longer than maxillary palp, with palpomere 2 much thicker than 3 or 4 . . . . .SPHAERIDIINAE (terrestrial)
- Metatarsus 4-segmented, or 5-segmented with segment 1 much shorter than 2; antenna subequal to or shorter than maxillary palp, with palpomere 2 subequal in thickness to 3 and 4 . . . . .5
- 5(4). Meso- and metasternum with a continuous median longitudinal keel, which is prolonged posteriorly into a spine between metacoxae (Fig. 1) . . . . .HYDROPHILINI 6
- Meso- and metasternum without a continuous median longitudinal keel . . . . .9
- 6(5). HYDROPHILINI—Length 8–19 mm . . . . .7
- Length 31–42 mm . . . . .8
- 7(6). Prosternum sulcate (Fig. 1) to receive anterior part of keel; smaller, 8.0–12.1 mm long. . . . .Tropisternum
- Prosternum carinate; larger, 14.8–18.9 mm long. . . . .Hydrochara
- 8(6). Prosternal sulcus closed anteriorly; 33.2–41.4 mm long . . . . .Hydrophilus triangularis
- Prosternal sulcus open anteriorly; 31–36 mm long . . . . .Dibolocelus ovatus
- 9(5). Meso- and metatibia with fringe of long swimming hairs; head strongly deflexed; scutellum elongate; 3.3–7.1 mm long . . . . .BEROSINI, *Berosus*
- Meso- and metatibia without fringe of long swimming hairs; head not strongly deflexed; scutellum almost as wide as long . . . . .10
- 10(9). HYDROBIINI—Apical maxillary palpomere longer than penultimate palpomere; maxillary palp short, about same length as antenna, except in *Sperchopsis* . . . . .11
- Penultimate maxillary palpomere as long or longer than apical palpomere; maxillary palp elongate, distinctly longer than antenna . . . . .16
- 11(10). Larger, > 6.0 mm long . . . . .12
- Smaller, < 3.4 mm long . . . . .13
- 12(11). Lateral margins of elytra weakly serrate basally; meso- and metatarsus with scattered fine hairs dorsally; elytra and venter brown; lotic; 7.9–9.3 mm long. . . . .Sperchopsis tessellata
- Lateral margins of elytra without serrations; meso- and metatarsus with a dorsal fringe of fine swimming hairs; elytra green, rust, or olive, venter black; lotic or lentic; 6.0–9.7 mm long . . . . .Hydrobius

- 13(11). Metatibia arcuate (Fig. 2); elytra without sutural striae; 2.2–3.6 mm long ..... *Laccobius*  
 Metatibia not arcuate (Fig. 3); elytra with sutural striae ..... 14
- 14(13). Metafemur shiny, at most sparsely pubescent ventrally at base; elytra usually with greenish or olive reflections; prosternum longitudinally carinate; 1.2–3.0 mm long ..... *Paracymus*  
 Metafemur densely pubescent ventrally in basal three-fourths or with distinct microsculpture; elytra without greenish or olive reflections; prosternum not carinate ..... 15
- 15(14). Metafemur dull, densely pubescent ventrally in basal three-fourths; eyes anteriorly not protruding from margin of head; lotic or lentic; mostly smaller, 2.1–3.0 mm long ..... *Anacaena lutescens*  
 Metafemur rather shiny, not densely pubescent, but with longitudinal microsculpture; eyes anteriorly protruding from margin of head; lotic; mostly larger, 2.6–3.4 mm long ..... *Crenitis digesta*
- 16(10). Ten deeply impressed striae on each elytron; 6.4–8.0 mm long ..... *Helocombus bifidus*  
 Elytral striae, if present, weak and confined to mesal and lateral areas ..... 17
- 17(16). All tarsi 5-segmented, first segment often very small; 3.0–8.3 mm long ..... *Enochrus*  
 Meso- and metatarsus 4-segmented; 3.0–6.3 mm long ... *Cymbiodyta*

#### HELOPHORINAE—*Helophorus* Fabricius, 1775

*Helophorus* species remained poorly known in North America until McCorkle (1965) keyed species in the Pacific Northwest, described several new species, and subsequently (1967) completed a revision for America north of Mexico, which was never published. Smetana (1985) revised Nearctic Helophorinae, describing all known species, nine of which were new; he also provided a key to species, illustrations of male genitalia, distribution maps, and notes on bionomics and identification. Adults of *Helophorus* are easily recognized by their elongate shape and seven longitudinal grooves on the pronotum that divide it into six raised areas called "intervals". From the middle pair outward intervals are named "internal", "middle", and "external" and grooves are named "median", "submedian", "submarginal" and "marginal". Intervals often contain "granules", which are round, flat tubercles with a central micropuncture. Where and to what degree granules are formed on each interval varies among species and is used for identification; the density of granules also varies somewhat within species. Females are larger than males; size ranges for each sex are included in the key below.

Adults are poorly adapted for swimming, having only a weak fringe of long setae on the tarsi; they mostly crawl about on aquatic vegetation. Most were collected with nets; 6% were collected at light traps. Eggs are laid in moist vegetation or debris at the margin of aquatic habitats. The predaceous larvae, which develop in riparian habitats that often are created by receding water levels, are poorly known. Richmond (1920) described larvae of two species and added life history notes; present knowledge was summarized by McCorkle (1967), but life cycles for North American species have remained unknown. Monthly abundance of adults and teneral adults of each species (Table 2) suggests three types of univoltine life cycles for species in Wisconsin. Type 1—Adults overwinter, probably in terrestrial habitats adjacent to breeding sites, and enter aquatic habitats in spring to mate and lay eggs at the margin. Larvae complete development in riparian habitats in early summer to early autumn, depending on the species. Evidence for this life cycle is numer-



Figures 1-3. 1. *Tropisternus* adult (ventral view) showing keel (K), labial palp (L), maxillary palp (M), and antenna (A). 2. Metatibia of *Laccobius* adult. 3. Metatibia of *Anacaena* adult.

ous aquatic adults in early spring, increased numbers in summer with many teneral adults, and decreasing numbers after peak numbers of teneral adults. **Type 2**—This is the same as type 1, except low numbers of adults occur in spring, indicating eggs are the primary overwintering stage. **Type 3**—Mature larvae, pupae, and/or recently emerged adults overwinter in riparian sites and complete development to mature adults, which enter water in early spring. Adults mate in spring and lay eggs that diapause; hatching occurs in late summer and larval development begins. Evidence for this life cycle is an absence of adults after July and peak adult numbers following occurrence of teneral adults in spring.



Table 2. Occurrence and monthly counts of adults and teneral adults of species of *Helophorus* in which teneral specimens were collected.

Species	Occurrence	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.
<i>angusticollis</i>	3 Apr. - 2 Oct.	0	23	11	27	49	39	6	1	0
(teneral)	21 Apr. - 2 Oct.	0	1	0	2	12	19	1	1	0
<i>furius</i>	27 Mar. - 9 July	26	19	12	5	0	0	0	0	0
(teneral)	20 Apr.	0	1	0	0	0	0	0	0	0
<i>inflectus</i>	24 Oct. - 20 Apr.	0	4	11	14	2	0	0	1	0
(teneral)	24 Oct. - 12 May	0	3	3	0	0	0	0	1	0
<i>lacustris</i>	25 Mar. - 8 Nov.	44	99	30	125	155	58	25	25	1
(teneral)	20 Apr. - 31 Oct.	0	2	2	38	62	28	11	16	0
<i>latipenis</i>	11 Apr. - 21 June	0	6	3	1	0	0	0	0	9
(teneral)	20 Apr.	0	2	0	0	0	0	0	0	2
<i>linearis</i>	19 Mar. - 26 Oct.	1	1	2	5	13	23	13	9	0
(teneral)	5 July - 19 Oct.	0	0	0	0	3	2	3	3	0
<i>lineatus</i>	20 Feb. - 17 Oct.	38	25	10	136	50	2	1	3	0
(teneral)	7 June - 16 July	0	0	0	34	22	0	0	0	0
<i>marginicollis</i>	1 Apr. - 3 Sep.	0	20	3	13	13	2	1	0	0
(teneral)	19 June - 3 Sep.	0	0	0	2	9	0	1	0	0
<i>nitiduloides</i> ?	30 Mar. - 13 Oct.	4	19	17	5	3	1	104	11	0
(teneral)	31 Aug. - 13 Oct.	0	0	0	0	0	1	82	3	0
<i>oblongus</i>	23 Apr. - 12 July	0	4	36	79	4	0	0	0	0
(teneral)	23 Apr. - 4 May	0	1	14	0	0	0	0	0	0
<i>orientalis</i>	19 Mar. - 7 Nov.	4	44	22	1107	380	84	149	34	5
(teneral)	1 June - 5 Nov.	0	0	0	256	90	4	3	1	3
<i>sempervarians</i>	11 Apr. - 30 Sep.	0	34	39	23	8	58	32	0	0
(teneral)	26 July - 30 Sep.	0	0	0	0	3	42	22	0	0
<i>smetanai</i> ?	11 Apr. - 2 Oct.	0	26	11	36	14	11	17	1	0
(teneral)	13 July - 2 Oct.	0	0	0	0	9	5	10	1	0

Key to Species of Adult *Helophorus* in Wisconsin

1. Prominent tubercles on some elytral intervals; black; 2.8–3.5 mm long ..... *tuberculatus*  
Without prominent tubercles on elytra; usually brown to dark brown ..... 2
- 2(1). Antenna 9-segmented ..... 3  
Antenna 8-segmented ..... 6
- 3(2). Apical margin of fifth abdominal sternum with a fringe of truncate teeth; very large, 5.6–6.7 mm long ..... *grandis*  
Apical margin of fifth abdominal sternum without truncate teeth; smaller, < 5.0 mm long ..... 4
- 4(3). Middle pronotal intervals wide and entirely smooth; pronotal grooves narrow; 2.9–4.1 mm long ..... *sempervarians*  
Middle pronotal intervals narrow or mostly granulose; pronotal grooves wide ..... 5
- 5(4). Middle and internal intervals granulose, the latter less so at middle and posterior end; last maxillary palpomere weakly infusate at apex; length ♂ 3.3–4.1 mm, ♀ 3.7–4.6 mm ..... *lineatus*  
Granules obsolete on posterior two-thirds of internal intervals, obscure on anterior third and on middle intervals; last maxillary palpomere infusate in apical third; ♀ 2.6–4.2 mm long, no ♂ ..... *orientalis*
- 6(2). More than 4 mm long, elytra usually with a greenish cast and granules obsolete on internal and middle pronotal intervals ..... 7  
If > 4 mm long, elytra are brown to dark brown and granules are distinct on at least anterior of internal pronotal intervals ..... 8
- 7(6). Elytral pseudopipleuron (raised elytral interval 11) not visible in ventral view or appearing only as narrow line laterad of epipleuron; larger, length ♂ 5.0–6.7 mm, ♀ 5.6–7.1 mm ..... *oblongus*  
Elytral pseudopipleuron distinctly visible in ventral view; smaller, length ♂ 4.0–4.8 mm, ♀ 4.2–5.6 mm ..... *inflectus*
- 8(6). Portions of elytral intervals 1, 3, 5, and 7 at least slightly, but distinctly, elevated above others; middle intervals of pronotum widened in anterior half, at least 1 1/2 times width at base ..... 9  
Odd numbered elytral intervals not elevated; middle pronotal intervals linear, or lacking granules in beetles < 3.0 mm long ..... 12
- 9(8). Last maxillary palpomere short and swollen in middle portion, slightly > twice as long as wide, symmetrical or nearly so (Fig. 4); length ♂ 3.2–3.5 mm, ♀ 3.6–4.1 mm ..... *orchymonti*  
Last maxillary palpomere elongate, about 3 times as long as wide, asymmetrical (Fig. 5) ..... 10
- 10(9). Granules indistinct on posterior two-thirds of internal intervals and often on much of middle intervals; outer margin of parameres convex at middle and slightly concave apically (Fig. 6); larger, ♂ 3.4–4.4 mm long, ♀ 3.7–5.2 mm long ..... *lacustris*  
Granules distinct on much or all of middle and internal pronotal intervals; outer margin of parameres not distinctly convex at middle (Figs. 7–8); mostly smaller ..... 11
- 11(10). Anterolateral portion of pronotum only slightly depressed, allowing unrestricted dorsal view of marginal groove; apical portion of parameres divergent, and basal apodemes of penis about twice as long as apex past juncture of apodemes (Fig. 7); length ♂ 2.9–3.9 mm, ♀ 3.5–4.4 mm ..... *marginicollis*  
Anterolateral portion of pronotum depressed so that external interval obscures much of marginal groove apically in dorsal view; para-

- meres not divergent, and basal apodemes of penis about 3 times as long as apex past juncture of apodemes (Fig. 8); length ♂ 2.8–3.5 mm, ♀ 3.1–4.0 mm. .... *angusticollis*
- 12(8). Apical margin of 5th abdominal sternum with a fringe of distinct truncate teeth; 2.8–4.0 mm long (Smetana 1985) .... *linearoides*
- Apical margin of 5th abdominal sternum without truncate teeth. .13
- 13(12). Stem of epicranial suture wide, widened anteriorly; all pronotal intervals uniformly narrow and separated by wide grooves; length ♂ 2.6–3.4 mm, ♀ 2.8–3.9 mm. .... *linearis*
- Stem of epicranial suture narrow, not widened anteriorly; all pronotal intervals not uniformly narrow and separated by wide grooves .....14
- 14(10). Lateral margin of pronotum narrowed and slightly concave posteriorly; middle pronotal interval narrowed in middle to accommodate lateral expansion of internal interval; parameres wide, abruptly narrowed apically to form a sharp point; longer, ♂ > 2.7 mm, ♀ > 3.0 mm. ....15
- Lateral margin of pronotum evenly arcuate; middle pronotal interval not narrowed in middle; parameres not as above; shorter, ♂ < 2.7 mm, ♀ < 3.0 mm. ....17
- 15(14). Male with parameres widened past middle and ending in a rapidly narrowed sharp point (Fig. 9); pronotum metallic, distinctly paler than elytra; length ♂ 2.7–3.4 mm, ♀ 3.0–3.9 mm. .... *smetanai*
- Male with parameres parallel-sided or narrowed past middle, and with outer margin rapidly bevelled to inner margin at apex (Figs. 10–11); pronotum and elytra usually similar in color. ....16
- 16(15). Male genitalia broad, with penis broadly rounded at apex (Fig. 10); pronotum with wide grooves; intervals mostly granulose; length ♂ 3.0–3.4 mm, ♀ 3.0–4.0 mm. .... *latipenis*
- Male genitalia elongate, with penis narrowed to apex (Fig. 11); pronotum with grooves narrowed by intruding granules; internal intervals not granulose in basal two-thirds; length ♂ 2.7–3.4 mm, ♀ 3.1–3.9 mm. .... *nitiduloides*
- 17(14). Pronotum distinctly transversely convex; internal and middle pronotal intervals smooth, with very fine punctation; median and submedian grooves very narrow, linear; apical half of parameres linear on outer margin and concave on inner margin, tapering to a narrow apex (Fig. 12); length ♂ 2.2–2.7 mm, ♀ 2.4–3.0 mm ..... *furiosus*
- Pronotum slightly transversely convex; internal and middle pronotal intervals not quite smooth and with coarser punctation; median and submedian grooves wider, not linear; apical half of parameres concave on outer margin and linear on inner margin, forming a narrow apex 2.0–2.9 mm long (Smetana 1985). .... *nitidulus*

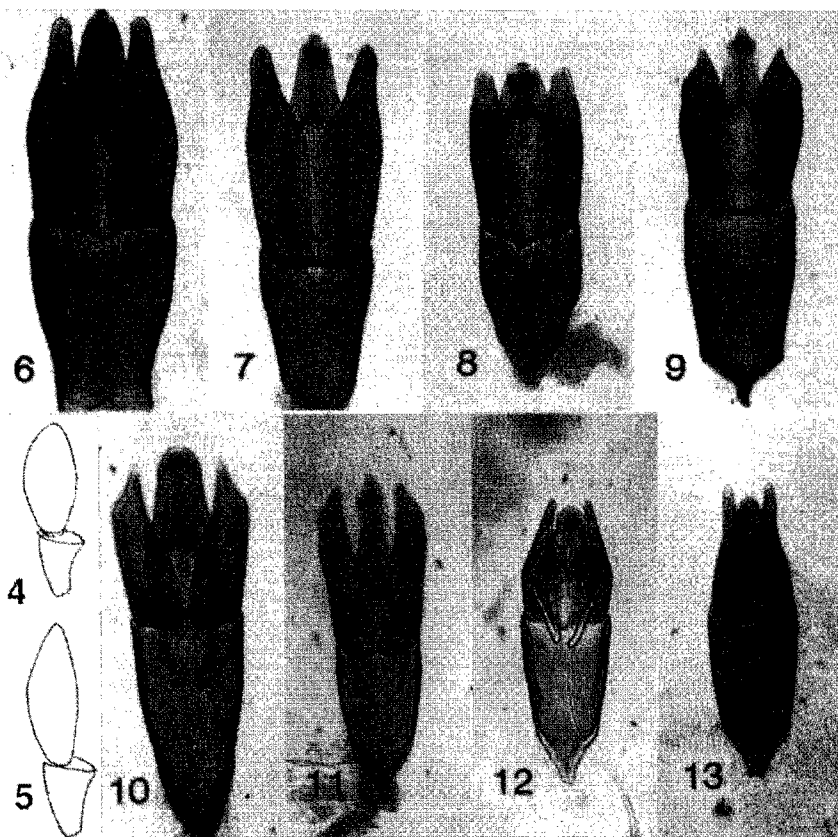
### *Helophorus angusticollis* d'Orchymont, 1945

**Distribution and Abundance:** Common in northwest to rare in southeast (Table 1). County records: 1–6, 8, 10–15, 17–21, 23, 25–27, 32–33, 35–39, 49, 54, 57, 60–61, 64, 68. Range: MN-NF-NJ-WI.

**Habitat:** Most adults were collected from shallow, vegetated ponds or other lentic habitats; some occurred along margins of streams.

**Life Cycle:** Adults have a typical type 1 *Helophorus* life cycle (Table 2). A teneral adult on 21 April probably resulted from an overwintering larva.

**Identification:** Adults are most similar to the slightly larger *H. marginicollis*. In addition to characters in the key, the pronotal bead has small, rather



Figures 4-13. *Helophorus* adults. 4-5. Right maxillary palpomeres 3-4 (ventral view). 4. *H. orchymonti*. 5. *H. angusticollis*. 6-13. Male genitalia at same magnification (ventral view). 6. *H. lacustris*. 7. *H. marginicollis*. 8. *H. angusticollis*. 9. *H. smetanai*. 10. *H. latipenis*. 11. *H. nitiduloides*. 12. *H. furius*. 13. *H. linearis*.

evenly-spaced, rounded serrations; these serrations are uneven and inconspicuous in *H. marginicollis*.

***Helophorus furius* Smetana, 1987 = *H. frater* Smetana, 1985**

**Distribution and Abundance:** Fairly common in southern third, rare farther north (Table 1). County records: 14, 39, 46-47, 49, 54, 61, 64-65, 67, 70-71. Range: BC-PQ-SD.

**Habitat:** Adults were collected from shallow ponds and marshes that usually contained water only in spring.

**Life Cycle:** Adults have a type 3 *Helophorus* life cycle; numerous adults in March suggest mostly adults overwinter (Table 2).

**Identification:** The very small size, smooth, linear pronotal intervals with an aeneous cast, and rufopiceous elytra that are paler in the apical third are distinctive. Parameres differed slightly from Smetana's illustrations (1985, 1988), being concave on the inner margin to form a narrow apex (Fig. 12).

***Helophorus grandis* Illiger, 1798**

**Distribution and Abundance:** Very rare in northern third (Table 1). County records: 2, 14, 16. Range: ON-NS-NH-WI; Palearctic, introduced into North America (Smetana 1985).

**Habitat:** Adults were collected from permanent sedge (*Carex*)-cattail (*Typha*) marshes adjacent to small ponds (Hilsenhoff 1990).

**Life Cycle:** Four male adults occurred 4 May – 18 July; none were teneral. Too few were collected to predict a life cycle.

**Identification:** The very large size, short scutellar stria at the base of each elytron, 9-segmented antennae, granular pronotal intervals, and truncate denticles on the apical margin of abdominal sternum 5 are diagnostic.

***Helophorus inflectus* McCorkle, 1965**

**Distribution and Abundance:** Uncommon in northeast and east-central areas, rare elsewhere (Table 1). County records: 3, 5, 15, 17, 20, 41–43, 45, 47–48, 61, 66. Range: BC-PQ-WI-WA.

**Habitat:** Adults were collected from shallow ponds and marshes.

**Life Cycle:** This species has a type 3 *Helophorus* life cycle, with larvae or pupae the predominant overwintering stage (Table 2).

**Identification:** Because of their large size and lack of granules on pronotal intervals, adults can be confused only with small adults of *H. oblongus*. Pronotal grooves are deeper than in *H. oblongus*, and middle intervals are distinctly widest apically.

***Helophorus lacustris* LeConte, 1850**

**Distribution and Abundance:** Common in south to fairly common in north (Table 1). County records: 3, 6–9, 12, 14, 17–18, 20–21, 23–25, 27–30, 32–33, 36–37, 39–49, 51–72. Range: AK-NF-NJ-IL-CA.

**Habitat:** In spring and early summer most adults were collected from shallow ponds or marshes, but after July increasing numbers were found along margins of streams.

**Life Cycle:** A type 1 *Helophorus* life cycle is indicated, with a partial second generation in some years that results in early autumn emergence and occasional overwintering larvae (Table 2). Many adults apparently overwinter in stream banks and return to ponds and marshes in early spring.

**Identification:** Adults most resemble those of *H. angusticollis* and *H. marginicollis*, which typically are distinctly smaller and have more granulose internal and middle pronotal intervals. Male genitalia are distinctive (Fig. 6), and females usually have distinct granules only on the apical fourth of internal intervals; occasional females have weak granules on middle intervals and on the basal portion of internal intervals. The anterior of the pronotum is less convex than in *H. angusticollis* and slightly more convex than in *H. marginicollis*.

***Helophorus latipenis* NEW SPECIES**

**Distribution and Abundance:** Rare in northern half (Table 1). County records: 2, 17, 36, 39. Range: probably boreal.

**Habitat:** Four males and six females were collected from shallow woodland ponds and the margin of a stream.

**Life Cycle:** Occurrence of two teneral females on 20 April indicates a type 3 *Helophorus* life cycle (Table 2).

**Identification and Description:** Because of size, pronotal shape, general shape of pronotal intervals, and pointed apices of male parameres, adults were previously identified as *H. nitiduloides*. Male genitalia are most similar to those of *H. nitiduloides*, but the penis is much broader and parameres meet at the basal fourth of the penis (Fig. 10) instead of past mid-length (Figs. 9, 11). Adults differ from those of *H. nitiduloides* and *H. smetanai* in several respects. Elytral intervals are quite uniform in height, with bases of intervals 2-6 not distinctly raised above interval 1, and interval 1 not distinctly elevated at mid-length as in the other two species. There is a pronounced black spot covering intervals 1-3 at mid-length and projecting forward along interval 1, and a black streak on interval 7 before mid-length; other spots are obsolete. The pronotal grooves are wider and shallower than in *H. nitiduloides* and *H. smetanai*, and lack distinct granules along margins of internal and middle intervals that project into the grooves to cause a ragged edge. The pronotum is not distinctly metallic, but near the color of the elytra. Otherwise adults fit descriptions of *H. nitiduloides* (d'Orchymont 1945 and Smetana 1985).

**Type Specimens:** HOLOTYPE male (3.1 mm long) label: "alder pool, Forest Co. WI, 19 May 1981". ALLOTYPE female (4.0 mm long) label: "alder pool 14, Forest Co. WI, 4 May 1983". Both were collected by W.L. Hilsenhoff from the same site on Forest Road 2168 0.1 mile east of Hwy 55. Eight Paratypes collected by W.L. Hilsenhoff are labeled as follows: 4♀ "C-6, Marquette Co. WI, 20 April 1992" (Hwy. J 0.3 miles east of Hwy. E); 1♀ "C-8, Marquette Co. WI, 1 April 1991" (4th Ave. 0.8 mile south of Hwy. A); 1♂ "woodland pond 21, Bayfield Co. WI, 21 June 1983" (Hwy. N 3.0 miles west of Hwy. 63); 1♂ "C-5, Marquette Co. WI, 25 April 1994" (Hwy. J 2.0 miles east of Hwy. 51); 1♂ (head and prothorax missing) "Cranberry Cr., Juneau Co. WI, 3 May 1969". The holotype, allotype, and two paratypes from Marquette Co. (20 April 1992) were deposited in the University of Wisconsin Aquatic Insect Collection. Other paratypes were distributed as follows: Bayfield Co. ♂ and Marquette Co. ♀ (20 April 1992) to the U.S. National Museum of Natural History; Marquette Co. ♂ and ♀ (20 April 1992) to the Canadian National Collection; Juneau Co. ♂ and Marquette Co. ♀ (21 April 1991) to the Museum of Comparative Zoology at Harvard University.

***Helophorus linearis* LeConte, 1855**

**Distribution and Abundance:** Fairly common in south-central area to rare in northern and eastern third. County records: 19, 23, 26-28, 32, 35-36, 48-49, 54, 56-58, 60-64, 71-72. Range: AB-NY-SC-TX-CA.

**Habitat:** Most adults were collected from shallow ponds.

**Life Cycle:** This species has a typical type 2 *Helophorus* life cycle (Table 2).

**Identification:** The small size, linear pronotal intervals separated by wide grooves, transversely flat and laterally rounded pronotum, apically-widened stem of the epicranial suture, and pointed parameres of males (Fig. 13) distinguish adults from all other species with 8-segmented antennae.

***Helophorus linearoides* d'Orchymont, 1945**

**Distribution and Abundance:** May occur only west of Wisconsin. Range: BC-MB-IA-NM-CA.

**Identification:** Truncate dents at the apex of the fifth abdominal sternum distinguish adults from those of other species with 8-segmented antennae.

***Helophorus lineatus* Say, 1823**

**Distribution and Abundance:** Fairly common in southwestern third to rare in northeastern third (Table 1). County records: 5-7, 17, 26-27, 29, 32-33, 35-36, 39-40, 47-48, 50-52, 54-58, 61-62, 64-67, 70-71. Range: ON-NB-FL-MO-ND.

**Habitat:** Adults were collected from a variety of shallow lentic habitats, especially ponds and marshes with cattails.

**Life Cycle:** This species has a type 1 *Helophorus* life cycle, with early larval development and emergence in late spring and early summer (Table 2).

**Identification:** The 9-segmented antennae, granulose pronotal intervals, and apically pointed parameres of males, readily distinguish adults from those of all other species. Females are separated by characters in the key from the mostly smaller female *H. orientalis*, which they resemble.

***Helophorus marginicollis* Smetana, 1985**

**Distribution and Abundance:** Fairly common in southwest and south-central areas, rare in southeast area (Table 1). County records: 49-50, 52-54, 56-58, 60-61, 63, 72. Range: WI-MA-VA-LA-MO.

**Habitat:** Most adults were associated with lotic habitats such as stream banks, sloughs, and spring ponds; one-fourth occurred in lentic habitats.

**Life Cycle:** A type 1 *Helophorus* life cycle with early emergence of adults appears typical for this species (Table 2).

**Identification:** Separation of adults from those of *H. angusticollis* is discussed under that species.

***Helophorus nitiduloides* d'Orchymont, 1945**

**Distribution and Abundance:** Common in southwest and south-central areas, rare elsewhere (Table 1). County records (males): 19, 25, 32, 49-50, 52-55, 61-64, 71. Range: probably south and west of Wisconsin.

**Habitat:** Most adults were collected from permanent ponds and marshes; a few were found in lotic habitats.

**Life Cycle:** Adults have a type 1 *Helophorus* life cycle, except hatching of eggs is delayed and larvae do not complete development until late summer and early autumn (Table 2).

**Identification:** Males differed from those of *H. smetanai* (Fig. 9) by their distinctive genitalia in which the parameres are concave apically on the inner margin and their outer margin is bevelled inward apically to a pointed apex (Fig. 11). Smetana (1985, 1988) illustrated three variations in the genitalia of *H. smetanai* (as *H. nitiduloides*), but none were like d'Orchymont's (1945) illustration of *H. nitiduloides*. Exhaustive comparisons of *H. nitiduloides* males and females from McKenna Pond, where they were very common, with those of *H. smetanai* from Burnett County, which is north of the range of *H. nitiduloides*, revealed only one other morphological difference; the apical maxillary palpomere is distinctly longer in males of *H. nitiduloides*. Unfortunately, this palpomere, which is shorter in females, was the same length in females of both species. Additional comparisons with males of *H. smetanai* from McKenna Pond and other ponds indicated elytra in mature individuals of

*H. smetanai* are darker than in those of *H. nitiduloides*, contrast more with the metallic pronotum, and lack the large pale area before the middle that is usually noticeable in *H. nitiduloides*. Ventrally, *H. nitiduloides* adults are typically paler than those of *H. smetanai*, especially on the abdomen, and their profemora are less infuscate basally; however, age and habitat affect color and I do not believe these differences can be used to reliably identify females.

***Helophorus nitidulus* LeConte, 1855**

**Distribution and Abundance:** Not yet found in Wisconsin. Range: BC-MN-MI-WA-CA+CO

**Habitat:** Smetana (1985) suggested adults occur in swamps, including semiaquatic habitats.

**Identification:** Because they are very small, adults could be confused only with those of *H. furius*, but they are darker and "often uniformly piceous-black" (Smetana 1985).

***Helophorus oblongus* LeConte, 1855**

**Distribution and Abundance:** Fairly common in northern third (Table 1). County records: 2, 10, 17, 20. Range: AK-PQ-WI-OR+WY+UT+CO.

**Habitat:** About 63% were collected from a vernal pond in Forest County. The remainder were found in other vernal ponds or shallow lentic habitats.

**Life Cycle:** This species has a type 3 *Helophorus* life cycle, with mostly larvae or pupae overwintering (Table 2).

**Identification:** The only other very large *Helophorus* adults are those of *H. grandis*, which differ in many respects; separation from the slightly smaller *H. inflectus* is discussed under that species.

***Helophorus orchymonti* Smetana, 1985 = *H. nitidulus* d'Orchymont, 1945**

**Distribution and Abundance:** Rare statewide (Table 1). County records: 18, 53-55, 57. Range: ON-VT-NJ-WI.

**Habitat:** Five adults were collected from streams and one from a spring pond.

**Life Cycle:** Adults occurred 15 April to 27 August; none were teneral. A type 1 *Helophorus* life cycle appears likely.

**Identification:** The short, broad, apical maxillary palpomere is distinctive. Adults are similar to those of *H. marginicollis* because the anterior of the pronotum is weakly convex, but in *H. orchymonti* the median, submarginal, and marginal pronotal grooves are wider, especially in the middle.

***Helophorus orientalis* Motschulsky, 1860 = *H. brevipalpis* McCorkle, 1965**

**Distribution and Abundance:** Very common statewide (Table 1). County records: 1-10, 12, 14-18, 21, 23-33, 35-36, 38-49, 51-68, 70-72. Range: BC-NS-NJ-IL-ND-NM-CA.

**Habitat:** Most adults were collected from shallow ponds, marshes, and ditches; occasionally they occurred along margins of streams.

**Life Cycle:** A type 2 *Helophorus* life cycle is indicated (Table 2). Adults that emerged in autumn may represent a partial second generation in some years.

**Identification:** This species is apparently parthenogenetic in Wisconsin; no males were found. Characters in the key readily distinguish females from the mostly larger, but similar, females of *H. lineatus*. The stem of the epicranial suture is greatly widened apically.



***Helophorus sempervarians* Angus, 1970 = *H. jacutus* d'Orchymont, 1945**

**Distribution and Abundance:** Common in northern third, uncommon in west-central counties (Table 1). County records: 1-4, 7-9, 12-20, 26-27, 30, 50-51. Range: AK-LB-PA-SD-BC

**Habitat:** Adults were collected from a variety of shallow lentic habitats; several teneral specimens were found along margins of streams.

**Life Cycle:** This species has a type 1 *Helophorus* life cycle, with overwintering adults returning to breeding sites after mid-April and most larvae completing development in late summer (Table 2).

**Identification:** Adults are easily distinguished from others with 9-segmented antennae by their wide and nearly smooth internal and middle pronotal intervals, which are separated by shallow, narrow grooves.

***Helophorus smetanai* NEW SPECIES**

**Distribution and Abundance:** Fairly common in northern third, uncommon farther south (Table 1). County records (males): 1-6, 8, 10-12, 17-20, 23-27, 33, 35, 37-38, 47-49, 52, 57, 59, 61. Range: probably northern United States and Canada.

**Habitat:** Adults were collected from a variety of shallow lentic habitats and occasionally from margins of streams.

**Life Cycle:** This species apparently has a type 1 *Helophorus* life cycle (Table 2).

**Identification and Description:** Separation from *H. nitiduloides* and *H. latipennis* is discussed under those species. This species is named after Dr. Ales Smetana in recognition of his North American revision of *Helophorus* (1985) and other valuable contributions to the study of North American Hydrophilidae. In his revision, he describes this species under *H. nitiduloides* and figures three variations in the male genitalia. All of his figures differ from d'Orchymont's (1945) illustration of *H. nitiduloides* male genitalia.

**Type Specimens:** HOLOTYPE male (3.1 mm long), ALLOTYPE female (3.6 mm long), 16 male and 2 female paratypes from a single collection by W.L. Hilsenhoff labeled: "pasture pond 12, Douglas Co. WI, 21 June 1983"; the pond is located in an open pasture on Hwy. B, 1.5 miles east of Hwy. S. The holotype, allotype, and four paratypes are in the University of Wisconsin Aquatic Insect Collection. Four male and one female paratype were deposited in the U.S. Museum of Natural History and in the Canadian National Collection; four male paratypes also were deposited in the Museum of Comparative Zoology at Harvard University.

***Helophorus tuberculatus* Gyllenhal, 1808.**

**Distribution and Abundance:** Very rare (Table 1). County records: 2, 61. Range: AK-PQ-MA-IA-OR. I did not collect any specimens, but Smetana (1985) lists four from Wisconsin, only one of which had a locality label (Bayfield County). A specimen in the UWIRC was collected in Dane County in 1898.

**Habitat:** Smetana (1985) states "there seems to be no doubt that *H. tuberculatus* is not a truly aquatic species", and suggests an association with *Sphagnum*.

**Identification:** The prominent tubercles on the elytra are distinctive.

**HYDROCHINAE—*Hydrochus* Leach, 1817**

Hellman (1975) revised *Hydrochus* in North and Central America, describing 28 new species, half of which occurred in the United States. Unfortunately, this revision was never published; Smetana (1988) described the only new species of Hellman that occurs in Wisconsin. He also described adults of all species occurring in Wisconsin, except *H. setosus*, and illustrated male genitalia. The head, pronotum, and/or elytral intervals of most species have small, round, flat, metallic tubercles with a central micropuncture that sometimes were called "squamae"; I refer to them as metallic spots. They usually are lighter than the background and have a metallic sheen. In several species they coalesce to form costae on elytral intervals. The extent and location of elytral costae is used to identify species, but this varies within species and genitalia of males should be checked to verify identifications of costate species.

All species apparently have a similar univoltine life cycle, which is not repeated below. Adults overwinter, probably in terrestrial habitats, and in early to mid-spring fly to aquatic sites where they mate and oviposit along the margins. Larvae complete development in riparian habitats from late June through August, and adults enter overwintering sites by early October. Richmond (1920) described eggs and larvae of *H. squamifer* and included life history notes. Adults, which have only sparse long setae on their tarsi and swim poorly, were collected from aquatic vegetation with nets. Light traps collected 67% of all adults; 77% of adult *H. squamifer* and 52% of adult *H. pseudosquamifer* were collected at lights, almost all during the summer at McKenna Pond.

**Key to Species of Adult *Hydrochus* in Wisconsin**

1. Large, > 4.5 mm long; very large oblique tubercles on posterior third of elytra; 4.5–5.3 mm long (Smetana 1988) ..... *scabratus*  
Smaller, < 4.5 mm long; without large oblique tubercles on elytra ... 2
- 2(1). Elytral intervals never costate, but with metallic spots ..... 3  
Elytral intervals costate at various points ..... 5
- 3(2). Elongate beetles, elytra slightly widened to apical third (Fig. 14); longer, 3.6–4.2 mm long ..... *granulatus*  
Robust beetles, elytra much widened at middle (Fig. 15); smaller, < 3.6 mm long ..... 4
- 4(3). Metallic spots on elytral intervals large, golden brown, often nearly contiguous, and forming irregular rows on disc; larger, 2.8–3.5 mm long ..... *currani*  
Metallic spots on elytral intervals small, dark metallic, separated by more than their diameters; smaller, 2.2–2.7 mm long ..... *setosus*
- 5(2). Small, broad, convex beetles; metallic spots absent from elytral intervals, pronotum, and head; 2.2–2.7 mm long (Smetana 1988) ..... *brevitarsis*  
Elongate beetles; if < 3.0 mm long, some elytral intervals, pronotum, and head with numerous metallic spots ..... 6
- 6(5). Pronotum without distinct metallic spots, area between punctures glabrous; parameres strongly dilated at mid-length (Fig. 16); 3.0–4.0 mm long ..... *rufipes*  
Pronotum with distinct metallic spots, some of which may be confluent; parameres not strongly dilated at mid-length (Figs. 17–20) ..... 7
- 7(6). Many pronotal metallic spots confluent; elytral intervals 1 to 7 basally wider and lighter than punctures, costae on 3, 4, 5, and 7 not dis-

- tinctly raised; elongate parameres broadly meet apically (splayed outward in Fig. 20); 3.0–3.8 mm long ..... *subcupreus*
- Pronotal metallic spots rarely confluent; if elytral intervals 1 to 7 have widened, pale, basal costae, costae on intervals 3, 4 and 5 and 7 are distinctly raised above intervals 1, 2, and 6 ..... 8
- 8(7). Metallic spots inconspicuous or absent between basal and medial costae on elytral intervals 3 and 4 and basally on interval 1; parameres sinuate laterally before widened apex (Fig. 17); smaller, 2.2–2.9 mm long ..... *neosquamifer*
- Distinct metallic spots, which may be confluent basally on elytral interval 1 and between basal and medial costae or replacing costae on intervals 3 and 4; rarely < 2.9 mm long ..... 9
- 9(8). Basal and medial costae on elytral intervals 3 and 4 prominent, with costae on interval 4 more prominent than on 5; interval 1 with basal metallic spots almost touching or confluent; parameres sagittate at apex (Fig. 19); 2.8–4.0 mm long ..... *squamifer*
- Medial costa on elytral interval 3 and basal costa on interval 4 weaker than other costa on same interval, the latter usually replaced with metallic spots that are less confluent or costate than those on interval 5; interval 1 with basal metallic spots separated by about width of a spot; parameres tapered to narrow apex (Fig. 18); 2.7–3.5 mm long ..... *pseudosquamifer*

#### ***Hydrochus brevitarsis* Knisch, 1922**

**Distribution and Abundance:** Not yet found in Wisconsin. Range: MN-MI-ON-PQ.

**Identification:** The small size, robust shape, and lack of metallic spots are distinctive. Elytral intervals 5 and 7 are moderately costate and metallic in the apical third. Adults of the other small species, *H. neosquamifer* and *H. setosus*, have distinct metallic spots.

#### ***Hydrochus currani* Brown, 1929**

**Distribution and Abundance:** Uncommon statewide (Table 1). County records: 3, 6, 8, 17, 19, 25, 39–40, 43, 45, 48–49, 54, 57–59, 61, 64, 66, 68, 70. Range: BC-PQ-NY-WI-WA

**Habitat:** All adults occurred in shallow ponds and marshes.

**Life Cycle:** Adults were collected 27 March–22 August, 87% May–July and 39% in June. Two in March and one 22 August were teneral, suggesting late summer emergence and some overwintering of larvae or pupae.

**Identification:** The robust shape (Fig. 15), rather small size, numerous golden, metallic spots, and lack of costae on pronotal intervals are distinctive. The numerous golden spots cause beetles to appear brown.

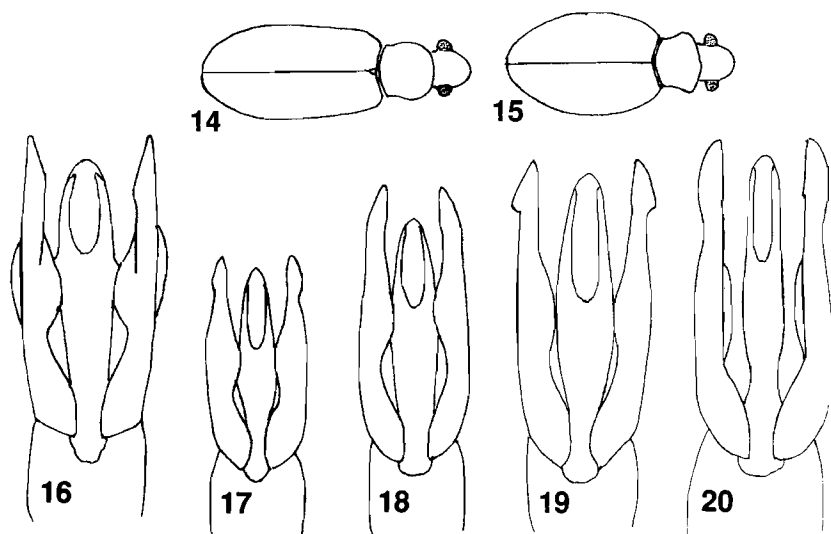
#### ***Hydrochus granulatus* Blatchley, 1910**

**Distribution and Abundance:** Rare statewide (Table 1). County records: 2, 8, 39, 61, 71. Range: BC-PQ-NY-MN

**Habitat:** Eight adults were collected from shallow ponds; one was found along a stream.

**Life Cycle:** Adults occurred 11 April–3 September; those on 13 August and 3 September were teneral.

**Identification:** The numerous metallic spots and complete lack of elytral costae distinguish adults from those of other larger, elongate *Hydrochus*.



Figures 14–20. *Hydrochus* adults. 14–15. (dorsal view). 14. *H. granulatus*. 15. *H. curani*. 16–20. Male parameres and penis drawn to same scale (ventral view with parameres splayed outward). 16. *H. rufipes*. 17. *H. neosquamifer*. 18. *H. pseudosquamifer*. 19. *H. squamifer*. 20. *H. subcupreus*.

***Hydrochus neosquamifer* Smetana, 1988**

**Distribution and Abundance:** Fairly common statewide (Table 1). County records: 4–6, 14, 16, 20, 22, 25–26, 29, 32, 34, 39, 49–52, 54, 57–58, 61, 64, 67–68, 71. Range: ND-PQ-VA-MS.

**Habitat:** Adults were collected from a variety of ponds and occasionally from marshes.

**Life Cycle:** Adults occurred 11 April–25 September, 73% June–August. Teneral adults (45) occurred 10 June–14 September, 84% 6 July–10 August.

**Identification:** The small size, bold silvery or golden elytral costae, and inconspicuous or absent metallic spots on many elytral intervals is diagnostic.

***Hydrochus pseudosquamifer* Miller, 1965**

**Distribution and Abundance:** Common in southeast to rare in northwest (Table 1). County records: 6, 17–18, 24, 37, 39–40, 42, 44–49, 52, 54, 58–59, 61, 63–72.

**Habitat:** Almost all adults were collected from shallow ponds.

**Life Cycle:** Adults occurred 27 March–1 October, 95% 1 May–6 September. Teneral adults (118) were found 8 June–1 October, 99% 28 June–3 September.

**Identification:** Adults are most similar to those of the smaller *H. neosquamifer* and larger *H. squamifer*, both of which have wider costate areas on the elytra. Elytral costae are narrow and poorly developed, and all intervals have metallic spots where they are not costate. The basal portion of elytral

interval 4 is rarely costate and always less costate than the basal portion of interval 5; in adults of *H. squamifer* and *H. neosquamifer* the basal portion of interval 4 is more costate than the basal portion of interval 5.

***Hydrochus rufipes* Melsheimer, 1846**

**Distribution and Abundance:** Uncommon in southwest quarter (Table 1). County records: 49, 51-52, 54-57, 61. Range: WY-NY-FL-TX.

**Habitat:** Almost all adults were collected from ponds, sloughs, and backwaters associated with large rivers.

**Life Cycle:** Adults occurred 12 June-23 September, with 56% being collected 6 July, including the only teneral adult; 32% occurred in September.

**Identification:** The relatively large size, elongate shape, and lack of metallic spots on the head, pronotum, or elytra is distinctive. Adults most resemble those of *H. subcupreus*, which also lack metallic spots on elytral intervals, and while having metallic spots on the head and pronotum, they are frequently confluent. Adults of *H. subcupreus* are narrower and more convex, and have more uniform and extensive elytral costae. In *H. rufipes* costae are greatly enlarged just past mid-length on elytral intervals 3 and 4 and before and past these costae on interval 5. Parameres of *H. rufipes* (Fig. 16) may be joined apically as in *H. subcupreus*, but the outer margin is straight before the pointed apex and not convex.

***Hydrochus scabratus* Mulsant, 1844**

**Distribution and Abundance:** Very rare in north-central area (Table 1). County record: 12. Range: WA-PQ-VA-TX.

**Habitat:** One adult was collected from the margin of Douglas Creek in Price County on 20 August.

**Identification:** The very large size, robust shape, and large oblique tubercles on the elytra are unique among *Hydrochus* adults.

***Hydrochus setosus* Leech, 1948.**

**Distribution and Abundance:** Very rare in east-central and south-central areas (Table 1). County records: 46, 61. Range: ND-MI-IL.

**Habitat:** Single adults were found in a stream backwater and a small, roadside pond.

**Life Cycle:** Adults occurred 30 April and 14 June; neither was teneral.

**Identification:** Adults resemble only those of the larger *H. currani*, from which they are distinguished by characters in the key. While they lack costae, there is a coalescing of larger metallic spots on small tubercles past the middle on elytral interval 7 and to a lesser extent on interval 5.

***Hydrochus squamifer* LeConte, 1855**

**Distribution and Abundance:** Very common statewide (Table 1). County records: 1-29, 33-61, 64-72. Range: BC-NB-NJ-KS-ND-OR+CA.

**Habitat:** Adults were collected from a wide variety of lentic habitats and occasionally from margins of streams.

**Life Cycle:** Adults occurred 8 April-5 October, 80% June-August and 95% May-September. Teneral adults (134) were found 23 June-1 October, 83% mid-July-August.

**Identification:** Separation from adults of *H. pseudosquamifer* is discussed under that species. Adults with exceptionally costate elytra resemble those of *H. subcupreus*. In *H. subcupreus* the basal portion of elytral intervals

1-7 have rather uniformly broad, flat costae, with only interval 3 somewhat higher, while in *H. squamifer* basal costae on intervals 3-5 and 7 are distinctly raised and that on 6 is weak or consisting of contiguous metallic spots.

***Hydrochus subcupreus* Randall, 1838**

**Distribution and Abundance:** Uncommon in northwestern two-thirds, rare in southern and eastern thirds (Table 1). County records: 1-7, 9, 11, 13-15, 17-18, 29, 31-33, 36, 57-58. Range: WI-PQ-VA-MI.

**Habitat:** Most adults were collected from shallow ponds; a few were found in marshes and swamps.

**Life Cycle:** Adults occurred 17 April-1 October, 87% May-August. Most teneral adults (14) were found 28 June-22 August; one also occurred 5 May in Douglas County.

**Identification:** Adults could be confused only with those of *H. rufipes* and *H. squamifer*; separation is discussed under those species. Hellman (1975) notes that farther south the pronotum is glabrous as in *H. rufipes*, and Smetana (1988) illustrates this condition, which apparently does not occur in Wisconsin.

**HYDROPHILINAE: BEROSINI - *Berosus* Leach, 1817**

Van Tassell (1966) completed a Ph.D. dissertation on the taxonomy and biology of *Berosus* in North and Central America, which was never published. She reported numerous biological observations that resulted from laboratory rearing. Shortly after mating, adults laid eggs in cases containing 2-5 eggs and fastened them to substrates under water; larvae hatched within 5 to 24 days. A single larva was reared to adult in 74 days, spending 8 days as a terrestrial pupa. The aquatic larvae fed mostly on arthropods of suitable size. Richmond (1920) described larvae of two species and provided life history notes.

Aquatic adults and larvae were collected with nets and bottle traps; 18% of adults were collected at light traps. Adults are well-adapted for swimming, having a dense fringe of long setae on the meso- and meta-tibiae and tarsi. They are distinctive because of their convex shape, elongate scutellum, meso- and metatarsal swimming hairs, and testaceous to brown elytra with several small, dark spots. Most species can be readily identified by using the key. Males have very large genitalia that are easily removed; those of all larger species are distinctive, providing an easy and precise means for identifying males. Larvae are easily recognized because of long lateral filaments on the first seven abdominal segments. These filaments apparently aid in respiration, allowing larvae of some species to overwinter under the ice; *Berosus* larvae were often the only insects remaining alive in bottle traps that were almost devoid of oxygen. Larvae of most species remain undescribed.

**Key to Species of Adult *Berosus* in Wisconsin**

1. Apical emargination of fifth abdominal sternum with two small teeth at center; mostly larger, > 4.2 mm long. . . . . 2
- Apical emargination with one tooth or projection; mostly smaller, < 4.9 mm long. . . . . 7
- 2(1). Elytral striae very fine, especially on disc, lightly or not impressed at base; mesosternal carina with long, sharp, recurved spine, longer than posterior height of carina (Fig. 21); 5.4-7.1 mm long. . . . . *styliifer*

- Elytral striae coarser, usually distinctly impressed; anterior spine on mesosternal carina short, much shorter than posterior height of carina (Fig. 22) ..... 3
- 3(2). Metasternal process with pointed, projecting, posterolateral lobes (Fig. 23) ..... 5
- Metasternal process without projecting posterolateral lobes (Fig. 24) ..... 4
- 4(3). Female elytra with short, sharp, pre-apical tooth; male with apices of parameres separated and blunt (Fig. 25); 4.7–6.6 mm long. . . . . *hatchi*
- Female elytra without a preapical tooth; male with parameres narrowed and touching apically (Fig. 26); 4.3–6.3 mm long ..... *fraternus*
- 5(3). Elytra of female shining, lacking reticulate microsculpture; male with parameres widened, rounded, and broadly touching at tip (Fig. 27); 4.2–6.3 mm long. . . . . *striatus*
- Elytra of female with reticulate microsculpture; male with parameres narrowed at apex and not broadly joined (Figs. 28–30) ..... 6
- 6(5). Elytra of female with elongate dark spots in basal third on intervals 2 and 3; male parameres wide, constricted basally (Fig. 28) and not curved downward before apex ..... *infuscatus*
- Elytra of female with dark spots indistinct, absent in basal third of interval 2; male parameres very slender and evenly curved downward to a sharp apex (Fig. 29) ..... *ordinatus*
- 7(1). Each elytron with 10 black spots; eyes very large, width one-half interocular distance or more; 3.7–4.9 mm long. . . . . *pantherinus*
- Each elytron with at most 6 brown spots; width of eyes about one-third interocular distance. . . . . 8
- 8(7). Head tan; female elytra shining, lacking reticulate microsculpture, and with prolonged apices and a preapical bump; parameres with elongate, extremely slender apices; 3.4–4.8 mm long ..... *aculeatus*
- Head black; female elytra with reticulate microsculpture and without prolonged apices; parameres rapidly narrowed and curved inward at apex; 3.3–4.9 mm long ..... *peregrinus*

### ***Berosus aculeatus* LeConte, 1855**

**Distribution and Abundance:** Uncommon statewide (Table 1). County records: 3, 9, 14, 28, 30, 41–42, 49, 51–52, 54, 56–57, 60–61, 63, 72. Range: WI-ME-FL-MS.

**Habitat:** Adults were collected from permanent ponds and sloughs.

**Life Cycle:** All adults occurred 1 June–29 August, except one on 3 October; teneral adults occurred 16 June–16 July. Adults apparently do not overwinter, but die after mating and oviposition. Eggs probably diapause and overwinter; larvae hatch in early spring to produce adults by late May or June.

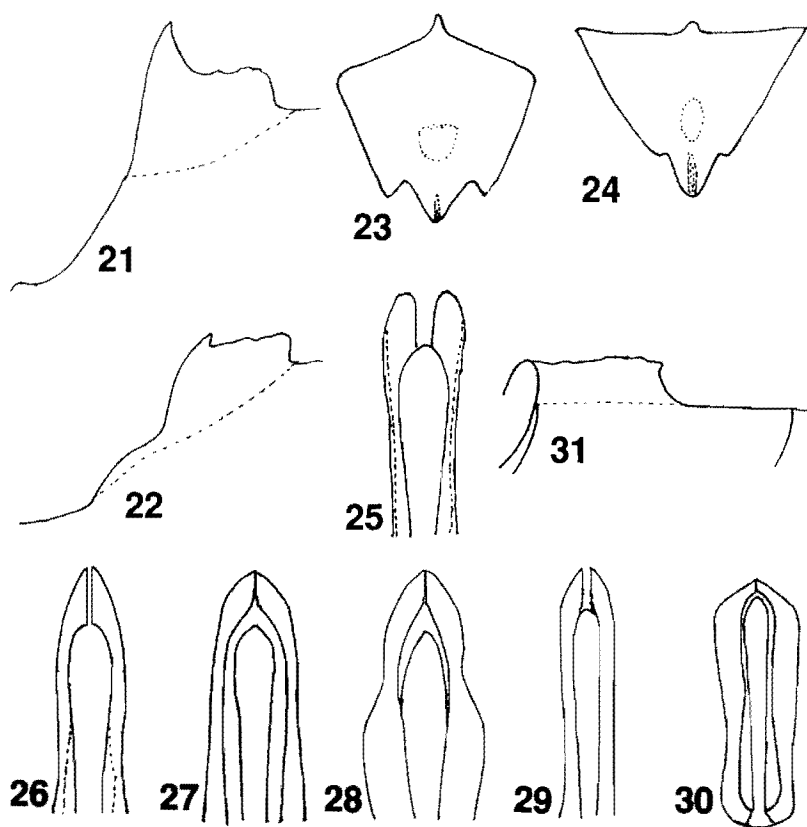
**Identification:** The small size and almost completely testaceous color make adults easy to recognize.

### ***Berosus fraternus* LeConte, 1855**

**Distribution and Abundance:** Common in southern third to uncommon in northern third (Table 1). County records: 3–4, 6, 11–12, 17, 22–25, 27–33, 35, 37–40, 42–43, 47–50, 54, 56–72. Range: BC-PQ-NJ-TN-CA.

**Habitat:** Most adults were collected from permanent ponds; occasionally they were found in other lentic habitats or streams.

**Life Cycle:** Adults occurred 22 March–6 November, 77% April–July and 92% March–August; teneral adults (52) were found 22 March–11 October, with 40% occurring from March–May and 48% July–August. Adults and



Figures 21-31. *Berosus* adults. 21-22. Mesosternal carina (lateral view from right). 21. *B. stylifer*. 22. *B. striatus*. 23-24. Elevated metasternal process (ventral view). 23. *B. striatus*. 24. *B. fraternus*. 25-30. Apical 0.75 mm of penis and parameres (ventral view). 25. *B. hatchi*. 26. *B. fraternus*. 27. *B. striatus*. 28. *B. infuscatus*. 29. *B. ordinatus* (FL). 30. *B. stylifer*. 31. Basal carina on abdominal sternum 1 (lateral view from right) of *B. hatchi*.

larvae obviously overwinter; the low number of teneral adults in June suggests eggs probably do not overwinter. The life cycle is probably univoltine with breeding throughout the spring and summer producing different cohorts.

**Identification:** Adults are similar to those of *H. hatchi*; separation is discussed under that species. Male genitalia are distinctive (Fig. 26).



***Berosus hatchi* Miller, 1965**

**Distribution and Abundance:** Fairly common in eastern two-thirds (Table 1). County records: 19–20, 24, 34, 38, 40, 43, 45, 47–48, 57–59, 61, 65, 67–68, 70–71. Range: NT-PQ-NY-OR-BC.

**Habitat:** Most adults were collected from temporary ponds and marshes.

**Life Cycle:** Adults occurred 22 March–3 September, all except one before 1 July; teneral adults (10) were found 22 March–11 May. To produce teneral adults so early in spring, larvae must overwinter. The gradual increase in adult numbers into early June suggests larvae are the only overwintering stage. Adults probably mate in spring, lay eggs in temporary habitats as they dry, and then die. Eggs apparently diapause and hatch when flooded with water in late summer or autumn.

**Identification:** The basal medial carina on the first abdominal sternum that rapidly disappears at the mid-length, is distinctive (Fig. 31). It is the only Wisconsin species in which males have blunt, separated parameres (Fig. 25); females have a unique preapical tooth on each elytron.

***Berosus infuscatus* LeConte, 1855**

**Distribution and Abundance:** Very rare in south (Table 1). County record: 60. Range: WI-NC-FL-CA-MO.

**Habitat:** One adult male was collected from a pond on 9 September.

**Identification:** Male genitalia are distinctive (Fig. 28). Females are similar to those of another southern species, *B. ordinatus*, which was not found in Wisconsin. The reticulate microsculpture of the female pronotum is more distinct than in *B. ordinatus*.

***Berosus ordinatus* LeConte, 1855**

**Distribution and Abundance:** May not occur in Wisconsin. Range: NY-MA-FL-AL+IN+MN; the southern Indiana and central Minnesota records are disjunct.

**Identification:** Male parameres (Fig. 29) are similar to those of *H. fraternus*, but more slender. Females could be confused with those of *B. infuscatus*, as discussed under that species. Only Florida adults were seen.

***Berosus pantherinus* LeConte, 1855**

**Distribution and Abundance:** Rare in south-central and southwest areas (Table 1). County records: 53, 60–61. Range: WI-WV-TX-NE.

**Habitat:** All adults were collected from permanent ponds.

**Life Cycle:** Five adults were found 11 May and three 4 October; individuals occurred 3 July, and 9 and 28 September. No teneral adults were collected. Adults probably overwinter in terrestrial habitats.

**Identification:** The small size, 10 conspicuous black spots on each elytron, and large eyes are distinctive.

***Berosus peregrinus* (Herbst, 1797)**

**Distribution and Abundance:** Common in southern third to rare in northern third (Table 1). County records: 3, 14, 30, 37, 40, 42, 44, 47, 52, 54, 56–58, 60–61, 64, 66–68, 70–72. Range: ON-NS-FL-WY-WI.

**Habitat:** Most adults (380) were collected in light traps, especially along the Wisconsin River; others were found in sloughs and ponds that usually were near large streams.

**Life Cycle:** Adults occurred 16 June–27 October, 98.5% June–August.

Teneral adults (98) occurred 19 June–5 September, all except one by 10 August. This suggests adults emerge during the summer, mate, oviposit, and die. Eggs probably diapause and hatch the following spring, with larval development being mostly completed by late spring or early summer.

**Identification:** Adults are likely to be confused only with those of *B. aculeatus*, but the head is black, even in teneral specimens, and not just partially infuscate as in *H. aculeatus*.

### ***Berosus striatus* (Say, 1825)**

**Distribution and Abundance:** Abundant statewide (Table 1). County records: 1–72. Range: BC-PQ-NC-IL-CA-WA+NT+FL.

**Habitat:** Almost all adults were collected from permanent ponds; a few were found in other lentic habitats or streams.

**Life Cycle:** Adults occurred 22 March–7 November, with significant numbers (98%) present April–September; peak numbers occurred May–June (49%). Teneral adults (532) were found 22 March–26 October, with all except four occurring 27 June or later; 53% occurred in August, 25% in July, and 18% in September. Adults overwinter, probably in terrestrial habitats, and enter ponds in spring to mate and oviposit. Most larvae complete development throughout the summer. Rarely, larvae also overwinter, accounting for four teneral adults 22 March–7 May.

**Identification:** Males have distinctive genitalia (Fig. 27), and females lack reticulate microsculpture on the elytra. The only other *Berosus* females in Wisconsin with a black head and no elytral microsculpture are those of *B. pantherinus*, which are smaller, have ten distinct spots on each elytron, and two spots on the pronotum instead of the parallel stripes found in *B. striatus*.

### ***Berosus stylifer* Horn, 1873**

**Distribution and Abundance:** Uncommon in western half (Table 1). County records: 10, 29–30, 50, 53, 55, 58, 60–61. Range: AB-WI-TX-AZ-MT.

**Habitat:** Almost all adults were collected from ponds.

**Life Cycle:** Adults occurred 31 May–7 November, 97% before October; teneral adults were found 31 May–3 July. An absence of adults before teneral specimens occurred in late spring, suggests eggs overwinter and hatch in early spring. Resulting adults probably mate and lay eggs during the summer and die, with eggs diapausing until the following spring.

**Identification:** Adults are distinctive because of very fine and lightly impressed striae punctures on the elytra and the long, sharp, recurved spine at the anterior of the mesosternal crest (Fig. 21). Males have very broad parameres (Fig. 30), and females have obsolete punctures on elytral intervals.

## **HYDRAENIDAE**

Adults of Hydraenidae resemble Hydrochinae except for their very small size (<2.0 mm) and antennae that have five segments past the cupule instead of three. They typically inhabit sandy margins of streams or ponds. Perkins (1980) revised Hydraenidae in the Western Hemisphere, providing keys and descriptions for identification of adults of all known species, and also information about their habitat and distribution. Only 35 adults were found while collecting other water beetles in Wisconsin; no special effort was made to collect hydraenid adults, and because of their very small size, many were perhaps overlooked. Perkins (1976) described techniques for collecting these psammophilous beetles, which cannot swim. By disturbing their habitat, adults can be collected as they float inverted in the surface film where they are



***Gymnochthebius d'Orchymont, 1943***

***Gymnochthebius nitidus* (Leconte, 1850)**

**Distribution and Abundance:** Not yet collected in Wisconsin. Range: NT-PQ-NJ-MO-MT.

**Habitat:** Adults probably inhabit margins of streams.

**Identification:** No other species having anterolateral pronotal lobes and lateral pronotal emarginations separated by a point (Fig. 34) occurs in eastern North America.

***Hydraena Kugelann, 1794***

Adults of the only two species likely to occur in Wisconsin were collected. Unfortunately, females from the Midwest cannot be reliably identified (Perkins 1980); 18 unassociated female *Hydraena* were collected statewide.

***Hydraena angulicollis* Notman, 1921**

**Distribution and Abundance:** Six male adults were collected from the north-central and northeast areas. County records: 9, 12, 18. Range: NT-ME-DE-MN-AB.

**Habitat:** One male occurred in a river slough, the remainder in ponds.

**Identification:** Characters in the key readily distinguish males from those of *H. pennsylvanica*.

***Hydraena pennsylvanica* Kiesenwetter, 1849**

**Distribution and Abundance:** Probably statewide, since five male adults and two associated females occurred in the northeast, central, south-central and southeast areas. County records: 18, 37, 54, 66, 70. Range: MN-PQ-VT-VA-IL.

**Habitat:** All adults occurred in ponds.

**Identification:** Separation from *H. angulicollis* is discussed above.

***Ochthebius* Leach, 1815**

***Ochthebius cribricollis* LeConte, 1850**

**Distribution and Abundance:** Not yet found in Wisconsin. Range: BC-ND-SD-CA+MI+PQ.

**Habitat:** Perkins (1980) suggested adults occur mostly in lentic habitats.

**Identification:** Absence of pronotal foveae (Fig. 35) distinguishes adults from those of other *Ochthebius* occurring east of the Rocky Mountains.

***Ochthebius kaszabi* Janssens, 1967**

**Distribution and Abundance:** Not yet found in Wisconsin. Range: AK-PQ-RI-ND-BC (Holarctic)

**Habitat:** Adults probably occur in both lotic and lentic habitats.

**Identification:** Pronotal foveae are distinctly separated and not joined laterally by a sinuate groove or depression as in *O. lineatus* (Fig. 36).

***Ochthebius lineatus* LeConte, 1852**

**Distribution and Abundance:** Probably statewide; four adults were collected. County records: 25, 52, 58, 61. Range: BC-MB-WI-TX-CA.

**Habitat:** Adults were collected from ponds and a bog; Perkins (1980) noted that they also occur in lotic habitats.

**Identification:** The sinuate groove or depressed area that connects lateral margins of the anterior and posterior foveae (Fig. 36) is distinctive.

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**LITERATURE CITED**

- Hellman, J.L. 1975. A taxonomic revision of the genus *Hydrochus* of North America, Central America and West Indies. Ph.D. Diss., Univ. Md. xviii + 420 pp.
- Hilsenhoff, W.L. 1985. Techniques for collecting water beetles from lentic habitats. *Proc. Acad. Nat. Sci. Philadelphia* 137:8-11.
- \_\_\_\_\_. 1987. Effectiveness of bottle traps for collecting Dytiscidae (Coleoptera). *Coleopts. Bull.* 41:377-380.
- \_\_\_\_\_. 1990. Occurrence of *Helophorus grandis* (Coleoptera: Hydrophilidae) in north-central Wisconsin. *Great Lakes Entomol.* 23:177-178.
- \_\_\_\_\_. 1991. Comparison of bottle traps with a D-frame net for collecting adults and larvae of Dytiscidae and Hydrophilidae (Coleoptera). *Coleopts. Bull.* 45:143-146.
- McCorkle, D.V. 1965. Subfamily Elohporinae, pp. 22-38 in Hatch, M.H. (Ed.). *The beetles of the Pacific Northwest. Part IV.* Univ. Wash. Publ. Biol. 16, Seattle.
- \_\_\_\_\_. 1967. A revision of the species of *Elophorus* Fabricius in America north of Mexico. Ph.D. Diss., Univ. Wash. iv + 162 pp.
- Newton, A.F. Jr., and M.K. Thayer 1992. Current classification and family-group names in Staphyliniformia (Coleoptera). *Fieldiana. Zoology New Ser.* No 67. 92pp.
- d'Orchymont, A. 1945. Sur des *Helophores*, spécialement Américains (Coleoptera Palpicornia Hydrophilidae). *Bull. Mus. roy. d'Histoire nat. Belgique* 21(8):1-28.
- Perkins, P.D. 1976. Psammophilous aquatic beetles in southern California: A study of microhabitat preferences with notes on responses to stream alteration (Coleoptera: Hydraenidae and Hydrophilidae). *Coleopts. Bull.* 30:309-324.
- \_\_\_\_\_. 1980. Aquatic beetles of the family Hydraenidae in the Western Hemisphere: classification, biogeography and inferred phylogeny (Insecta: Coleoptera). *Quaest. Entomol.* 16:1-554.
- Richmond, E.A. 1920. Studies of the biology of the aquatic Hydrophilidae. *Bull. Amer. Mus. Nat. Hist.* 42:1-93 + 16 pl.
- Smetana, A. 1985. Revision of the subfamily Helophorinae of the Nearctic region (Coleoptera: Hydrophilidae). *Mem. Entomol. Soc. Can.* No. 131. 154 pp.
- \_\_\_\_\_. 1988. Review of the family Hydrophilidae of Canada and Alaska (Coleoptera). *Mem. Entomol. Soc. Can.* No. 142. 316 pp.
- Van Tassell, E. 1966. Taxonomy and biology of the subfamily Berosinae of North and

- Central America and the West Indies (Coleoptera: Hydrophilidae). Ph.D. Diss., Catholic Univ. v + 329 pp.
- Willson, R.B. 1967. The Hydrophilidae of Michigan with keys to species of the Great Lakes region. M.S. Thesis, Mich. State Univ. vi + 100 pp.
- Wooldridge, D.P. 1967. The aquatic Hydrophilidae of Illinois. Trans. Ill. Acad. Sci. 60:422-431.