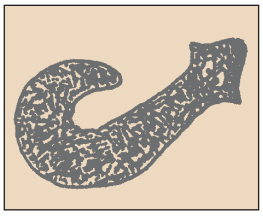
RESEARCH/MANAGEMENT
FINDINGS

"Put a piece of raw meat into a small stream or spring and after a few hours you may find it covered with hundreds of black worms... When not attracted into the open by food, they live inconspicuously under stones and on vegetation."

— BUCHSBAUM, et al. 1987



D WATERMOLEN

Aquatic and Terrestrial Flatworm (Platyhelminthes, Turbellaria) and Ribbon Worm (Nemertea) Records from Wisconsin

Dreux J. Watermolen
Bureau of Integrated Science Services

INTRODUCTION

The phylum Platyhelminthes encompasses three distinct groups of flatworms: the entirely parasitic tapeworms (Cestoidea) and flukes (Trematoda) and the free-living and commensal turbellarians (Turbellaria). Aquatic turbellarians occur commonly in freshwater habitats, often in exceedingly large numbers and rather high densities. Their ecology and systematics, however, have been less studied than those of many other common aquatic invertebrates (Kolasa 2001). Terrestrial turbellarians inhabit soil and leaf litter and can be found resting under stones, logs, and refuse. Like their freshwater relatives, terrestrial species suffer from a lack of scientific attention.

Most texts divide turbellarians into microturbellarians (those generally < 1 mm in length) and macroturbellarians (those 5-20 mm in length, with most being 10 mm or greater), a division that reflects superficial morphological similarities rather than phylogenetic relationships (Kolasa 2001). Biologists have recorded approximately 150 species of freshwater microturbellarians in North America (Kolasa 2001), but we know almost nothing about the smaller soil-dwelling turbellarians (Ball and Sluys 1990). Many additional genera and species of microturbellarians await discovery and description.

All macroturbellarians belong to the order Tricladida, also known as planarians. These have been studied more thoroughly than the microturbellarians. Biologists have used two species, *Girardia dorotocephala* and *G. tigrina*, extensively for decades as laboratory and classroom animals. Approximately 40 freshwater and at least 12 nonnative terrestrial macroturbellarian species have been recorded in North America (Kenk 1989, Ball and Sluys 1990, Ogren and Kawakatsu 1998, Kolasa 2001), but the actual number of taxa that occur here is likely substantially higher.

Nemerteans resemble turbellarians and possess many flatworm features[1]. About 900 (mostly marine) species comprise this phylum, which is represented in North American freshwaters by three species of benthic, predatory worms measuring 10-40 mm in length (Kolasa 2001). These ribbon worms occur in both lakes and streams.

Although flatworms show up commonly in invertebrate samples, few biologists have studied the Wisconsin fauna. Published records for turbellarians and ribbon worms in the state remain limited, with most being recorded under generic rubric such as "flatworms," "planarians," or "other worms." Surprisingly few Wisconsin specimens can be found in museum collections and a specialist has yet to examine those that are available. No state checklist has been available. To help remedy this situation, I here review the literature, summarize records, and provide a provisional list of species.

METHODS

I examined the principal literature on these taxonomic groups and then conducted an extensive review of material pertaining to Wisconsin's macrobenthic biota in an attempt to locate freshwater turbellarian and nemertean records from the state. I also examined the pedobiological literature and the land planarian indices prepared by Ogren and Kawakatsu (1987, 1998), with subsequent corrections and additions (Kawakatsu, et al. 2000, 2003, 2004), for Wisconsin records of terrestrial species. I contacted several museums in the state and a number of academic and government biologists working in Wisconsin in search of additional specimens or records. Finally, I scoured the Internet and conducted an online search of the National Museum of Natural History's invertebrate

[1] *Recent morphological and molecular studies (e.g., Turbeville, et al. 1992) suggest ribbon worms are more closely related to segmented worms (Annelida) and mussels (Mollusca) than they are to flatworms. Nonetheless, I treat flatworms and ribbon worms together in this paper for convenience sake.*

WISCONSIN DEPT. OF NATURAL RESOURCES

zoology database (NMNH 2005) and the Turbellarian Taxonomic Database (Tyler, et al. 2005). From these sources, I compiled the provisional list of Wisconsin species presented below.

Ordinal and familial level taxonomy in the flatworm checklist generally follows Kolasa (2001), with species listed alphabetically within each family. I use Tyler, et al. (2005) for up-to-date species nomenclature. I omit general "Wisconsin" records from the checklist except when site-specific information remains unavailable. Accounts are annotated with comments on habitat and associated species when this information is available readily in the literature. I discuss misidentifications, poorly described species, otherwise problematic records, and a few species that have not yet been reported from Wisconsin, but which likely occur here, under "Uncertain Turbellarian Species."

PROVISIONAL CHECKLIST OF WISCONSIN TURBELLARIANS

MICROTURBELLARIANS

Order Catenulida

Family Catenulidae

Catenula virginiana Kepner and Carter 1930

Hayes (1942) collected *C. virginiana* from various waterways in Dane and Vilas counties. He considered it "outstanding for tolerating bog conditions."

Family Stenostomidae

Myostenostomum tauricum Nasonov 1924

Hayes (1942) reported collecting *M. tauricum* specimens from Wisconsin localities. Tyler, et al. (2005), however, considered *M. tauricum*, a species previously reported from several eastern United States, South American, African, and European localities, to be a *nomen dubium*.

Rhynchoscolex simplex Leidy 1851

Hayes (1942) collected *R. simplex* from two localities in Dane County and seven in Vilas County. He found it in a variety of habitats, but believed "it seems to be best able to compete under strictly bog conditions especially in the well leached detritus." Kolasa, et al. (1987) found 42 of their 51 New York specimens in interstitial waters. They collected their other specimens in stream surface sediments (1) and springs (8).

Stenostomum anops Nuttycombe and Waters 1938

Hayes (1942) collected *S. anops* twice in July 1941, once from a Vilas County bog and once from a nearby lake drain.

Stenostomum arevaloi Gieysztor 1931

Hayes (1942) collected *S. arevaloi* at several Vilas County localities and thought it "difficult to believe that it does not occur around Madison, unless, perhaps, the water is too hard."

Stenostomum grande Child 1902

Hayes (1942) collected *S. grande* from the Bad River in Ashland County, Lake Mendota in Dane County, and several lakes and lake drains in Vilas County. At most sites, he reported *S. grande* as being "abundant" in July and "common" or "fairly common" in August. Kolasa, et al. (1987) collected all of their New York specimens from stream surface sediments.

Stenostomum leucops (Duges 1828)

S. leucops occurs in interstitial waters throughout much of the eastern United States. Hayes (1942) reported collecting *S. leucops* in Wisconsin. Some of Higley's (1918) specimens may also have been collected in Wisconsin.

Stenostomum predatorium Kepner and Carter 1931

Hayes (1942) collected *S. predatorium* from three Vilas County lakes, but considered it "fairly common" at only one. In New York, this species has been found primarily in stream surface sediments and interstitial waters (Kolasa, et al. 1987).

Stenostomum ventronephrium Nuttycombe 1932

Hayes (1942) collected a few specimens from the Bad River in Ashland County in August 1941 that he thought "probably belong to this species."

Stenostomum virginianum Nuttycombe 1931

Hayes (1942) considered *S. virginianum* to be "one of the most widely distributed rhabdocoeles in Wisconsin." He collected it at "every littoral collecting station in Dane County" and "from bogs, fresh ponds, rivers, and lakes of Vilas County."

Order Macrostomida

Family Macrostomidae

Macrostomum ruebushi Ferguson 1940

Hayes (1942) found *M. ruebushi*, usually in small numbers, at all "thoroughly worked littoral collecting stations in Dane County at various seasons." He also collected it from several Vilas County sites. Hayes noted that "*Macrostomum* has not been found living in Wisconsin under strictly bog conditions, but has been found at all other types of station."

Family Microstomidae

Microstomum lineare (O.F. Müller 1774)

Hayes (1942) found *M. lineare* at all of his Dane County littoral collection stations and several Vilas County sites. He described the seasonal sexual development of this species in southern Wisconsin. He also noted that this "American form" actually may not be the common European species. In New York, *M. lineare* has been found primarily in stream surface sediments (Kolasa, et al. 1987).

Order Dalyellioida

Family Provorticidae

Pilgramilla virginiensis (Ruebush and Hayes 1939)

Hayes (1942) reported collecting this species at several Dane County localities and Mann Lake in Vilas County. The only other North American records of this species appear to be the type specimens and Kolasa, et al.'s (1987) report from interstitial waters in New York.

Family Dalyelliidae

Castrella pinguis (Silliman 1884)

Hayes (1942) collected *C. pinguis* at several Ashland, Dane, and Vilas county localities and later (1945) provided a complete description of and taxonomic commentary on this species, based entirely on his Wisconsin collections.

Microdalyellia rossi (Graff 1911)

Hayes (1942) described a new variety, *aklados*, of this species based on specimens collected from a drainage ditch in Dane County. He also described a second new variety, *multispina*, based on specimens collected in a Vilas County bog. He reported additional Vilas County collection localities for this variety as well. Finally, Hayes (1942) reported collecting a previously described variety, *tennesseensis,* in Dane and Vilas counties.

Order Typhloplanoida (Neorhabdocoela)

Family Typhloplanidae

Castrada hofmanni Braun 1885

Hayes (1942) described a new variety, *minuta*, from specimens collected in the Manitowish River (Vilas County). He also reported collecting *C. hofmanni* in nearby Black Oak and White Sand lakes and characterized it as "common" in July and "abundant" in August.

Mesostoma ehrenbergii (Focke 1836)

Muttkowski (1918) collected *M. ehrenbergii* in late July and August in Lake Mendota (Dane County) and reported that it was "very common" in May and June in nearby Picnic Pond. Hayes (1942) described a new variety, *indiverticulata*, based on specimens taken in the Manitowish River (Vilas County).

Phaenocora kepneri Gilbert 1938

Hayes (1942) found *P. kepneri* "abundant" in Lake Mendota (Dane County), where he collected it in April, May, and June.

Protoascus wisconsinensis Hayes 1941

Hayes (1941) described this species based on material collected in a "permanent ditch located southeast of Lake Wingra" (Dane County) in autumn and spring collections. The NMNH's invertebrate zoology database includes records (catalog nos. 20571 and 20572) of four syntype specimens.

Rhynchomesostoma rostratum (O.F. Müller 1774)

Hayes (1942) collected "a few specimens" of *R. rostratum* at three sites in Vilas County.

Strongylostoma elongatum Hofsten 1907

Hayes (1942) collected *S. elongatum* at several Ashland, Dane, and Vilas county localities. He believed his records to be the first valid report of this genus from the Western Hemisphere. Kolasa, et al. (1987) later collected a single specimen in interstitial waters in southeastern New York.

(continued on next page)

Order Kalyptorhynchia

Family Polycestididae

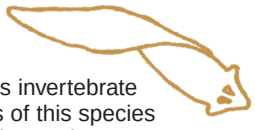
Gyratrix hermaphroditus Ehrenberg 1831

Hayes (1942) collected *G. hermaphroditus* from several Ashland, Dane, and Vilas county localities. He found *G. hermaphroditus* generally to be "abundant" in April and November and "fairly common" in August and October, but did not indicate specific microhabitats. Kolasa, et al. (1987) collected all of their New York specimens from interstitial waters.

MACROTURBELLARIANS

Order Tricladida

Family Dugesiidae



Cura foremanii (Girard 1852)

C. foremanii inhabits cool streams (Kenk 1944, 1974b, 1976). The NMNH's invertebrate zoology database includes a record (catalog no. 50662) of five specimens of this species from Wisconsin. C.A. Long and J. Krause collected these from the Little Plover River (Portage County) in October 1973 and the specimens are apparently the vouchers for their distribution note (Long and Krause 1974) and physiological study (Krause 1974).

Girardia dorotocephala (Woodworth 1897)

G. dorotocephala occurs in both running and standing waters (Kenk 1944, 1976). Stringer (1918) made early reference to this species occurring in Wisconsin. Muttkowski (1918) reported *G. dorotocephala* as "abundant" in Merrill Springs and "occasional" in Lake Mendota (Dane County). Krause (1974) collected it from small ponds and streams near Amherst (Portage County) in September and October 1973. A *G. dorotocephala* specimen was taken in an unnamed tributary to Raccoon Creek (Rock County) in 1995 (M.J. Wetzel, Illinois Natural History Survey, pers. comm.).

Baumann, et al. (1977) tested the effects of Antimycin A, a fish toxicant, on *G. dorotocephala*. They suggested *G. dorotocephala* was "abundant in portions of the Rock River system." Their experimental animals, however, came from a biological supply house and the collection locality remains unknown. Wisenden and Millard (2001) also used experimental animals collected from unnamed natural Wisconsin populations in their assessment of chemical alarm cues used as part of the antipredator behaviors of this species.

Girardia tigrina (Girard 1850)

G. tigrina is widely distributed, "generally in warm ponds, lakes, and rivers" (Kenk 1976) and "one finds it commonly along the shores of lakes on the undersides of stones" (Kenk 1944). Muttkowski (1918) found *G. tigrina* at various depths in Lake Mendota (Dane County). He noted that the specimens he collected were highly variable and commented that he may have lumped several species together under this name. Baker (1924) reported *G. tigrina* from the Lake Winnebago region and Hyman (1939) reported it occurring in southern Lake Michigan. Barton and Hynes (1978) found *G. tigrina* common in the wave-zone along Lake Superior's north shore. It certainly occurs along this lake's south shore as well.

Family Planariidae

Phagocata gracilis (Haldeman 1840)

According to Kenk (1970, 1974b), *P. gracilis* occupies streams, springs, and subterranean waters in caves. Stringer (1918) recorded *P. gracilis* from Wisconsin, but Kenk (1970) considered this a doubtful record. Further work will be necessary to confirm Stringer's record.

Phagocata morgani (Stevens and Boring 1906)

The subspecies *P. morgani morgani* (Stevens and Boring 1906) inhabits springs and cold creeks (Kenk 1974b, 1976). Kenk (1944) and Hyman (1951) included Wisconsin, without further details, in their tallies of states where *P. morgani* had been reported. Kenk (1944) also noted that *P. morgani* "appears to be common" across the border in Michigan's Upper Peninsula.

Phagocata velata (Stringer 1909)

Kenk (1974b, 1976) reports *P. velata* from springs, streams, and spring-fed ponds and Ball, et al. (1981) and Smith (1991a) record it from vernal ponds and intermittent streams. Kenk (1944) believed Castle and Hyman's (1934) record from near Madison needed "further verification," which he apparently found. The NMNH's invertebrate zoology database includes two records of four specimens (catalog nos. 52565 and 52566) collected by Kenk at the Nevin Fish Hatchery south of Madison (Dane County) in August 1967. Ball, et al. (1981) reported this record. Elsewhere, *P. velata* has been collected in temporary ponds with *Hymanella retenuova* (Ball, et al. 1981) and from a spring with *Cura foremanii* (Kenk 1943).

Family Dendrocoelidae

Procotyla fluviatilis Leidy 1857

Stringer (1918), Kenk (1943, 1944, 1976), and Hyman (1951) reported this species from unspecified Wisconsin localities. According to Kenk (1974b, 1976), *P. fluviatilis* inhabits ponds, lakes, rivers, streams, and springs. Muttkowski (1918) found *P. fluviatilis* occurred "frequently" in 0-1 m depths in Lake Mendota (Dane County). Smith and Verrill (1871) and Smith (1874) reported *P. fluviatilis* in Canadian waters of Lake Superior at depths of 4-13 fathoms. It likely occurs in the southern parts of this lake as well.

Family Rhynchodemidae

Microplana terrestris (O.F. Müller 1774)

The NMNH's invertebrate zoology database includes a record (catalog no. 40935) of three *M. terrestris* specimens from Wisconsin. A.R. Cahn collected these near Oconomowoc (Waukesha County) in July 1927, and these are the basis for Hyman's (1939, 1943) reports from the state, one of only three North American records (Ball and Sluys 1990). Hyman (1939, 1943) noted that the uniformly black specimen was found inhabiting rotten wood.

Rhynchodemus sylvaticus (Leidy 1851)

Ogren (1955, 1986) recorded three immature specimens of the nonnative *R. sylvaticus* collected along a roadside at New Glarus Woods State Park in August 1952.

UNCERTAIN TURBELLARIAN SPECIES

The identity of several "species" reported from Wisconsin remains in question. Hoy (1872) reported "a small white *Planaria*" as part of the deep-water benthos collected in Lake Michigan offshore from Racine. It is impossible to know based on his scant report what species he encountered. Woodworth (1896) described "*Planaria simplex*" based on a single immature specimen dredged "off N.Y. Point, Lake Michigan in August 1894." His diagnosis, however, was inadequate making it impossible to know what species he actually had and causing *P. simplex* to be considered a *species inquirienda* (Kenk 1976). Muttkowski (1918) reported "*Polycelis nigra*" from Lake Mendota. *Polycelis nigra* (Müller 1774), however, is a European and north African species not otherwise reported from North America. The only two North American species of *Polycelis*, *P. coronota* (Girard 1891) and *P. sierrensis* Kenk 1973, inhabit the western half of the continent leading me to believe that Muttkowski's identification almost certainly was made in error. Peck and Christiansen (1990) collected a "new and very primitive flatworm" from Popps Cave in Richland County. They listed this as "family, genus, and species undetermined" in the "Alloeocoela." Alloeocoela, however, has remained ill defined and of uncertain taxonomic position (Tyler, et al. 2005) and this new species has yet to be described.

Higley (1918) collected turbellarians throughout the Upper Midwest, including from ponds near Milwaukee (Milwaukee County). Unfortunately, her species accounts included only general references to the habitats in which the worms were collected, making it virtually impossible to know the specific localities her specimens came from. Some species that Higley (1918) may have collected in the Milwaukee area include: *Stenostomum leucops*, *Anotocelis caudata* (Leidy, 1851), *Gieysztoria dodgei* (Graff 1911), *Phaenocora megacephala* (Higley 1918), and *Rhynchomesostoma rostratum* (O.F. Müller 1774). Higley (1918) also described *Stenostomum glandiferum* and *Mesostoma simplex* from localities in the area, but these are now considered *nomen dubium* (Tyler, et al. 2005).

Hayes (1942) reported collecting a number of species from Wisconsin lakes that currently are considered valid (Table 1), but which are not included in Kolasa's (2001) list of species recorded from North America. He also reported collecting the European *Macrostomum tuba* Graff 1882 from a tank in a greenhouse on the University of Wisconsin campus, but noted that there was no way of knowing from where it had been introduced (Hayes 1942). Kolasa (2001) did not include *M. tuba* in his list of North American microturbellarians.

In his thesis, Hayes (1942) provided descriptions of eight species new to science based on specimens collected in Wisconsin. He never published formal descriptions of seven of these (Table 2), however, leaving their validity in question. Hayes (1942) also reported records of specimens of nine species that he could identify only to the genus level (Table 3). Representatives of all of these genera, except *Koinocystis*, have been reported from North America (Kolasa 2001, Tyler, at al. 2005), but Hayes believed several of his unidentified material to represent undescribed species.

Table 1. *Valid species reported by Hayes (1942) from Wisconsin, but not included in Kolasa's (2001) list of North American species.*

Gieysztoria dodgei (Graff 1911)
Gieysztoria triquetra (Fuhrmann 1894)
Klattia virginiensis Kepner, Stirewalt and Ferguson 1939
Stenostomum saliens Kepner and Carter 1931
Typhloplana viridata (Abildgaard 1789)

Table 2. *Species newly described by Hayes (1942) in his thesis, but not elsewhere in the literature.*

Castrella trifurca Hayes 1942
Microdalyellia oligostyrakia Hayes 1942
Microdalyellia pteridoides Hayes 1942
Microdalyellia stephanoma Hayes 1942
Mesostoma magnoreceptaculum Hayes 1942
Mesostoma ochnobolbos Hayes 1942
Opistomum microparynx Hayes 1942

Table 3. *Specimens uncertainly identified by Hayes (1942).*

Castrada (?) sp. 1 and sp. 2
Koinocystis sp.
Krumbachia sp.
Microdalyellia sp. 1 and sp. 2
Olisthanella sp.
Phaenocora sp.
Prorhynchella sp.

Several additional species likely occur in Wisconsin. Ball (1969b) confirmed the presence of the nonindigenous *Dugesia polychroa* (Schmidt 1861) in the St. Lawrence River system. Although it has not yet been reported from Wisconsin, it is possible that *D polychroa* has spread elsewhere from its point of introduction and may now occur in Lake Michigan as well. *Hymanella retenuova* Castle 1941 occurs in vernal pools, floodplain pools, and seepage springs throughout the eastern United States (Kenk 1976, Ball, et al. 1981, Smith 1991a). Although not yet reported from Wisconsin, further survey work will likely show that *H. retenuova* occurs here.

Finally, an unidentified *Bipalium* sp. was collected in a Milwaukee-area greenhouse in the mid-1990s. This could have been the widely distributed *Bipalium kewense* Mosely 1878, which has been found in about 19 eastern states including neighboring Illinois (Ogren 1984, Ball and Sluys 1990) or *B. adventitium* Hyman 1943, which Zaborski (2000) recently reported from Illinois.

RIBBON WORMS (NEMERTEA) IN WISCONSIN

There is only one published ribbon worm record from Wisconsin. Browning (1972) reported *Prostoma rubrum* from Silver Creek in the City of Ripon (Fond du Lac County). According to the NMNH's online invertebrate zoology database (NMNH 2005), voucher specimens (catalog no. 45773) from this report are available in the NMNH collection. *P. rubrum* is no longer a valid species (Gibson and Moore 1976, Gibson 1995), however, so this observation has to be treated as *Prostoma* sp. until the vouchers can be examined to determine the species involved.

CONCLUDING REMARKS

The conservation status of flatworms and ribbon worms in Wisconsin remains unknown. Neither state nor federal agencies consider any platyhelminths or nemerteans to be endangered, threatened, or of "special concern," but biologists have not conducted a statewide, systematic survey for these groups. I have been able to document only 31 turbellarian and one nemertean species based on the literature, considerably more than the two triclads included in Ball's (1969a) tally, but probably far short of the total number of species that occurs here. Most of the limited museum specimens have yet to be examined by a specialist. Cave habitats, vernal pools, and interstitial and subterranean waters have not been investigated significantly.

The basic biology, taxonomy, distribution, phenology, population dynamics, status, habitat selectivity, and trophic relationships of these animals remain areas that could benefit from additional research. The potential impacts of nonnative species also merit investigation. The literature cited in this report and in Kenk (1974a,c, 1989), Gibson and Moore (1976), Moore and Gibson (1985), Ball and Sluys (1990), Gibson (1995), and Kolassa (2001) can serve as starting points for interested investigators. Kolasa (2001) summarizes techniques for obtaining both quantitative and qualitative samples of freshwater turbellarians. Winsor (1998) provides directions for collection and preservation of terrestrial species, which are more cryptic and difficult to find. Routine preservation of field samples in alcohol or formalin, unfortunately, makes most turbellarians unrecognizable. Ribbon worms, however, can be preserved in 80% ethanol, but should be narcotized first (Kolasa 2001).

Many turbellarians can be identified by squash mounts of live animals. Identification, however, remains a challenge for inexperienced researchers as histological preparations also often are required. Similarly, the principal taxonomic characters used to distinguish species of *Prostoma* are restricted to internal anatomical features of the anterior end. Thus, identification necessarily involves preparing histological sections of the head of the animal (Smith 1991b).

Fortunately, basic literature to aid in species identification is available. Cannon (1986) provides a key to turbellarian families and genera. Kolasa (2001) provides a key to the orders and suborders of North American freshwater species and Kenk (1976) provides descriptions of North American freshwater macroturbellarians. Ball and Sluys (1990) include a provisional key to known North American terrestrial planarians, with recognition that additional species certainly will be found. Ruebush (1941) provides a useful, though somewhat dated, key to the genera of microturbellarians. Kolasa (2001) presents an illustrated key to the three North American species of *Prostoma*.

ACKNOWLEDGEMENTS

Work on this report began as a result of the "Wisconsin's Species Diversity: The State of Scientific Knowledge" symposium sponsored by the Aldo Leopold Chapter of the Society for Conservation Biology in April 1997. I am indebted to the chapter for providing the push to initiate this synthesis and publish it now to support work on Wisconsin's Comprehensive Wildlife Conservation Plan.

LITERATURE CITED

Baker, F.C. 1924. The fauna of the Lake Winnebago region. *Transactions of the Wisconsin Academy of Sciences, Arts, and Letters* 21:109-146.

Ball, I.R. 1969a. An annotated checklist of the freshwater Tricladida of the Nearctic and Neotropical Regions. *Canadian Journal of Zoology* 47:59-64.

Ball, I.R. 1969b. *Dugesia lugubris* (Tricladida: Paludicola), a European immigrant into North American fresh waters. *Journal of the Fisheries Research Board of Canada* 26(2):221-228.

Ball, I.R., N. Gourbault, and R. Kenk. 1981. The planarians (Turbellaria) of temporary waters in eastern North America. *Life Sciences Contributions* (127):1-27. Royal Ontario Museum, Toronto.

Ball, I.R. and R. Sluys. 1990. Turbellaria: Tricladida: Terricola. Pp. 137-153 In D.L Dindal (ed). *Soil Biology Guide*. John Wiley & Sons, New York.

Barton, D.R. and H.B.N. Hynes. 1978. Wave-zone macrobenthos of the exposed Canadian shores of the St. Lawrence Great Lakes. *Journal of Great Lakes Research* 4(1):27-45.

Baumann, P.C., J.W.A. Jaeger, and M.E. Antonioni. 1977. Toxicity of Antimycin A to *Asellus intermedius*, *Dugesia dorotocephala*, *Gammarus pseudolimnaeus*, and *Hyalella azteca*. *Transactions of the Wisconsin Academy of Sciences, Arts, and Letters* 65:246-253.

Browning, R.F. 1972. A record of the freshwater Nemertean, *Prostoma rubrum*, in Wisconsin. *Trans. Wisconsin Academy of Sciences, Arts, and Letters* 60:179-180.

Cannon, L.R.G. 1986. *Turbellaria of the World – A Guide to Families and Genera*. Queensland Museum, South Brisbane, Australia. 136 pp.

Castle, W.A. and L.H. Hyman. 1934. Observations on *Fonticola velata* (Stringer), including a description of the anatomy of the reproductive system. *Transactions of the American Microscopical Society* 53(2):154-171.

Gibson, R. 1995. Nemertean genera and species of the world: an annotated checklist of original names and description citations, synonyms, current taxonomic status, habitats and recorded zoogeographic distribution. *Journal of Natural History* 29:271-562.

Gibson, R. and J. Moore. 1976. Freshwater nemerteans. *Zoological Journal of the Linnean Society* 58:177-218.

Hayes, W.J., Jr. 1941. Rhabdocoela of Wisconsin. I. Morphology and taxonomy of *Protoascus wisconsinensis*, n. g., n. sp. *American Midland Naturalist* 25(2):388-401.

Hayes, W.J., Jr. 1942. Taxonomic and morphological studies on Wisconsin Rhabdocoela. Ph.D. thesis. University of Wisconsin, Madison. 163 pp. + plates.

Hayes, W.J., Jr. 1945. Rhabdocoela of Wisconsin. II. Morphology and taxonomy of *Castrella pinguis* (Silliman 1884) Fuhrmann 1900. *American Midland Naturalist* 33(2):440-448.

Higley, R. 1918. Morphology and biology of some Turbellaria from the Mississippi basin. *Illinois Biological Monographs* 4(3):1-194.

Hoy, P.R. 1872. Deep-water fauna of Lake Michigan. *Transactions of the Wisconsin Academy of Sciences, Arts, and Letters* 1:98-101.

Hyman, L.H. 1939. New species of flatworms from North, Central, and South America. *Proceedings of the United States National Museum* 86(3055):419-439.

Hyman, L.H. 1943. Endemic and exotic land planarians in the United States with a discussion of necessary changes of names in the Rhynchodemidae. *American Museum Novitates* (1241):1-21.

Hyman, L.H. 1951. North American triclad Turbellaria. XII. Synopsis of the known species of fresh-water planarians of North America. *Transactions of the American Microscopical Society* 70:154-167.

Kawakatsu, M., E.M. Froehlich, H.D. Jones, R.E. Ogren, and G-Y Sasaki. 2003. Additions and corrections of the previous land planarian indices of the world – 11. *Bulletin of Fuji Women's University* (series II) (41):89-114. Available on the worldwide web at **http://planarian.net/db/lpindex/ix2003.pdf**. Accessed June 2005.

Kawakatsu, M., E.M. Froehlich, H.D. Jones, R.E. Ogren, M. Takai, and G-Y Sasaki. 2004. Additions and corrections of the previous land planarian indices of the world – 12. *Bulletin of Fuji Women's University* (series II) (42):81-96. Available on the worldwide web at **http://planarian.net/db/lpindex/ix2004.pdf**. Accessed June 2005.

Kawakatsu, M., R.E. Ogren, E.M. Froehlich, and G-Y Sasaki. 2000. *Land Planarian Indices of the Word (1987-2000…..): Electronic Version.* CD-ROM. Fuji Women's College, Sapporo, Japan.

Kenk, R. 1943. Notes on the planarian fauna of Canada. *Canadian Field-Naturalist* 57:5-6.

Kenk, R. 1944. The fresh-water triclads of Michigan. Museum of Zoology, University of Michigan *Miscellaneous Publications* 60:1-44 + 7 plates.

Kenk, R. 1970. Freshwater Triclads (Turbellaria) of North America, IV: the polypharyngeal species of *Phagocata. Smithsonian Contributions in Zoology* (80):1-17.

Kenk, R. 1973. Freshwater Triclads (Turbellaria) of North America, V: the genus *Polycelis. Smithsonian Contributions in Zoology* (135):1-15.

Kenk, R. 1974a. Index to the genera and species of the freshwater Triclads (Turbellaria) of the world. *Smithsonian Contributions to Zoology* (183):1-90.

Kenk, R. 1974b. Chapter 3, Flatworms (Platyhelminthes: Tricladida). Pp. 67-80 In C.H. Hart, Jr. and S.L.H. Fuller (eds). *Pollution Ecology of Freshwater Invertebrates*. Academic Press, New York.

Kenk, R. 1974c. History of the study of Turbellaria in North America. Pp. 17-22 In N.W. Riser and M.P. Morse (eds.). *Biology of the Turbellaria*. McGraw-Hill Book Company, New York.

Kenk, R. 1976. Freshwater planarians (Turbellaria) of North America. *Water Pollution Control Research Series* 18050 ELDO2/72 (2nd printing, originally published as *Biota of Freshwater Ecosystems Identification Manual* 1 in 1972). Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, OH.

Kenk, R. 1989. Revised list of the North American freshwater planarians (Platyhelminthes: Tricladida: Paludicola). *Smithsonian Contributions to Zoology* (476):1-10.

Kolasa, J. 2001. Flatworms: Turbellaria and Nemertea. Pp. 155-180 In J.H. Thorp and A.P. Covich (eds). *Ecology and Classification of North American Freshwater Invertebrates, 2nd ed.* Academic Press, San Diego.

Kolasa, J., D. Strayer, and E. Bannon-O'Donnell. 1987. Microturbellarians from interstitial waters, streams, and springs in southeastern New York. *Journal of the North American Benthological Society* 6(2):125-132.

Krause, J.E. 1974. Planarians, Part II: Oxygen consumption and standard metabolism of two turbellarians, *Dugesia dorotocephala* (Woodworth) and *Cura formanii* (Girard), from Wisconsin. *Reports on the Flora and Fauna of Wisconsin* 9:1-9. Museum of Natural History, University of Wisconsin-Stevens Point.

Long, C.A. and J. Krause. 1974. Planarians, Part I: The flatworm *Cura formanii* (Girard) in Wisconsin. *Reports on the Flora and Fauna of Wisconsin* 9:1. Museum of Natural History, University of Wisconsin-Stevens Point.

Moore, J. and R. Gibson. 1985. The evolution and comparative physiology of terrestrial and freshwater nemerteans. *Biological Reviews [of the Cambridge Philosophical Society]* 60:257-312.

Muttkowski, R.A. 1918. The fauna of Lake Mendota: a qualitative and quantitative survey with special reference to the insects. *Transactions of the Wisconsin Academy of Sciences, Arts, and Letters* 19:374-482.

National Museum of Natural History. 2005. Invertebrate zoology database. Available on the worldwide web at: **http://goode.si.edu/webnew/pages/nmnh/iz/Query.php**. Accessed May 2005.

Ogren, R.E. 1955. Ecological observations on the occurrence of *Rhychodemus*, a terrestrial turbellarian. *Transactions of the American Microscopical Society* 74:54-60.

Ogren, R.E. 1984. Exotic land planarians of the genus *Bipalium* (Platyhelminthes: Turbellaria) from Pennsylvania and the Academy of Natural Sciences, Philadelphia. *Proceedings of the Pennsylvania Academy of Science* 58:193-201.

(continued on next page)

Bureau of Integrated Science Services
Wisconsin Department of Natural Resources
P.O. Box 7921
Madison, WI 53707

Presorted Standard
U.S. Postage
Paid
Madison, WI
Permit No. 906

Printed on recycled paper.

PUB-SS-755 2005

Ogren, R.E. 1986. Development of the reproductive apparatus of the land planarian *Rhynchodemus sylvaticus* (Turbellaria: Tricladida) and its significance for classification in the genus. *Hydrobiologia* 132:175-180.

Ogren, R.E. and M. Kawakatsu. 1987. Index to the species of the genus *Bipalium* (Turbellaria, Tricladida, Terricola). *Bulletin of Fuji Women's College* 25:79-119.

Ogren, R.E. and M. Kawakatsu. 1998. American Nearctic and Neotropical planarian (Tricladida: Terricola) faunas. *Pedobiologia* 42:441-451.

Peck, S.B. and K. Christiansen. 1990. Evolution and zoogeography of the invertebrate cave faunas of the Driftless Area of the Upper Mississippi River Valley of Iowa, Minnesota, Wisconsin, and Illinois, U.S.A. *Canadian Journal of Zoology* 68:73-88.

Ruebush, T.K. 1941. A key to the American freshwater turbellarian genera, exclusive of the Tricladida. *Transactions of the American Microscopical Society* 60:29-40.

Smith, D.G. 1991a. On some larger turbellarian worms (Platyhelminthes) living in temporary fresh waters of southern New England. *Hydrobiologia* 220:255-265.

Smith, D.G. 1991b. *Keys to the Freshwater Macroinvertebrates of Massachusetts*. Publ. by author. Department of Zoology, University of Massachusetts, Amherst. 236 pp.

Smith, S.I. 1874. Sketch of the invertebrate fauna of Lake Superior. Pp. 690-707 In Report of the Commissioner for 1872 and 1873, U.S. Commission Fish and Fisheries.

Smith, S.I. and A.E. Verrill. 1871. Notice of the Invertebrata dredged in Lake Superior in 1871. *American Journal of Science and Arts* 102:448-454.

Stringer, C.E. 1918. Chapter XII: The free-living flatworms (Turbellaria). Pp. 323-364 In H.B. Ward and G.C. Whipple. *Fresh-water Biology*. John Wiley and Sons, New York.

Turbeville, J.M., K.G. Field, and R.A. Raff. 1992. Phylogenetic position of phylum Nemertini, inferred from 18S rRNA sequences: molecular data as a test of morphological character homology. *Molecular Biology and Evolution* 9(2):235-249.

Tyler S., S. Schilling, M. Hooge, and L.F. Bush (comps.). 2005. Turbellarian taxonomic database. Version 1.4 . Available on the worldwide web at: **http://devbio.umesci.maine.edu/styler/turbellaria/**. Accessed June 2005.

Winsor, L. 1998. Collection, handling, fixation, histological and storage procedures for taxonomic studies of terrestrial flatworms (Tricladida: Terricola). *Pedobiologia* 42:405-411.

Wisenden, B.D. and M.C. Millard. 2001. Aquatic flatworms use chemical cues from injured conspecifics to assess predation risk and to associate risk with novel cues. *Animal Behaviour* 62:761-766.

Woodworth, W.M. 1896. Report on the Turbellaria collected by the Michigan State Fish Commission during the summer of 1893 and 1894. *Bulletin of the Museum of Comparative Zoology, Harvard* 29:239-243 + 1 plate.

Zaborski, E. 2000. New predators and parasites of earthworms in Illinois. *Illinois Natural History Survey Reports* (May-June). Available on the worldwide web at: **http://www.inhs.uiuc.edu/chf/pub/surveyreports/may-jun00/worms.html**. Accessed June 2005.

AUTHOR CONTACT INFORMATION

Address:
Wisconsin DNR
Bureau of Integrated Science Services
PO Box 7921, Madison, WI 53707-7921

Telephone: (608) 266-8931

E-mail: dreux.watermolen@dnr.state.wi.us

Graphic Design: Michelle E. Voss
Illustrations: Dreux J. Watermolen