The Great Lakes Entomologist

Volume 34
Number 2 - Fall/Winter 2001 *Number 2 - Fall/ Winter 2001*
Article 4

October 2001

Distribution of Terrestrial Isopods (Crustacea: Isopoda) Throughout Michigan: Early Results

Jennifer L. Stoyenoff
University of Michigan

DISTRIBUTION OF TERRESTRIAL ISOPODS (CRUSTACEA: ISOPODA) THROUGHOUT MICHIGAN: EARLY RESULTS

Jennifer L. Stoyenoff[1]

ABSTRACT

Results are reported from the first two years of a multi-year study on the distribution of terrestrial isopods (Crustacea: Isopoda) in Michigan. During the first year of the study (1997), intensive investigations were carried out using pitfall traps in a small area of Midland, MI. The study was resumed in 2001 with opportunistic collection and hand-sorting of litter samples for terrestrial isopods throughout 30 Michigan counties. As a result of this data collection, the species *Haplophthalmus danicus*, previously unrecorded in the state, has been located in seven counties, and 83 new county records have been established for eight other terrestrial isopod species in Michigan. In particular, this study adds extensively to distributional knowledge for four species so far: *Hyloniscus riparius*, *Trichoniscus pusillus*, *Oniscus asellus*, and *Armadillidium vulgare*. Another species, *Armadillidium nasatum*, previously reported only inside greenhouses in three somewhat southern locations in the state, was found as clearly well-established outdoor populations in two additional counties further north. Habitat/microhabitat information is presented for all species.

The isopod fauna of Michigan is poorly studied. Much information is lacking on species occurrence and distributions, associations with habitats and microhabitats, and biology and ecology of the organisms. As of 1991, only 12 papers listing any new records for isopod distributions in Michigan had been published, and just two of those had appeared in the preceding 40 years (Snider 1991). The most up-to-date compilation of records from both published literature and museum holdings (Snider 1991) indicated that 11 terrestrial species were known from the state as of 1991, many of these from only a few localities (Table 1).

Of the 83 counties in Michigan, nine counties had no known terrestrial isopod records as of 1991, 36 counties had records of only a single species, and 25 counties had only two or three species reported (Snider 1991). The remaining 13 counties in the state—11 with four or five isopod species recorded, one with seven species records, and one with 10 known species—suggest that the other 70 counties are likely not as barren in terms of terrestrial isopod fauna as current records would indicate. More in-depth and current survey work has been sorely needed on this group of organisms.

It is likely that some or all of the numerous terrestrial isopod species occurring in surrounding areas of the Great Lakes region may be found in similar distribution patterns in Michigan as well. For instance, workers in Wisconsin have recorded *Cylisticus convexus* (DeGeer), *Porcellio spinicornis* Say, and *Trachelipus rathkei* (Brandt) from every county in their state (Jass and Klausmeier 1996). It is reasonable to expect that these same species may be widespread in Michigan also. In fact, two of these species had been recorded from numerous localities in the state as of 1991, although they had not yet been found state-wide; the third species, *P. spinicornis*, has been much less known in Michigan. Further investigation is needed to determine which if any species are present state-wide here.

While surrounding areas have many of the same terrestrial isopod species as Michigan, 11 additional species not previously reported from Michigan have

[1] Dow Gardens, Midland, MI 48640 (correspondence address) and University of Michigan, School of Natural Resources and Environment, Ann Arbor, MI 48109-1115.

Table 1. Terrestrial isopod species known from Michigan, and the number of counties in which each species had been recorded as of 1991 (data from Snider 1991 with an emendation from Hatchett 1947), as well as after the present survey. There are a total of 83 counties in the state of Michigan.

Species	Counties where known in 1991	Counties where known in 2001
Ligidium elrodii Packard	1	1
Haplophthalmus danicus Budde-Lund	0	7
Hyloniscus riparius (C. L. Koch)	1	15
Trichoniscus pusillus Brandt	2	21
Oniscus asellus Linnaeus	3	14
Armadillidium nasatum Budde-Lund	3	5
Armadillidium vulgare (Latreille)	14	36
Cylisticus convexus (DeGeer)	30	35
Porcellio scaber Latreille	21	25
Porcellio spinicornis Say	9	15
Porcellionides pruinosus (Brandt)	5	5
Trachelipus rathkei (Brandt)	73	73

been found in Ohio, Indiana, Illinois, Wisconsin, or southern Ontario (Table 2) (see also Jass and Klausmeier 2001, 1990). Many of these additional species potentially reside in Michigan, but may simply be unknown from the state due to lack of collecting efforts.

Isopods often are present at high densities in suitable ecosystems (Stoyenoff, unpubl. data; Oliver and Meechan 1993, Sutton 1972). These organisms are involved in decomposition and nutrient cycling processes (Zimmer and Topp 1999, 1998; Van Wensem et al. 1993, Coûteaux et al. 1991, Hassall et al. 1987, Hassall and Sutton 1978, Hassall 1977) and also serve as a food source for other organisms (Sutton 1972). Knowing which terrestrial isopod species are present and what their patterns of distribution are across the state will form a basis of knowledge for additional study on the biology and ecology of these organisms.

MATERIALS AND METHODS

Isopod collections began in 1997 with an intensive investigation carried out using pitfall traps on lands owned by the Dow Gardens in Midland, Michigan, USA (latitude 43° 62' N, longitude 84° 25' W). The Dow Gardens is composed of a complex of landscape beds and turf areas under varying levels of management, patchworked with largely unmanaged woodlots and floodplain ecosystems. During a two-week period which began on 14 July 1997, 242 unbaited pitfall traps were operated in a variety of ecosystem types located throughout these lands.

Each pitfall trap consisted of two clear plastic cups nested together. The inner 414 ml cup was 9.5 cm tall and 9 cm in diameter. The outer 473 ml cup was 11 cm tall and 9.5 cm in diameter. This diameter was just enough larger than that of the inner cup to ensure that when the cups were nested together,

Table 2. Terrestrial isopod species not reported in Michigan as of 1991 but reported from surrounding areas (Ohio, Indiana, Illinois, Wisconsin, or southern Ontario).

Species	Location reported and reference
Ligidium hypnorum (Cuvier)	Ontario (Belaoussoff et al. 1998)
Ligidium longicaudatum Stoller	Ontario (Belaoussoff et al. 1998)
Androniscus dentiger Verhoeff	Ontario (Van Name 1940, Belaoussoff et al. 1998)
Haplophthalmus danicus Budde -Lund	Indiana (Richardson 1905, Eberly 1953); Ohio (Keeney 1990); Ontario (Walker 1927, Judd 1965, Belaoussoff et al. 1998)
Miktoniscus barri Vandel	Indiana (Vandel 1965, Schultz 1976)
Miktoniscus medcofi (Van Name)	Illinois (Van Name 1940); Indiana (Schultz 1976); Ohio (Muchmore 1964, Schultz 1976); Wisconsin (Jass and Klausmeier 1996)
Trichoniscus pygmaeus Sars	Illinois (Van Name 1940); Ohio (Hobbs and Flynn 1981); Ontario (Belaoussoff et al. 1998)
Philoscia muscorum (Scopoli)	Ontario (Belaoussoff et al. 1998)
Trichorhina tomentosa Budde-Lund	Ohio (Keeney 1990)
Venezillo parvus (Budde-Lund)	Ohio (Keeney 1990)
Porcellio laevis Latreille	Ohio (Richardson 1905, Van Name 1936); Ontario (Thompson 1932, Hatch 1947, Belaoussoff et al. 1998)

the rims fit snuggly and level with one another. These nested cups were installed so that their rims were level with the ground surface. The inner cup contained an ethyl alcohol solution as a killing agent and was the cup used for sample collection. The outer cup served as a sleeve lining the hole which allowed the inner cup to be easily removed and replaced during collection of contents without further disturbance of the soil surrounding the hole. Each pitfall trap was shielded by a 15 by 15 cm plywood rain cover supported by three 15 cm long legs that staked into the ground.

In 2001, the study was resumed with opportunistic collection and hand-sorting of litter samples for terrestrial isopods throughout 30 Michigan counties. Meander surveys in each county were structured to include a variety of areas with likely habitat, such as riverine ecosystems, meadows, agricultural areas, and areas of different forest cover types. During all meander surveys, litter was hand sorted for isopods in the field, and refuges such as rocks, tree root flares, stumps, and downed woody debris were examined (Sutton 1972). This type of targeted search covering specific microhabitats was a more efficient means of encountering isopods than is a sampling scheme such as collecting at fixed intervals along a

transect. In addition, litter and soil samples were often collected for later hand sorting in the laboratory. Specimens collected in the field, along with the samples of soil and litter, were held alive in plastic bags on ice. They were transported back to the laboratory in Midland, MI, where isopods were removed by hand and field identifications confirmed.

Specimens were determined using keys in Muchmore (1990). I also consulted keys in Belaoussoff et al. (1998) and Hatchett (1947), as well as species descriptions in Jass and Klausmeier (1996). Classification follows Oliver and Meechan (1993), who combined the classification system of Bowman and Abele (1982) with emendations from Holdich et al. (1984). Materials from this study were preserved in 70% ethyl alcohol in glass vials with double-seal lids. Voucher specimens are deposited at Michigan State University, East Lansing, MI.

RESULTS

Distribution maps incorporating known county records prior to 1991 along with the new county records determined in this study are shown in Figs. 1-7. Included for purposes of comparison and completeness are distribution maps for three species known from the state of Michigan, but for which no new records have been found to date in this survey.

Order Isopoda

Suborder Oniscidea

Section Synocheta

Superfamily Trichoniscoidea

Family Trichoniscidae

***Haplophthalmus danicus* Budde-Lund. NEW MICHIGAN RECORD.** Species identification was verified by Richard J. Snider, Dept. of Zoology, Michigan State University, East Lansing, MI. (Fig. 1a). **MICHIGAN** collection records: **Bay Co.,** Maple Leaf Golf Course, T16N/R4E/S33, 09/11/01, edge of drainage ditch. **Crawford Co.,** T28N/R4W/S35, 08/08/01, mixed woody and grassy litter in very wet soil on the banks of the Au Sable River; very high numbers of this species were present in this area. **Huron Co.,** T15N/R9E/S8, 08/18/01, in and under wood and leaf litter on soil that varied from sandy to heavy clay along the Sebewaing River. **Manistee Co.,** T21N/R14W/S8, 08/11/01, very wet soil near Pine Creek. **Midland Co.,** Dow Gardens, Midland, 07/24/97 – 07/30/97, taken in pitfall traps in several ecosystem types: seasonally flooded lowland deciduous woodlot areas in the Snake Creek floodplain; beds of ostrich ferns; beds of spreading junipers; and shady beds with complex vegetation structure dominated by deciduous overstory trees and including shrub and weedy ground cover layers. **Saginaw Co.,** Oakwood Cemetery, T12N/R4E/S30, 09/24/01, in a large pile of coarse woody debris mixed with maple leaves and other deciduous leaf litter in a woodlot area. **Wexford Co.,** T23N/R12W/S11, 08/12/01, grass and sedge litter in very wet, organic soil near banks of Manistee River.

***Hyloniscus riparius* (C. L. Koch).** (Fig. 1b). **MICHIGAN** collection records: **Genesee Co.,** Captain's Club Golf Course, T6N/R7E/S36, 09/27/01, in very moist leaf litter by the side of a small stream. **Huron Co.,** T15N/R9E/S8, 08/18/01, in and under wood and leaf litter in soils that varied from sandy to heavy clay along the Sebewaing River. **Isabella Co.,** Veit's Woods, Mount Pleasant, 07/24/01, in wet, heavy clay soil in a large depressional area. **Jackson Co.,** T2S/R2E/S11, 11/04/01, woody litter and leaf litter by the side of a drainage ditch. **Kent Co.,** Rockford, 10/19/01, small patch of trees including walnut and small box elders in an urban area next to a factory parking lot, with a small drainage ditch down a steep slope of 4-5 m; isopods were inside walnut shells, woody debris, leaf litter, under cinder blocks, and in miscellaneous trash items left at the site. **Leelanau Co.,** T28N/R11W/S28, 08/11/01, in damp leaf litter along an

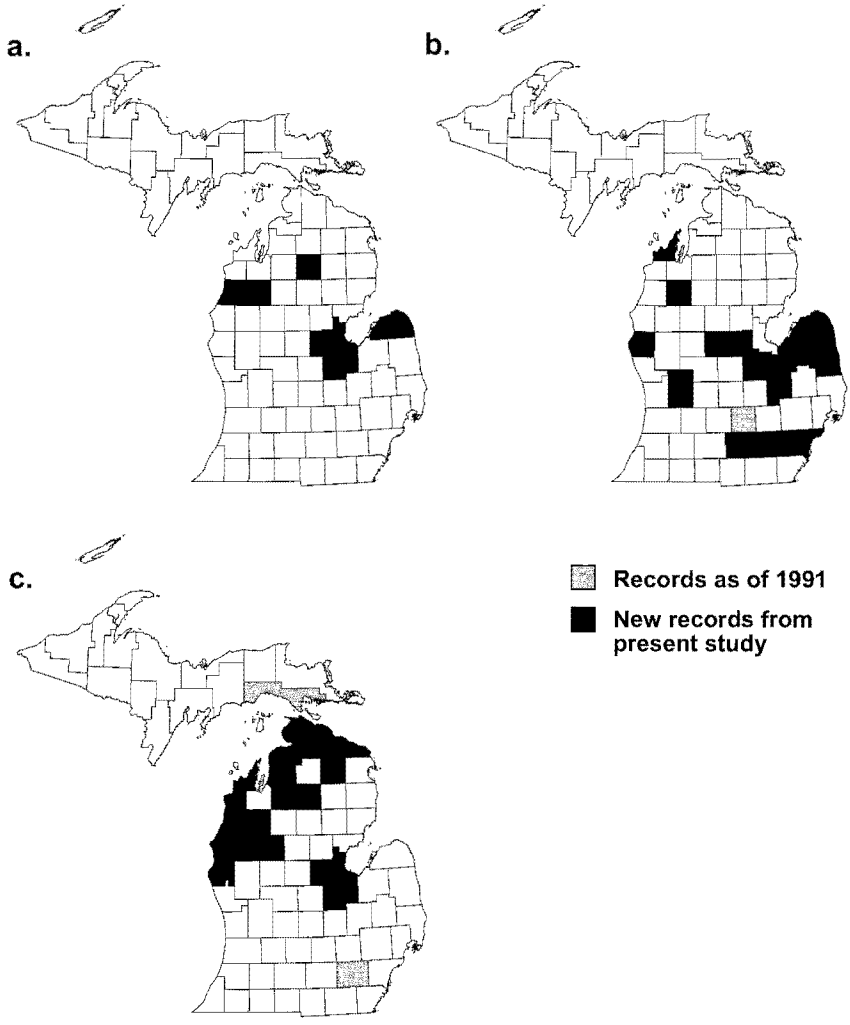

Figure 1. Michigan distribution of isopod species in the family Trichoniscidae: a) *Haplophthalmus danicus* Budde-Lund, b) *Hyloniscus riparius* (C. L. Koch), and c) *Trichoniscus pusillus* Brandt.

unnamed creek in a small woodlot. **Midland Co.,** Dow Gardens, Midland, 07/21/97 – 07/30/97, taken in pitfall traps in several ecosystem types: seasonally flooded lowland deciduous woodlot areas in the Snake Creek floodplain; upland deciduous woodlot areas; areas of non-irrigated, low maintenance turf; beds of ostrich ferns; beds of spreading junipers; bed of annual flowers; beds of dense, creeping or trailing ground cover of various species commonly used in landscaping; large beds of needle mulch under groups of many pine trees; smaller oblongs of needle mulch surrounded by turf under pairs of trees; small circles of needle mulch surrounded by turf under individual pine trees; shady beds with complex vegetation structure dominated by deciduous overstory trees and including shrub and

weedy ground cover layers; and shady beds with complex vegetation structure dominated by coniferous overstory trees and including ericaceous and other shrubs with a weedy ground cover layer. They were particularly abundant in lowland woodlot areas, beds of junipers, and large beds of needle mulch under groups of pine trees. **Oceana Co.,** T16N/R17W/S10, 08/12/01, damp organic material on flats along the north branch of the Pentwater River. **Saginaw Co.,** T11N/R6E/S27, 09/10/01, under stones and logs and in leaf litter on the banks of the Cass River. Also, Kluck Nursery, T11N/R3E/S2, 09/10/01, under leaf litter along a drainage ditch by an open, grassy field. Also, Oakwood Cemetery, T12N/R4E/S30, 09/24/01, in and under a small pile of trash located under juniper shrubs in a landscape bed in the cemetery. **Sanilac Co.,** T13N/R12E/S18, 08/18/01, inside bark on a damp log. **Tuscola Co.,** near Vanderbilt Park, T14N/R7E/S28, 08/08/01, edge of drainage ditch along an agricultural field. Also, T11N/R7E/S28, 09/25/01, in a pile of large woody debris on the banks of the Cass River. **Washtenaw Co.,** Ann Arbor, 08/05/01, under and in logs and other smaller woody debris in leaf humus in a shaded garden. **Wayne Co.,** near Belleville, T3S/R8E/S21, 11/22/01, in woody debris and leaf litter in a wooded area with mixed deciduous and coniferous trees (overstory composed largely of Scotch pines and red pines). **Wexford Co.,** T23N/R12W/S11, 08/12/01, grass and sedge litter in very wet, organic soil near banks of Manistee River.

***Trichoniscus pusillus* Brandt.** (Fig. 1c). **MICHIGAN** collection records: **Antrim Co.,** Jordan River Campground area, T30N/R6W/S10, 07/14/01, in white pine and hemlock litter on a muddy creek bank, also muck soil in the Jordan River floodplain. Also, Cascade Road, T30N/R6W/S21, 07/14/01, in rotten logs and damp soil; along creek bank; in mucky soil in floodplain. **Bay Co.,** Maple Leaf Golf Course, T16N/R4E/S33, 09/11/01, edge of drainage ditch. **Benzie Co.,** T27N/R14W/S29, 08/11/01, near Platte River. **Charlevoix Co.,** T33N/R4W/S34, 07/15/01, in damp leaf litter near the bottom of a ravine in an oak site with a red maple component. **Cheboygan Co.,** University of Michigan Biological Station, Grapevine Point Nature Trail, T37N/R3W/S28, 07/12/01, in and under rotting wood. **Crawford Co.,** T28N/R4W/S35, 08/08/01, in very wet soil under grass and wood litter near the Au Sable River. **Emmet Co.,** T37N/R4W/S29, 07/29/01, in rotten wood and wet leaf litter in the floodplain of the west branch of the Maple River. **Kalkaska Co.,** near Wood Road, T28N/R7W/S2, 08/08/01, in very wet northern white cedar litter in the flats along the Rapid River. **Lake Co.,** T19N/R13W/S11, 08/12/01, in litter on the banks of the Little Manistee River. **Leelanau Co.,** T28N/R11W/S28, 08/11/01, in damp leaf litter along an unnamed creek in a small woodlot. **Manistee Co.,** T21N/R14W/S8, 08/11/01, very wet soil near Pine Creek. **Mason Co.,** Ludington State Park, T19N/R18W/S17, 08/12/01, in litter in a swampy area by Lost Lake. **Midland Co.,** Dow Gardens, Midland, 07/21/97 – 07/30/97, taken in pitfall traps in several ecosystem types: seasonally flooded lowland deciduous woodlot areas in the Snake Creek floodplain; upland deciduous woodlot areas; areas of non-irrigated, low maintenance turf; beds of ostrich ferns; beds of spreading junipers; beds of dense, creeping or trailing ground cover of various species commonly used in landscaping; large beds of needle mulch under groups of many pine trees; smaller oblongs of needle mulch surrounded by turf under pairs of trees; and shady beds with complex vegetation structure dominated by coniferous overstory trees and including ericaceous and other shrubs with a weedy ground cover layer. **Montmorency Co.,** T29N/R2E/S9, 07/25/01, muck soil along Avery Creek. **Oceana Co.,** T16N/R17W/S10, 08/12/01, damp organic material on flats along the north branch of the Pentwater River. **Osceola Co.,** T18N/R7W/S1, 08/06/01, muddy banks of sloughs by Muskegon River. **Presque Isle Co.,** T35N/R3E/S22, 07/28/01, northern white cedar needle litter and wood pieces near banks of Ocqueoc River. **Saginaw Co.,** Oakwood Cemetery, T12N/R4E/S30, 09/24/01, in a large pile of coarse woody debris mixed with maple leaves and other deciduous leaf litter in a woodlot area. **Wexford Co.,** T23N/R12W/S11, 08/12/01, grass and sedge litter in very wet, organic soil near banks of Manistee River.

Section Crinocheta

Superfamily Oniscoidea

Family Oniscidae

***Oniscus asellus* Linnaeus.** (Fig. 2). **MICHIGAN** collection records: **Alpena Co.,** Ella S. White Elementary School Nature Area, Alpena, 07/27/01, under wood and rocks; also in leaf litter under shrubs. **Benzie Co.,** T26N/R14W/S8, 08/11/01, in grassy litter on the banks of the Platte River. **Huron Co.,** T15N/R9E/S8, 08/18/01, in and under wood and leaf litter in soils that varied from sandy to heavy clay along the Sebewaing River. **Jackson Co.,** T2S/R2E/S10, 11/04/01, oak leaf litter and oak wood by seasonal pond. **Kent Co.,** Rockford, 10/19/01, small patch of trees including walnut and small box elders in an urban area next to a factory parking lot, with a small drainage ditch down a steep slope of 4-5 m; isopods were inside walnut shells, woody debris, leaf litter, under cinder blocks, and in miscellaneous trash items left at the site; one large, mature, intermolt, individual caught had a very unusual color pattern for this species, featuring a checkering of dark patches on a snowy white background. **Leelanau Co.,** T28N/R11W/S28, 08/11/01, in damp leaf litter along an unnamed creek in a small woodlot. **Midland Co.,** Dow Gardens, Midland, 07/25/97, taken in pitfall traps in seasonally flooded lowland deciduous woodlot areas in the Snake Creek floodplain. **Presque Isle Co.,** T35N/R2E/S2, 07/28/01, grassy litter on banks of Rainy River. **Saginaw Co.,** Oakwood Cemetery, T12N/R4E/S30, 09/24/01, in a large pile of coarse woody debris mixed with maple leaves and other deciduous leaf litter in a woodlot area; there was a very high density of this species here, especially on and in the woody debris. Also, Oakwood Cemetery, T12N/R4E/S30, 09/24/01, in and under a small pile of trash located under juniper shrubs in a landscape bed in the cemetery. **Tuscola Co.,** T11N/R7E/S28, 09/25/01, in a pile of large woody debris on the banks of the Cass River. **Wayne Co.,** near Belleville, T3S/R8E/S21, 08/05/01, in a wood pile; in a compost heap; inside walnut shells; very large populations were present in all of these microsites, with this species being much more abundant than the co-occurring *Porcellio scaber* Latreille.

Superfamily Porcellionoidea

Family Armadillidiidae

***Armadillidium nasatum* Budde-Lund.** (Fig. 3a). **MICHIGAN** collection records: **Genesee Co.,** Captain's Club Golf Course, T6N/R7E/S36, 09/27/01, under rocks piled near the maintenance building in a very dry area at the edge of non-irrigated turf. **Midland Co.,** Dow Gardens, Midland, 07/22/97 – 07/29/97, taken in pitfall traps in several ecosystem types: areas of irrigated, high maintenance turf; beds of ostrich ferns; beds of spreading junipers; beds of annual flowers; and shady beds with complex vegetation structure dominated by deciduous overstory trees and including shrub and weedy ground cover layers. There was an extremely dense population of this species in one large bed of spreading junipers at the side of a pond. Also collected in a greenhouse, where it was present in large numbers.

***Armadillidium vulgare* (Latreille).** (Fig. 3b). **MICHIGAN** collection records: **Alpena Co.,** Ella S. White Elementary School Nature Area, Alpena, 07/27/01, under wood and rocks; also in leaf litter under shrubs. Also, T31N/R5E/S23, 07/27/01, in litter in cattail swamps along the lower south branch of Thunder Bay River. Also, T30N/R5E/S17, 07/27/01, in dead wood on the shore of Fletcher Pond. **Antrim Co.,** T31N/R5W/S8, 08/09/01, in grassy litter in a damp ditch bordering farm fields. **Benzie Co.,** T26N/R14W/S8, 08/11/01, in grassy litter on the banks of the Platte River. **Charlevoix Co.,** T32N/R5W/S16, 08/09/01, on the grassy banks of a river near Boyne Mountain. **Crawford Co.,** T28N/R4W/S35, 08/08/01, in very wet soil under grass and wood litter near the Au Sable River. **Grand Traverse Co.,** T26N/R11W/S5, 08/10/01, in

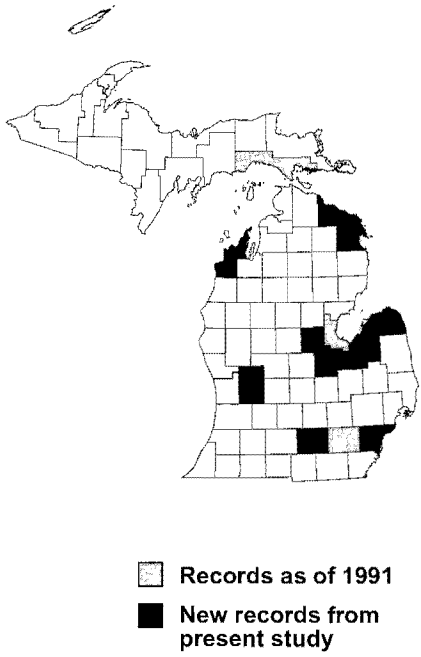

Figure 2. Michigan distribution of isopod species in the family Oniscidae: *Oniscus asellus* Linnaeus.

small rocks mulching a dry landscape bed of junipers surrounded by concrete at a gas station. Also, T27N/R10W/S30, 08/11/01, along banks of Mitchell Creek, in area of cattails. **Hillsdale Co.,** T7S/R2W/S15, 11/04/01, in stones of an old building foundation; dry area. **Huron Co.,** Sebewaing, T15N/R9E/S8, 08/18/01, in very dry area of landscaping rocks around grave stones in city cemetery. **Isabella Co.,** Central Michigan University Dow Science Building, Ottawa Road, Mount Pleasant, 07/24/01, under and around rocks in a dry landscape bed. Also, Central Michigan University Botany Greenhouse, Mount Pleasant, 07/24/01, in leaf litter in dry landscape beds outside the greenhouse building. Also, Preston and Washington Streets, Mount Pleasant, 07/24/01, in damp leaf litter and rotten logs in a small woodlot. **Jackson Co.,** T2S/R2E/S11, 11/04/01, woody litter and leaf litter by the side of a drainage ditch. **Kalkaska Co.,** near Wood Road, T28N/R7W/S21, 08/08/01, in very wet northern white cedar litter in the flats along the Rapid River. **Kent Co.,** Rockford, 10/19/01, small patch of trees including walnut and small box elders in an urban area next to a factory parking lot, with a small drainage ditch down a steep slope of 4-5 m; isopods were inside walnut shells, woody debris, leaf litter, under cinder blocks, and in miscellaneous trash items left at the site. **Lake Co.,** T19N/R13W/S11, 08/12/01, in litter on the banks of the Little Manistee River. **Leelanau Co.,** Lincoln Road near Co. 633 or Cherry Bend Road, T28N/R11W/S29, 08/11/01, under stones in a very dry landscape bed with junipers. Also, T28N/R11W/S28, 08/11/01, in damp litter along an unnamed creek in a woodlot. **Manistee Co.,** T22N/R14W/S33, 08/11/01, under logs in floodplain of Manistee River. **Mason Co.,** Ludington, 08/12/01, under shrubs in a dry landscape bed surrounded by cement at a gas station. **Midland Co.,** Dow Gardens, Midland, 07/21/97 – 07/30/97, taken in pitfall traps in several ecosystem types: seasonally flooded lowland deciduous woodlot areas in the Snake

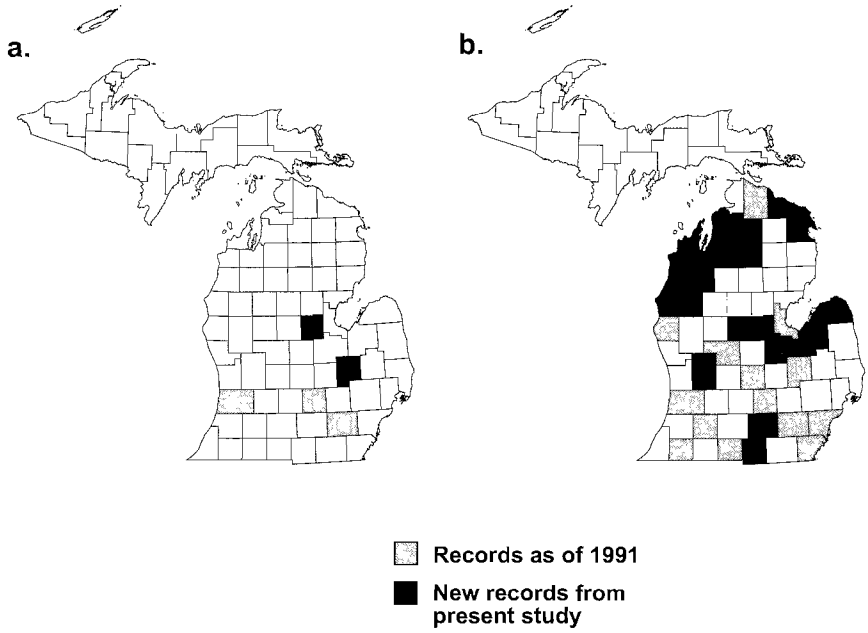

Figure 3. Michigan distribution of isopod species in the family Armadillidiidae: a) *Armadillidium nasatum* Budde-Lund and b) *Armadillidium vulgare* (Latreille).

Creek floodplain; upland deciduous woodlot areas; areas of irrigated, high maintenance turf; areas of non-irrigated, low maintenance turf; beds of ostrich ferns; beds of spreading junipers; beds of annual flowers; beds of dense, creeping or trailing ground cover of various species commonly used in landscaping; large beds of needle mulch under groups of many pine trees; smaller oblongs of needle mulch surrounded by turf under pairs of trees; small circles of needle mulch surrounded by turf under individual pine trees; shady beds with complex vegetation structure dominated by deciduous overstory trees and including shrub and weedy ground cover layers; and shady beds with complex vegetation structure dominated by coniferous overstory trees and including ericaceous and other shrubs with a weedy ground cover layer. This species was especially common under junipers and in various-sized beds of pine needle mulch, being encountered most times these types of habitats were examined. Very high density populations, on the other hand, were located in a particular bed of landscaping groundcover and in a bed of ferns. Also collected inside a greenhouse. **Otsego Co.,** Department of Natural Resources, Region 5 Headquarters, Gaylord, 08/08/01, under shrubs in dry landscape beds. **Presque Isle Co.,** T35N/R2E/S2, 07/28/01, grassy litter on banks of Rainy River. **Saginaw Co.,** Saginaw Country Club, T12N/R4E/S28, 08/27/01, in a flight trap (approx. 1 m tall) set for Japanese beetle adults baited with floral attractants and a pheromone lure. Also, T11N/R6E/S27, 09/10/01, under stones and logs and in leaf litter on the banks of the Cass River. **Tuscola Co.,** near Vanderbilt Park, T14N/R7E/S28, 08/08/01, edge of drainage ditch along an agricultural field. Also, T11N/R7E/S28, 09/25/01, in a pile of large woody debris on the banks of the Cass River. **Wexford Co.,** T23N/R12W/S11, 08/12/01, grass and sedge litter in very wet, organic soil near banks of Manistee River.

Family Cylisticidae

***Cylisticus convexus* (DeGeer).** (Fig. 4). **MICHIGAN** collection records: **Crawford Co.,** T28N/R4W/S35, 08/08/01, in very wet soil under grass and wood litter near the Au Sable River. **Hillsdale Co.,** T7S/R2W/S15, 11/04/01, in stones of an old building foundation; dry area. **Isabella Co.,** Preston and Washington Streets, Mount Pleasant, 07/24/01, in damp leaf litter and rotten logs in a small woodlot; very large numbers of this species were present at high density in the rotting logs. **Kent Co.,** Rockford, 10/19/01, small patch of trees including walnut and small box elders in an urban area next to a factory parking lot, with a small drainage ditch down a steep slope of 4-5 m; isopods were inside walnut shells, woody debris, leaf litter, under cinder blocks, and in miscellaneous trash items left at the site. **Midland Co.,** Dow Gardens, Midland, 07/21/97 – 07/30/97, taken in pitfall traps in several ecosystem types: seasonally flooded lowland deciduous woodlot areas in the Snake Creek floodplain; upland deciduous woodlot areas; beds of ostrich ferns; beds of spreading junipers; beds of annual flowers; beds of dense, creeping or trailing ground cover of various species commonly used in landscaping; large beds of needle mulch under groups of many pine trees; small circles of needle mulch surrounded by turf under individual pine trees; and shady beds with complex vegetation structure dominated by deciduous overstory trees and including shrub and weedy ground cover layers. They were particularly abundant in juniper beds.

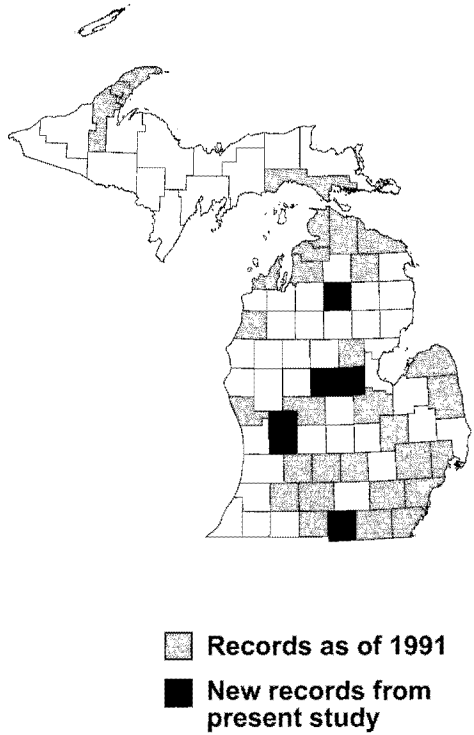

Figure 4. Michigan distribution of isopod species in the family Cylisticidae: *Cylisticus convexus* (DeGeer).

Family Porcellionidae

***Porcellio scaber* Latreille.** (Fig. 5a). **MICHIGAN** collection records: **Kent Co.,** Rockford, 10/19/01, small patch of trees including walnut and small box elders in an urban area next to a factory parking lot, with a small drainage ditch down a steep slope of 4-5 m; isopods were inside walnut shells, woody debris, leaf litter, under cinder blocks, and in miscellaneous trash items left at the site. **Mason Co.,** Ludington, 08/12/01, under shrubs in a dry landscape bed surrounded by cement at a gas station. **Midland Co.,** Dow Gardens, Midland, 07/21/97 – 07/28/97, taken in pitfall traps in large beds of needle mulch under groups of pine trees and in small circles of needle mulch surrounded by turf under individual pine trees. **Wayne Co.,** near Belleville, T3S/R8E/S21, 08/05/01, in a wood pile; in a compost heap; inside walnut shells.

***Porcellio spinicornis* Say.** (Fig. 5b). **MICHIGAN** collection records: **Alpena Co.,** Ella S. White Elementary School Nature Area, Alpena, 07/27/01, under wood and rocks; also in leaf litter under shrubs. **Huron Co.,** Sebewaing, T15N/R9E/S8, 08/18/01, in dry landscaping rocks around grave stones in city cemetery; very dry area; there was a very large population present at this site. **Isabella Co.,** Central Michigan University Botany Greenhouse, Mount Pleasant, 07/24/01, in leaf litter in dry landscape beds outside the greenhouse building. Also, Preston and Washington Streets, Mount Pleasant, 07/24/01, in damp leaf litter and rotten logs in a small woodlot. **Midland Co.,** Eastman Avenue, Midland, 07/20/01, in deep, damp leaf litter; in rotting hole filled with organic material in a tree trunk; and on brick walls in a very shady urban garden. **Tuscola Co.,** T11N/R7E/S28, 09/25/01, in a pile of large woody debris on the banks of the Cass River. **Wayne Co.,** near Belleville, T3S/R8E/S21, 11/22/01, in leaf litter under bricks.

No new county records have been found to date in this survey for *Porcellionides pruinosus* (Brandt) (also in family Porcellionidae) (Fig. 5c), *Trachelipus rathkei* (Brandt) (section Crinocheta, superfamily Porcellionoidea, family Trachelipidae) (Fig. 6), or *Ligidium elrodii* Packard (section Diplocheta, family Ligiidae) (Fig. 7).

DISCUSSION

Distribution and dispersal of isopods. The terrestrial isopod fauna is quite rich throughout much of the world. In their 1993 publication, Oliver and Meechan reported that there were approximately 900 species of terrestrial isopods known worldwide. More recently, number of terrestrial isopod species known worldwide has been placed at 4,000–5,000 (Kensley et al. 2002, Brusca 1997). It is thought that a large number of isopod species in the world are yet to be described. Greece alone, for example, hosts close to 200 known terrestrial species and is expected to yield numerous additional new species upon further exploration (Sfenthourakis and Giokas 1998).

By comparison, the North American fauna is rather depauperate in terms of known species. In Michigan, only 11 terrestrial isopod species were known as of 1990 (Snider 1991). Eleven additional species not previously reported from Michigan have been identified in the surrounding areas of Ohio, Indiana, Illinois, Wisconsin, or southern Ontario (Jass and Klausmeier 2001, 1996, 1990; Belaoussoff et al. 1998, Keeney 1990, Hobbs and Flynn 1981, Schultz 1976, Judd 1965, Vandel 1965, Muchmore 1964, Eberly 1953, Hatch 1947, Van Name 1940, 1936; Thompson 1932, Walker 1927, Richardson 1905). One of these species that was previously unknown in Michigan, *Haplophthalmus danicus*, was discovered in this survey to exist here as well, bringing the current state tally to 12 terrestrial isopod species.

Except for *Ligidium elrodii*, all of the terrestrial isopod species identified in Michigan to date are exotic organisms of European origin which have become

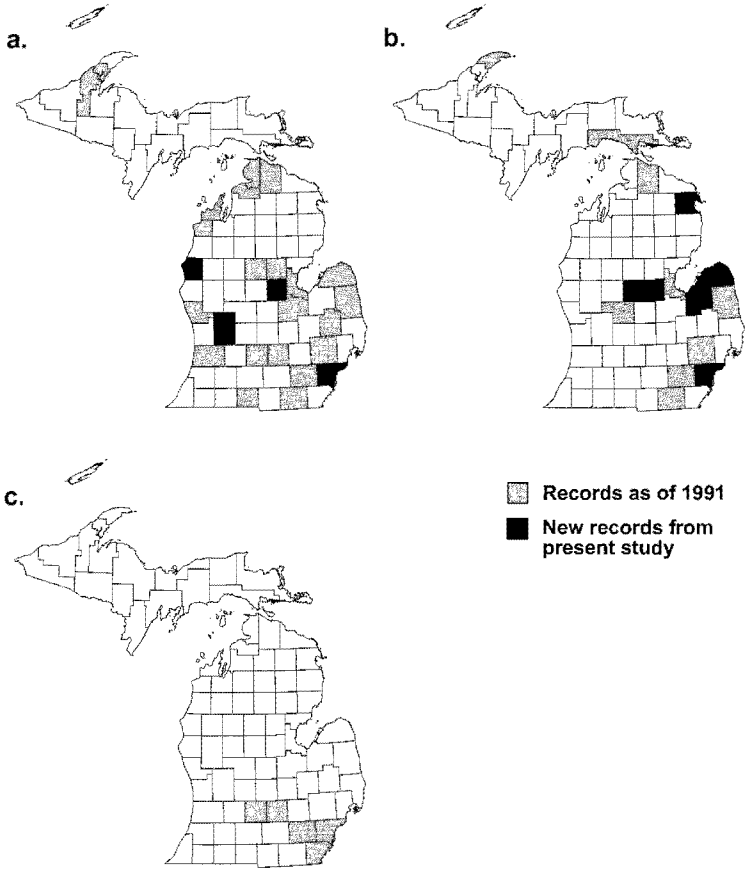

Figure 5. Michigan distribution of isopod species in the family Porcellionidae: a) *Porcellio scaber* Latreille, b) *Porcellio spinicornis* Say, and c) *Porcellionides pruinosus* (Brandt).

naturalized in North America (Jass and Klausmeier 2001, 2000; Muchmore 1990). Many of these species are reported to be rather synanthropic in their native locations (Oliver and Meechan 1993, Harding and Sutton 1985, Sutton 1972), and it is hypothesized that they were introduced to various places in North America and around the world with plants and other material moved by humans or in ballast soil that was off-loaded from ships (Sutton 1972). In North America, these isopods are still frequently found in synanthropic situations, but they have in many cases also spread very successfully into areas quite some distance from their probable places of introduction. Others have suggested that such spread may have been possible due to the availability of previously unfilled niches or to efficient resource use that aided the isopods in outcompeting native organisms with possibly similar ecology, such as some of the millipedes (Sutton 1972, Van Name 1936).

In the present study, isopods were frequently encountered in synanthropic locations such as near buildings and parking lots, in landscape beds and urban

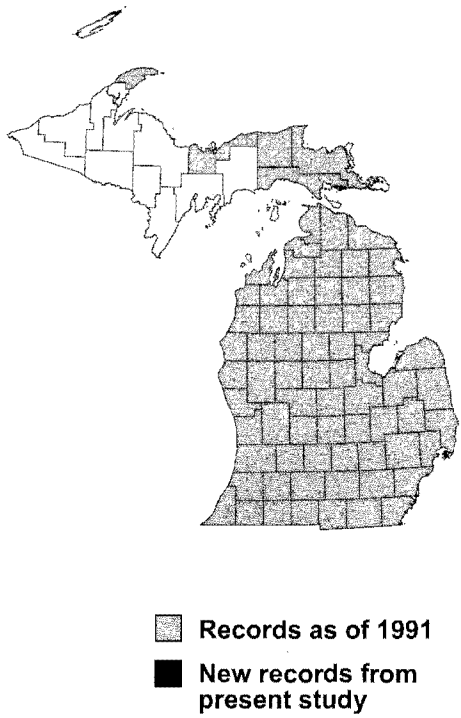

Figure 6. Michigan distribution of isopod species in the family Trachelipidae: *Trachelipus rathkei* (Brandt).

gardens, and in cemeteries, golf courses, nurseries, and parks. However, many other specimens were taken in areas with less obvious human influence—areas along waterways or in rural forests that had not been modified by human earth-moving, planting of landscape materials, or dumping. In more remote areas, as well as near settlement, isopods seemed to be found especially commonly on the banks or in the floodplains of waterways.

Bodies of water, whether flowing or still, are likely important as refuges for maintenance of populations during dry periods. Many small isopod species, in particular, desiccate very rapidly and perhaps can only persist in areas that regularly have rather high moisture content, such as in litter on beaches or banks (Jass and Klausmeier 1996, Oliver and Meechan 1993, Sutton 1972, Tack and Edgar 1966). In some locations, conditions are appropriate for populations of these isopods to spread out away from the waterside and live in forest litter or similar situations in surrounding areas. However, it is possible that the populations in woodland litter or other places may be strongly affected or even potentially die out if serious drought conditions occur for extended periods, as can happen during Michigan summers. Areas near bodies of water may then potentially serve as a source of re-colonizers when moister conditions return. For other species that can more easily move further afield, perpetually damp areas at watersides could serve as important places for nearby individuals to move toward during periods of extended drought.

Figure 7. Michigan distribution of isopod species in the family Ligiidae: *Ligidium elrodii* Packard.

Collecting methods used. This study made use of both pitfall trapping and hand sorting of litter to collect isopods in Michigan ecosystems. Pitfall trapping was used in the finer-scale, more intensive investigation that took place in Midland County, MI, while hand sorting was the method employed in the broader-scale investigation made throughout numerous Michigan counties. Pitfall traps have the advantage of operating constantly, often collecting large numbers of specimens with relatively little effort and allowing collection of species that are active at night but that may not be as easily hand-collected during the day. Hand sorting has some benefits over pitfall trapping, however, because pitfall traps measure the activity-density of organisms rather than simply species presence. That is, species that are very mobile are taken more readily in traps. Species that are less mobile or that carry out their activity and movement in cryptic areas such as inside of large, downed woody items or under the soil surface instead of moving across the forest floor will be taken only infrequently or not at all in the traps. Differences in agility among the species can also affect the usefulness of pitfall traps in their capture. For mobile isopod species, traps may collect large numbers of individuals, impacting the population in the area around the trap to a greater extent than is necessary for the goals of the study. Very small or highly agile species may be more able to avoid falling into traps when they are encountered because the trap lip represents a wide area for these small organisms, and they may have great ability to turn quickly from their path. An additional advantage of hand-sorting over pitfall trapping is that when isopods are collected live by hand, one can easily examine the pseudotracheae on the organisms, the presence and number of which are important characters for delineating certain groups. Presence or absence of white patches on the

exopodites of pleopods, indicating pseudotracheae, can not be readily determined after an isopod has been killed or preserved, however. Although each of these collecting methods has advantages and disadvantages, employing the different techniques in combination in this study allowed me to fit my methods to the goals set in the different study areas.

Species accounts. Since terrestrial isopods are very common organisms in many ecosystems, it is surprising that relatively little detailed information is available on habitat/microhabitat associations and ecology of the various species. A great deal of the information that is known comes from Europe, where these organisms have been more extensively studied. The findings of this Michigan survey support much of the information reported in other literature but also reveal some differences as compared to previously published findings.

Haplophthalmus danicus. *H. danicus*, previously unknown in Michigan, has been found in seven counties in the central and northern portions of the Lower Peninsula during the first portion of this survey. It was previously reported to be locally common in eastern North America north to Newfoundland in moist litter and decaying wood (Muchmore 1990). European sources indicate that this species is strongly associated with deciduous woodlands that have very humus-rich, free-draining soil, where *H. danicus* is found deep in the litter, in the upper layers of the soil, or under the bark of fallen trees (Oliver and Meechan 1993, Harding and Sutton 1985). It has also been reported in some synanthropic situations where there is damp, humus-rich soil (Harding and Sutton 1985). This Michigan survey likewise tended to find *H. danicus* in association with decaying woody litter in very damp soils, particularly near waterways. In some situations, the soils were quite wet and not particularly free-draining. *H. danicus* was never observed on or near the surface of the litter, but was generally on top of or in the first few centimeters of the soil underneath a considerable covering of litter. By far the majority of the situations where *H. danicus* was found involved litter of deciduous trees. One exception was its presence in landscape beds in Midland County that were planted with spreading junipers. However, despite the fact that a great deal of juniper needle litter was present in these beds, there was also a fair amount of deciduous leaf litter because the shrubs' architecture caused them to catch and hold masses of fallen leaves as they blew about in autumn. In general, beds of landscape junipers often hosted a high diversity and high density of many types of terrestrial isopods. *H. danicus*, however, although present under junipers, was not found at high densities in these settings, but rather as occasional specimens.

Hyloniscus riparius. This is another species that for some time was thought not to be present in Michigan. *H. riparius* remained unknown in the state until 1990, when one adult and two juveniles were collected in Ingham County (Snider 1991). The present survey has now located this species in 14 additional counties scattered throughout the Lower Peninsula, and I expect to find it in many more counties as this survey extends its reach throughout the state in the future. *H. riparius* was previously reported in several of the eastern states in the U. S. and has been found north to Newfoundland in moist litter and refuse (Muchmore 1990). Also reported from Wisconsin, this species is said to be associated with leaf litter near wooded streams and river bottoms (Jass and Klausmeier 1996). While many of the locations where *H. riparius* was taken in this survey are in excellent agreement with this, I also located this species in some places that seem less typical. In the intensive Midland County work, *H. riparius* was found in large beds of pine needle mulch under groups of pine trees and in smaller circles and oblongs of pine needle mulch around individual landscape conifers or pairs of conifers set into turf areas. It was also found in Midland County in beds with complex vegetation structure dominated by coniferous overstory trees and ericaceous shrubs and in a small wooded area in Wayne County with a conifer-dominated overstory and much needle litter. It is likely that the litter layer and at least the upper soil layer are somewhat acidic in areas where thick

beds of pine needle mulch have been maintained under conifer trees for many years. *H. riparius* was also found in Midland County in a few open, sunny areas of non-irrigated, low-maintenance turf, which seems to dry out severely and where the grasses go dormant in mid and late summer. In one case, it was taken in a sunny, dry bed of annual flowers that had no mulch of any type on the soil surface. Outside the boundary of the flower bed was turf. The flowers were grown from seed in sterile media in an on-site greenhouse prior to planting out, and it was highly unlikely that the isopod was introduced to the bed with this plant material. Less severe locations, but still places that seem somewhat atypical for the species based on previously published information, were the occurrences in upland deciduous woodlots located well above area waterways and numerous collections made in beds of juniper shrubs in two counties. Locating *H. riparius* in many of these settings was surprising because this species desiccates rather rapidly when removed from its habitation to the open; yet some of the locations where it was collected were environments that did not seem possible to describe as regularly moist. However, these collections are not likely a fluke, since *H. riparius* was taken in multiple patches of each of these ecosystem types, with the exception of the single capture in one annual flower bed. Possibly this species is transient in these areas, being present only during times when moisture conditions are suitable for it.

Trichoniscus pusillus. Another small, moisture-sensitive species reported to be widespread from eastern North America to Newfoundland is *T. pusillus* (Muchmore 1990). Previously known from only two counties in Michigan, this survey has located it in an additional 19 counties. So far, with the exception of a prior researcher's record of this species in Washtenaw County, its distribution appears to be more central and northern in the Lower Peninsula, in contrast to *H. riparius*, for which all but two locality records have occurred in southern and central counties of the Lower Peninsula. This seeming distribution difference may simply be an artifact of the survey being incomplete at this point. However, collections made in 13 counties in the northern half of the Lower Peninsula revealed the presence of *T. pusillus* but not *H. riparius*, while collections in five southern counties yielded *H. riparius* but no *T. pusillus*. In the central portion of the Lower Peninsula, both species were present in the collections of three counties, only *T. pusillus* was found in one county, and only *H. riparius* was found in four counties. Additional up-coming survey work will further examine this issue.

In the literature, *T. pusillus* has, on one hand, been reported to prefer wet areas, even waterlogged habitats, in deciduous woods (Muchmore 1990, Sutton 1972, Hatchett 1947). On the other hand, it has also been reported to have a very wide range of habitats, occurring in most situations including grassland, acid moorland, and synanthropic situations (Oliver and Meechan 1993, Muchmore 1990, Harding and Sutton 1985, Sutton 1972). Most of the locations where this species has been collected so far in the Michigan survey were quite wet, many times waterlogged, and usually along waterways occurring in deciduous woodland areas. This accords well with what has been reported for this species by workers in nearby Wisconsin (Jass and Klausmeier 1996). However, on several occasions it also has been found in wet coniferous litter along waterways, including litter from white pine, hemlock, and northern white cedar. It has additionally been found in conifer-dominated habitat patches that are considerably drier, including beds of landscape junipers, beds of pine needle mulch under large groups of pines or around pairs of landscape conifers, and beds with complex vegetation structure dominated by coniferous overstory trees and including ericaceous shrubs. *T. pusillus* also was collected in upland deciduous woodlots and once in an area of non-irrigated, low-maintenance turf that goes dormant in mid and late summer due to lack of moisture. These other collections indicate that *T. pusillus* may have a somewhat wider habitat range than was previously thought for Michigan (Hatchett 1947).

Oniscus asellus. *O. asellus* is another species whose Michigan distribution records have been expanded considerably during this survey. Previously known from only three counties in the state, it has been located in 11 additional counties scattered throughout the Lower Peninsula. Reported to be widely distributed in the northern United States and southern Canada (Muchmore 1990), *O. asellus* is frequently abundant around human habitations, both in Europe and North America (Muchmore 1990, Harding and Sutton 1985, Sutton 1972, Hatchett 1947). This species favors moist areas with rotting wood, occurring in almost any natural or synanthropic habitat where these two features are found, even in acidic conditions (Oliver and Meechan 1993, Harding and Sutton 1985, Sutton 1972). Jass and Klausmeier (1996) associated it especially with microhabitats under loose tree bark on dead wood. Catches of *O. asellus* in the present study were in locations that were in good agreement with the comments published by other workers. The most surprising factor for this species was that in the more intensive survey area in Midland County, *O. asellus* was taken only in areas of seasonally flooded lowland deciduous woodlot. Given that several other ecosystem types surveyed also would have contained moist, rotting wood, and given the fact that often catches of other species in the intensive survey area included more habitat breadth than was expected for them, it is surprising that *O. asellus* was so limited in its occurrence here.

Armadillidium nasatum. *A. nasatum* is a species that is reported to be locally common in North America (Muchmore 1990). Although it has been observed outdoors in relatively dry, sunny habitats in Wisconsin (Jass and Klausmeier 1996), no populations of this organism have previously been found established outdoors in Michigan (R. J. Snider, Dept. of Zoology, Michigan State University, East Lansing, MI, pers. comm. 2001; Hatchett 1947). Rather, all records of *A. nasatum* in this state are from glasshouses, a habitat where it is also frequently reported to exist in other localities (Oliver and Meechan 1993, Muchmore 1990, Harding and Sutton 1985). However, during the course of this study, I located clearly established populations of *A. nasatum* living outdoors in two counties near the central part of the Lower Peninsula. In Genesee County, this species was common under rocks at the edge of non-irrigated turf in a quite open, sunny, dry location near a golf course maintenance building. This habitat is in excellent agreement with information in the literature, which states that *A. nasatum* prefers rather dry areas and is frequently associated with stones or old quarries, particularly in calcareous conditions, as well as being found in disturbed, exposed grasslands and near human habitations (Jass and Klausmeier 1996, Oliver and Meechan 1993, Muchmore 1990, Harding and Sutton 1985, Sutton 1972). In Midland County, low numbers of this species were found in three different areas of irrigated, high-maintenance turf, in two locations in beds of dense ostrich ferns, in two beds of annual flowers with bare soil and no mulch, and in one instance in a shady bed with complex vegetation structure dominated by deciduous overstory trees. In addition to these several scattered occurrences of low population levels, a very high density *A. nasatum* population was found in a bed of landscape junipers at the side of a pond.

Armadillidium vulgare. Another Armadillidiid, *A. vulgare*, was frequently encountered during this study and is notable for the habitat breadth it displays in comparison to most other isopods. This species is reported by Muchmore (1990) to be more widespread than *A. nasatum* and found in a wide variety of habitats, but like *A. nasatum* it is often located in very dry areas and may be numerous in glasshouses. When Hatchett published his 1947 paper, *A. vulgare* was unknown anywhere north of Bay City, MI, in the central part of the Lower Peninsula, except for one collection in Cheboygan County. Hatchett felt that this Cheboygan County observation was an aberrant result due to the isopods likely being imported with landscaping materials that were brought into the site just shortly before he made his collection. Between 1947 and the present study, no additional county records were secured for *A. vulgare* in the

northern part of the Lower Peninsula. However, the present survey has established new locality records for *A. vulgare* in 14 counties in the northern half of the Lower Peninsula, in addition to adding five counties to the known distribution records for this species in the central portion of the Lower Peninsula and three more counties in the southern portion.

In the literature, *A. vulgare* is reported occurring in habitats that range from very dry to moist and was said rarely to be far from humans (Jass and Klausmeier 1996, Hatchett 1947). Ecosystems cited for it include coastal locations, sand dunes, grassland, stony areas, and areas with calcareous soil (Oliver and Meechan 1993, Harding and Sutton 1985, Sutton 1972). In Michigan, I likewise commonly found this species in sites at both ends of the moisture spectrum, as well as at many points between. It was very common to find *A. vulgare* in quite moist litter on banks and beaches, near watercourses in seasonally flooded lowland deciduous woodlots, and even in cattail swamps along rivers. However, I also encountered it numerous times in very dry ecosystems such as in between stones in an old building foundation located on a dry site, in very dry landscape beds of junipers surrounded by concrete in cities, in very dry areas of rocks around gravestones, and in areas of non-irrigated turf. In the intensive study carried out in Midland County, this species was especially common under junipers and in various-sized beds of pine needle mulch, being encountered most times these types of habitats were examined. However, the highest density populations were located in a particular bed of dense landscaping groundcover and in a bed of ferns.

Cylisticus convexus. *C. convexus* is another species that was found in a wide variety of conditions, although perhaps not quite as wide as *A. vulgare*. While some workers have stressed that this species has a greater preference for moisture (Jass and Klausmeier 1996, Hatchett 1947), others have noted that it may also be found in dry sites, sunny positions, disturbed areas, rocky areas, exposed sites with little vegetation, quarries, and old walls (Oliver and Meechan 1993, Harding and Sutton 1985, Sutton 1972). Most sources have additionally noted the strong association of this species with humans in synanthropic habitats. Although I did not as commonly encounter this isopod as some of the other species, I did find *C. convexus* in both wet and dry habitats. I was somewhat surprised that I did not locate this species more frequently. Muchmore (1990) noted that it is widespread in the northern half of the United States and southern Canada; Hatchett (1947) stressed that it is broadly distributed in Michigan with a spread second only to *T. rathkei*; Snider (1991) compiled existing records for this species in 30 of Michigan's 83 counties; and Jass and Klausmeier (1996) reported it as one of only three species known to be found in every county in Wisconsin. To date, this survey has added only five new counties to the distribution records for *C. convexus*. Perhaps future survey work will amend the lack of new records for this species in Michigan, and it will yet be proven to be in most counties of the state, as one might expect based upon the experience with this species in Wisconsin.

Porcellio scaber. *P. scaber* is another species reported to be widespread and very common in the United States and Canada (Muchmore 1990) but little encountered in new locations at this point in the Michigan survey. It is cited in others' work from diverse habitats, with some authors stressing a hygrophilous nature for the species (Hatchett 1947, Blake 1931), while others remark upon its adaptation to drier habitats, even sites that are compacted, detritus-poor, sandy, or acidic (Belaoussoff et al. 1998, Muchmore 1990, Sutton 1972). While common in both grasslands and woodlands, it is also said to be often found in synanthropic situations like many other isopod species (Jass and Klausmeier 1996, Oliver and Meechan 1993, Muchmore 1990, Harding and Sutton 1985). Hatchett (1947), however, disagreed with a strictly synanthropic nature for the species, stating that he had also located it in Michigan in forest areas with no habitations and at some distance from human activity. It appears to be somewhat unusual

in that, in addition to its typical ground-dwelling habit, it has been noted to frequent bark of living trees, being found to carry out its activity somewhat up the trunk above the ground (Oliver and Meechan 1993, Harding and Sutton 1985, Sutton 1972). In the current study, *P. scaber* was found only in urban settings or suburban garden settings. In the intensive investigation in Midland County, *P. scaber* was taken only in variously sized beds of pine needle mulch. It seems surprising that it was not encountered in any of the several other ecosystem types examined.

Porcellio spinicornis. *P. scaber*'s congener, *P. spinicornis*, is noted in the literature for strong association with crevices in calcareous rocky areas such as limestone, sandstone, and mortared walls, as well as a preference for dry sites and a synanthropic nature (Jass and Klausmeier 1996, Oliver and Meechan 1993, Harding and Sutton 1985, Sutton 1972, Hatchett 1947, Stoller 1902). Muchmore (1990) states that this species is widespread and common in the United States and Canada. Hatchett (1947) remarks that the Upper Peninsula of Michigan is nearly at the northern boundary of the species' range and that in most of the widely scattered Michigan counties where it had been located only a few specimens were found, these being from very limited areas in each county. Jass and Klausmeier (1996), however, report this species to be present in every county in Wisconsin. Previously known from nine counties scattered throughout Michigan, this survey has been able so far to add only six more counties to *P. spinicornis*' known distribution in the state. While some of these collections were from the expected types of locations, this species was also taken in damp leaf litter, inside rotting logs and woody debris, and in one case in a rotting hole in a tree trunk that was filled with organic matter. Only relatively few individuals were observed in these other settings, however. The single large aggregation seen of this species was in dry rocks around grave stones. On balance, *P. spinicornis* does seem at this point to perhaps not be as common as several of the other species in the state.

Ligidium elrodii, Porcellionides pruinosus, and Trachelipus rathkei. I found no new county records for three isopod species that are known to be present in Michigan. These species include *T. rathkei*, which at this point has the widest known distribution of any terrestrial isopod species in the state. This species is unknown only from most of the western two-thirds of the Upper Peninsula. The lack of new county records for *T. rathkei* in this study is due to the fact that the Upper Peninsula was not investigated during the first two years of work; rather, it is slated to be surveyed in the upcoming field seasons. *T. rathkei* was frequently observed in counties where it has already been recorded, however. Like *A. vulgare*, this species seems to occur over quite a wide range of conditions and habitats in Michigan. It was the most frequently encountered isopod during this survey work. The other two species for which no new locality records were determined are *L. elrodii* and *P. pruinosus*. Both of these species have been very seldom recorded in Michigan, with *L. elrodii* known only from a single county and *P. pruinosus* collected in only five counties of the state. In each case, the collections have occurred in counties in the southern quarter of the Lower Peninsula, an area not yet extensively explored by the present survey. Collections have likely not been extensive enough at this point to pick up these perhaps more rare and perhaps more southerly-distributed species.

Conclusion. Jass and Klausmeier (1996) described particular species associations, or groups of isopod species that may commonly be found together in Wisconsin. Such groups were less easy to delineate in this study. For instance, I found both *T. rathkei* and *A. vulgare* co-occurring at some time or another with each of the other species encountered in this study. Presence or absence of a species at a particular location is likely controlled by the general site characteristics and by the microsites available nested within that. Certain sites investigated supported several species. For instance, three sites each had

six different species present, while numerous other sites each had five species present. Species that are habitat-restricted in some way or that occupy habitats with more extreme conditions tend to be most limited in terms of their co-occurrence with other species since they are only associated with others who can handle the same types of habitat conditions. Unfortunately, much of the habitat information available at this time seems somewhat general and often repetitious across species. This is due either to many species being truly somewhat general in their habitat preferences, or to lack of adequately specific, detailed information for the various species. Further study is needed on associations of isopod species with particular microhabitat characteristics to allow us to better understand fine divisions in the way various species partition available habitats and to provide insight into their ecological interactions in these locations.

ACKNOWLEDGMENTS

Richard Snider (Dept. of Zoology, Michigan State University, East Lansing, MI) kindly consulted with me on numerous questions and provided species verifications on a number of my early samples including the first specimen taken of the state record species reported here; equally importantly, he enthusiastically encouraged me to pursue further work on isopods in this region. Joan Jass (Zoology Section, Milwaukee Public Museum, Milwaukee, WI) supplied a useful description for separating some of the "little guy" isopod species. Mark Obrien (Museum of Zoology, University of Michigan, Ann Arbor, MI) shared information on museum holdings with me. John Witter (School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI) willingly stopped numerous times at likely-looking sites when we were out doing field work for other projects. My assistant, Rebecca Dyer, patiently and carefully sorted much material from pitfall trap samples and waded through many bags of "schmuck" brought back from field collections. Numerous individuals involved in isopod research from around the world generously sent me copies of various keys, species lists, and journal reprints. Laboratory space and other background support for this project were supplied by the Dow Gardens, Midland, MI. Many useful comments for improving this manuscript were provided by Joan Jass, Barbara Klausmeier, John Witter, William Muchmore, and an anonymous reviewer.

LITERATURE CITED

Belaoussoff, S., D. S. Guenther, P. G. Kevan, S. Murphy, and C. Swanton. 1998. Do tillage regimes and crop types influence terrestrial isopod diversity? (with a practical key to identification of species in northeastern North America). Proc. Entomol. Soc. Ont. 129: 39-45.

Blake, C. H. 1931. Distribution of New England wood lice. Occ. Papers Boston Soc. Nat. Hist. 5: 349-355.

Bowman, T. E. and L. G. Abele. 1982. Classification of the recent Crustacea, pp. 1-27. *In*: L. G. Abele (ed.), The biology of Crustacea, vol. 1. Academic Press, London.

Brusca, R. 1997. Isopoda. *In:* D. Maddison (coord. and ed.), Tree of Life Web Proj. web site. http://tolweb.org/tree?group=Isopoda&contgroup=Peracarida

Coûteaux, M-M., M. Mousseau, M-L. Célérier, and P. Bottner. 1991. Increased atmospheric CO_2 and litter quality: decomposition of sweet chestnut leaf litter with animal food webs of different complexities. Oikos 61: 54-64.

Eberly, W. R. 1953. The terrestrial isopods (Oniscoidea) of Indiana. Proc. Indiana Acad. Sci. 63: 272-277.

Harding, P. T. and S. L. Sutton. 1985. Woodlice in Britain and Ireland: distribution and habitat. Instit. Terrestrial Ecol., Monks Wood Expt. Sta., Abbots Ripton, Huntingdon, U. K. 151 p.

Hassall, M. 1977. Consumption of leaf litter by the terrestrial isopod *Philoscia muscorum* in relation to food availability in a dune grassland ecosystem. Ecol. Bull. 25: 550-553.

Hassall, M. and S. L. Sutton. 1978. The role of isopods as decomposers in a dune grassland ecosystem. Sci. Proceed. Royal Dublin Soc., Srs. A 6: 235-245.

Hassall, M., J. G. Turner, and M. R. W. Rands. 1987. Effects of terrestrial isopods on the decomposition of woodland leaf litter. Oecologia 72: 597-604.

Hatch, M. H. 1947. The Chelifera and Isopoda of Washington and adjacent regions. Univ. Wash. Publ. Biol. 10: 159-235.

Hatchett, S. P. 1947. Biology of the Isopoda of Michigan. Ecol. Monogr. 17: 47-79.

Hobbs, H. H., III, and M. F. Flynn. 1981. The cave fauna of Ohio. Pholeos 1: 7-14.

Holdich, D. M., R. J. Lincoln, and J. P. Ellis. 1984. The biology of terrestrial isopods: terminology and classification. Symposia Zool. Soc. London 53: 1-6.

Jass, J. and B. Klausmeier. 1990. Terrestrial isopod (Crustacea, Isopoda) species recorded from the Great Lakes region. Great Lakes Entomol. 23: 165-169.

Jass, J. and B. Klausmeier. 1996. Terrestrial isopods (Isopoda: Oniscidea) of Wisconsin. Great Lakes Entomol. 29: 11-20.

Jass, J. and B. Klausmeier. 2000. Endemics and immigrants: North American terrestrial isopods (Isopoda, Oniscidea) north of Mexico. Crustaceana 73: 771-799.

Jass, J. and B. Klausmeier. 2001. Terrestrial isopod (Crustacea: Isopoda) atlas for Canada, Alaska, and the contiguous United States. Milwaukee Pub. Mus. Contrib. Biol. Geol. 95: 1-105.

Judd, W. W. 1965. Terrestrial sowbugs (Crustacea: Isopoda) in the vicinity of London, Ontario. Canad. Field-Naturalist 79: 197-202.

Keeney, G. D. 1990. Some exotic terrestrial isopods (Oniscoidea) from the Columbus Zoo Exploration Center, Powell, Ohio: two new state records. Ohio J. Sci. 90: 133-134.

Kensley, B., M. Schotte, and S. Schilling (compilers). 2002 (revision of 1998 edit.). World list of marine, freshwater and terrestrial isopod crustaceans. Smithsonian Natl. Mus. Nat. Hist., Dept. Syst. Biol., Invert. Zool. web site. http://www.nmnh.si.edu/iz/isopod/

Muchmore, W. B. 1964. New terrestrial isopods of the genus *Miktoniscus* from Eastern United States (Crustacea: Isopoda: Oniscoidea). Ohio J. Sci. 64: 51-57.

Muchmore, W. B. 1990. Terrestrial Isopoda, pp. 805-817. *In*: D. L. Dindal (ed.), Soil biology guide. Wiley, New York.

Oliver, P. G. and C. J. Meechan. 1993. Woodlice: Keys and notes for identification of the species. Field Studies Council, Shrewsbury, U. K.

Richardson, H. 1905. Monograph on the isopods of North America. Bull. U. S. Natl. Mus. 54: i-liii, 1-727.

Schultz, G. A. 1976. *Miktoniscus halophilus* Blake, *M. medcofi* (Van Name) and *M. morganensis* n. comb., reconsidered with notes on New World species of the genus (Crustacea, Isopoda, Trichoniscidae). Am. Midl. Nat. 95: 28-41.

Sfenthourakis, S. and S. Giokas. 1998. A biogeographical analysis of Greek Oniscidean endemism. Israel J. Zool. 44: 273-282.

Snider, R. J. 1991. The Michigan Isopoda fauna. Mich. Acad. 24: 195-200.

Stoller, J. H. 1902. Two new land isopods. 54 Rep. New York State Mus.: 208-213.

Sutton, S. 1972. Woodlice. Ginn and Co. Ltd., London, U. K.

Tack, S. L. and A. L. Edgar. 1966. Reactions of Michigan isopods to various conditions of moisture and light. Mich. Acad. Sci., Arts, and Letters 51: 97-107.

Thompson, R. W. 1932. Notes on control substances for sowbugs. Ann. Rept. Entomol. Soc. Ontario 62: 87-89.

Vandel, A. 1965. Les Trichoniscidae cavernicoles (Isopoda terrestria; Crustacea) de l'Amerique du Nord. Annales de Speleologie 20: 347-389.

Van Name, W. G. 1936. The American land and fresh-water isopod Crustacea. Bull. Am. Mus. Nat. Hist. 71: 1-535.

Van Name, W. G. 1940. Supplement to American isopod Crustacea. Bull. Am. Mus. Nat. Hist. 77: 109-142.

Van Wensem, J., H. A. Verhoef, and N. M. Van Straalen. 1993. Litter degradation stage as a prime factor for isopod interaction with mineralization processes. Soil Biol. Biochem. 25: 1175-1183.

Walker, E. M. 1927. The woodlice or Oniscoidea of Canada (Crustacea, Isopoda). Canad. Field-Naturalist 41: 174-179.

Zimmer, M. and W. Topp. 1998. Microorganisms and cellulose digestion in the gut of *Porcellio scaber* (Isopoda: Oniscidea). J. Chem. Ecol. 24: 1397-1408.

Zimmer, M. and W. Topp. 1999. Relationships between woodlice (Isopoda: Oniscidea) and microbial density and activity in the field. Biol. Fertil. Soils 30: 117-123.