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Chironomidae (Diptera) in Freshwater Coastal Rock Pools at Isle Royale, Michigan

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ABSTRACT

Chironomid pupal exuviae were collected from coastal rock pools at Isle Royale National Park, Michigan, from April to October in 2009 and 2010. Pools in bedrock depressions were separated into those higher on the shore, where desiccation is likely an important disturbance, and lower on the shore, where wave-wash from Lake Superior is likely a fundamental influence. The 102 species collected represent 42 genera in six subfamilies. The distribution and ecology of each species is summarized. Also included are remarks on species with significant range expansions, either with Palearctic or Nearctic disjunct ranges, or novel habitat use among species that are typically considered lotic but occur in splash zone pools at Isle Royale.

Key words: Lake Superior, Nearctic, aquatic ecology, pupal exuviae, arctic and alpine disjunct

INTRODUCTION

Species of Chironomidae are generally ubiquitous, abundant, and diverse components of aquatic ecosystems. Studies on aquatic invertebrate communities regularly report Chironomidae to the family or subfamily level due to identification challenges. This can mask important community dynamics and responses to environmental variables (Rosenberg, 1992). Generic-level identifications can be used to good effect and are often necessary, such as assessing subfossil midge assemblages (e.g., Quinlan et al., 2012). However, within a genus there may be wide species-level differences in habitat use or response to ecological variation. Several comprehensive keys allow efficient identification for Nearctic genera (e.g., Wiederholm, 1986; Ferrington et al., 2008). Species-level identification may be relatively easy when revisionary works include comprehensive keys to immatures, or may be either challenging or impossible in genera for which keys do not exist or do not conform to contemporary taxonomic standards.

Few chironomid studies offer comments and justifications for species lists, which may be based on life stages other than the adult male, or are not confirmed with reared specimens. Major range expansions for chironomids are commonly documented when previously understudied systems are investigated, such as the discovery of new genus records and significant range expansions from a benthic study in Lake Superior (Stroom et al., 2010). We report components of the chironomid community in freshwater coastal rock pools, including species not otherwise known from the Nearctic or Great Lakes region, or previously undetected in rock pool habitats.

MATERIALS AND METHODS

Isle Royale National Park (IRNP), Michigan, is a wilderness area consisting of an archipelago of one large (544 km²) island surrounded by hundreds of smaller islands in northwestern Lake

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Superior, with the nearest point to the mainland approximately 19 km. The volume, depth, and surface area of Lake Superior have a considerable buffering influence on local climate, with a cooling effect in summer and warming effect in winter. Study sites were located on exposed, south-facing bedrock shorelines made of basaltic and andesitic lava flows at the east end of the archipelago. Two shoreline zones were differentiated using a typically distinct line between abundant and colorful lichens upslope (the "lichen zone" where pool recharge includes upland inputs) and drab or no lichens downslope (the "splash zone" where wave wash also recharges pools and possibly has an important disturbance influence). Samples were collected from pools in both zones at 18 sites on or near Isle Royale: four on the main island, thirteen on surrounding islands, and one on nearby Passage Island (Figure 1).

Using techniques modified from Ferrington et al. (1991), surface-floating pupal exuviae were collected from pool surfaces approximately monthly from April to October, in 2009 and 2010. A tray was dipped into the pool to collect water and floating material, poured through a 250 µm sieve, and field-preserved in 80% ethanol. In 2009, samples at each site were separated by zone, with ten minutes of collection occurring in each zone. In 2010, samples were separated both by zone and pool permanence; ten minute collections occurred for ephemeral pools (likely to dry in drought conditions) in each zone, with an additional five minutes of collecting at each of two permanently established study pools that were likely to retain water regardless of rainfall patterns.

A total of 285 samples were collected. Exuviae were permanently slide mounted in euparal. Generic-level identifications used keys in Wiederholm (1986) and Ferrington et al. (2008). Species-level identifications were generally accomplished using keys listed in each species summary below, with the Palearctic key by Langton (1991) used if no other key existed. The species-level abbreviation "cf." (latin "confere") is used to indicate that specimens closely match both original species descriptions and known habitats well, but based on extreme range disjunction they may represent an undescribed Nearctic species. The abbreviation "nr." indicates specimens that key near a species but do not match any descriptions in the genus. Vouchers are deposited in the University of Minnesota Insect Collection, St. Paul (UMSP), Minnesota, USA.

RESULTS

Chironomidae collected at Isle Royale represented six subfamilies, 42 genera, and 102 species. Distribution descriptions focus on published Nearctic range. Sixty-two species are known from the western Great Lakes or Nearctic generally, and 19 species were not identifiable due to lack of descriptions of pupal exuviae. Ten species were determined as Palearctic, with no prior confirmation in the Nearctic; some of these may be undescribed, closely-related species, while others represent range expansions of described species. Seven species were known previously from arctic or alpine ranges that are disjunct from the area of Lake Superior, generally northern Canada, with two from western mountains in British Columbia and California. Four species had ranges that include Nearctic locations but IRNP appears to be a range expansion. In addition, at least 13 rheophilic species were collected from splash zone pools, which are all known regionally except *Cricotopus intersectus* with only one other Nearctic record from Manitoba. In the distribution descriptions, the name "Northwest Territories" includes the Canadian province of Nunavut since most sources do not distinguish the two. Standard state and provincial abbreviations used for distributions.

Subfamily Podonominae

***Parochlus kiefferi* (Garrett)**

Distribution — Only known *Parochlus* in Holarctic. Widely distributed, including Greenland, BC to QC and south to CA, NM, CO, and NY.

Ecology — Larvae grazers and collector-gatherers. Occupies small, fast-running, cold lotic systems and springs in a temperature range of 0.4 – 8.8 °C.

Remarks — One IRNP specimen from a lichen zone pool. Species likely cold-stenothermic.

Sources — Oliver et al.,1990; Lencioni et al., 2007; Andersen et al., 2013; Langton, 1991.

Subfamily Tanypodinae

***Ablabesmyia* (*Ablabesmyia*) *aspera* Roback**

Distribution — Widespread but generally northern, from BC to ON and south to CA and FL.

Ecology — Larvae obligate predators. Recorded in small to large lentic waters, including ditches and possibly caves. *Ablabesmyia* larvae usually in shallow, mud-bottomed, slow moving areas.

Remarks — IRNP specimens from lichen zone pools.

Sources — Roback, 1985; Saether, 2011.

***Ablabesmyia* (*Ablabesmyia*) *monilis* (L)**

Distribution — Species very widely distributed in the Nearctic, from arctic areas in AK and Canada, to the southwestern U.S. and across to the midwest and northeast. Has also been found in the Carolina's and FL.

Ecology — Larvae obligate predators and are usually in shallow, muddy-bottomed, slow moving areas of creeks, or in lakes. Species recorded in medium lentic and small-to-medium lotic systems, and in stagnant water. Also in littoral or upper profundal zone of oligotrophic lakes and periphyton substrates.

Remarks — IRNP specimens from both zones. According to genetic work by Stur and Ekrem, two species may be represented within *A. monilis*, including *A. americana* (Fittkau), but a revision is needed.

Sources — Roback, 1971; Roback, 1985; Hudson et al., 1990; Langton, 1991; Saether 2011.

***Ablabesmyia* (*Karelia*) *illinoensis* (Malloch)**

Distribution — Known from ON, MB and SK, south to most western, plains, and midwestern states; in the east it spans from MA to VA. Material has been noted from the southeast, from the Carolina's to FL, although Epler is skeptical it occurs in the southeast.

Ecology — Larvae obligate predators, and appear to occur in small lakes and ponds, maybe also marshes, with *Karelia* species usually in lentic water. Genus only rarely in cold, oligotrophic lakes.

Remarks — IRNP specimens generally from lichen zone pools, but occasionally found in splash zone.

Sources — Roback, 1971; Roback, 1985; Hudson et al., 1990; Epler, 2001; Saether, 2011.

***Conchapelopia* (*Conchapelopia*) *fasciata* Beck and Beck**

Distribution — From AB to ON and south to KS, Great Lakes states, and FL.

Ecology — Rivers and creeks, generally small to medium sized shallow streams, and often in places with organic waste. Noted in FL as a vernal species.

Remarks — IRNP specimens from splash zone pools.

Sources — Roback, 1981; Oliver et al., 1990; Beck and Beck, 1966; Simpson and Bode, 1980.

***Conchapelopia* (*Helopelopia*) *cornuticaudata* (Walley)**

Distribution — Wide distribution in eastern North America, from ON to QC and south to AL and FL.

Ecology — Creeks and rivers, generally medium sized streams. Genus commonly encountered in riffles of river systems, often in places with organic waste.

Remarks — IRNP specimens from splash zone pools.

Sources — Roback, 1971; Roback, 1981; Hudson et al., 1990; Andersen et al., 2013; Simpson and Bode, 1980.

***Procladius* (*Holotanypus*) *abetus* Roback**

Distribution — Only known locations are AB, ON, and PA.

Ecology — *Procladius* known as predators of zooplankton and small invertebrates, including chironomids. Genus often in muddy littoral and profundal standing water or calm flowing water, and

sometimes large, deep lakes.

Remarks — IRNP specimens from lichen zone pools. Based on known range, may be a northern species. Lichen zone pools fit general habitat type, but not previously reported from bedrock substrate.

Sources — Roback, 1971; Roback, 1980; Andersen et al., 2013.

***Procladius* (*Holotanypus*) nr. *culiciformis* (L)**

Distribution — Not applicable.

Ecology — See *P. abetus* for ecology of this genus.

Remarks — One IRNP specimen from a lichen zone pool. Did not match described species, but appeared to be *Holotanypus* and morphologically similar to *P. culiciformis.* Notable traits include thoracic horn that is linear, narrow, about 550 µm long, dark and without strong reticulation; anal lobe about 785 µm long with 38-40 spines per side; and medial spines on a short posterior expansion.

Sources — Roback, 1980.

***Thienemannimyia* (*Thienemannimyia*) *norena* (Roback)**

Distribution — Primarily an eastern Nearctic species, from ON to NH and NJ, but also known from KS and OR.

Ecology — Genus commonly encountered in rivers, often in places with organic waste, but also habitats including oligotrophic lakes. Species usually in medium sized shallow streams, but also known from rivers and one large lake.

Remarks — IRNP specimens from splash zone pools.

Sources — Roback, 1971; Roback, 1981; Andersen et al., 2013; Simpson and Bode, 1980.

***Zavrelimyia* cf. *melanura* (Meigen)**

Distribution — Not previously known in the Nearctic; has Western Palearctic range. Global distribution could not be determined from primary literature.

Ecology — Species generally found in northern and montane lakes, pools and streams, and *Zavrelimyia* species are cold stenothermic.

Remarks — IRNP specimens from lichen zone pools match descriptions of *Z. melanura*, although this may be an undescribed Nearctic species. Notable traits include plastron plate with long neck and clear rim, atrium over ½ of the thoracic horn width, segment eight with lateral shagreen that is medially constricted, pleura of segments 2-7 covering most or all of the lateral area, and total length about 5.2 mm.

Sources — Oliver et al., 1990; Langton, 1991; Andersen et al., 2013.

Subfamily Diamesinae

***Diamesa insignipes* Kieffer**

Distribution — WY, UT and PA.

Ecology — Species found in fast-flowing creeks in prairies, plateaus, and flat country generally, but also montane streams and lakes. *Diamesa* often in northern or alpine habitats and probably cold-stenothermic.

Remarks — IRNP specimens from splash zone pools. Hansen considered Nearctic and Palearctic males to be the same species, but many *Diamesa* not described as pupal exuviae.

Sources — Hansen, 1973; Oliver et al., 1990; Pagast, 1947; Langton, 1991; Saether and Andersen, 2013.

***Pagastia orthogonia* Oliver**

Distribution — Wide Nearctic distribution, from AK to ME and south to CA and GA.

Ecology — Diet probably includes predation of small invertebrates, including chironomids, and collector-gatherer of detritus and diatoms. Usually lotic, but also in lakes and springs.

Remarks — IRNP specimens from splash zone pools. In Makarchenko and Makarchenko specimens cannot be separated from *P. lanceolata*, but all clearly the Lake Superior variant described by Caldwell.

Sources — Hudson et al., 1990; Oliver et al., 1990; Caldwell, 2007; Makarchenko and Makarchenko, 2000.

***Potthastia gaedii* (Meigen)**

Distribution — Nearctic range includes PA, GA, and NC, with a general eastern U.S. distribution.

Ecology — Northern and montane lakes and streams, or restricted to streams in southern areas of Europe. *Potthastia* described for flowing water generally.

Remarks — IRNP specimens from splash zone pools. Possible that there is a Nearctic-Palearctic difference in species that are currently all labelled *P. gaedii*.

Sources — Hudson et al., 1990; Oliver et al., 1990; Langton, 1991; Andersen et al., 2013; Epler, 2001.

***Protanypus hamiltoni* Saether**

Distribution — BC and NT.

Ecology — Rivers and lakes from a broad range of depths from 3.5-117 m. *Protanypus* generally found in oligotrophic lakes.

Remarks — IRNP specimens from splash zone pools. MI represents a large Nearctic range expansion.

Sources — Saether, 1975a; Andersen et al., 2013.

***Protanypus ramosus* Saether**

Distribution — ON and MB.

Ecology — Deep water in large lakes like Lake Huron or in shallow waters of smaller lakes.

Remarks — IRNP specimens from splash zone pools. *P. hamiltoni* and *P. ramosus* thought to be geographically separated, but IRNP data suggest overlap in the Lake Superior region.

Sources — Saether, 1975a; Oliver et al., 1990.

***Pseudodiamesa* (*Pseudodiamesa*) *branickii* (Nowicki)**

Distribution — Wide Holarctic distribution. Rocky Mountains of BC and AB, also NM, PA, OR and Greenland.

Ecology — Cold running water in montane regions.

Remarks — IRNP specimens from splash zone pools. While specimens match *P. branickii*, pupal exuviae can be difficult to separate from *P. nivosa,* and *P. pertinax* exuviae not described.

Sources — Oliver, 1959; Oliver et al., 1990; Langton, 1991.

Subfamily Prodiamesinae

***Monodiamesa tuberculata* Saether**

Distribution — BC, NT and across the Canadian prairie provinces to the Great Lakes region.

Ecology — Sublittoral and profundal zones of oligotrophic lakes, in substrates of sand, silt, organic debris, and clay. At depths of 3-167 m in the Great Lakes and Lake Winnipeg. Appears to require cold water (<18°C) and may be sensitive to low dissolved oxygen.

Remarks — IRNP specimens from splash zone pools. Saether suggests this is a glacial relict because it occurs mostly in large, deep, oligotrophic lakes.

Sources — Saether, 1973; Oliver et al., 1990.

***Prodiamesa olivacea* (Meigen)**

Distribution — Holarctic, with a wide Nearctic range.

Ecology — Lakes, ponds, rivers and drains. Genus somewhat tolerant of pollution.

Remarks — One IRNP specimen from a splash zone pool. No source found for the other known Nearctic species, *P. cubita* (Garrett).

Sources — Oliver et al., 1990; Andersen et al., 2013; Langton, 1991; Wirth and Stone, 1956.

Subfamily Orthocladiinae

***Corynoneura arctica* Kieffer**

Distribution — NT and PA.

Ecology — Montane and northern pools and lakes.

Remarks — IRNP specimens emerged from both zones, though preference for the splash zone may occur.

Sources — Oliver et al., 1990; Langton, 1991.

Corynoneura doriceni Makarchenko and Makarchenko

Distribution — The only prior Nearctic material is from OH. Species initially known from Russian Far East.

Ecology — *Corynoneura* known from very broad habitat types. No habitat described for *C. doriceni.*

Remarks — IRNP specimens emerged from both zones.

Sources — Fu and Saether, 2012; Andersen et al., 2013.

Cricotopus (*Cricotopus*) cf. *albiforceps* (Kieffer)

Distribution — Not previously documented with certainty in the Nearctic. Listed from NC, but Epler notes some skepticism about this. Widely known in Europe.

Ecology — Lakes and slow flowing or stagnant water.

Remarks — IRNP specimens emerged from lichen zone pools. All exuviae fit *C. albiforceps* well, though Nearctic uncertainty suggests this may be an undescribed species.

Sources — Hudson et al., 1990; Epler, 2001; Hirvenoja, 1973; Langton, 1991.

Cricotopus (*Cricotopus*) *annulator* Goetghebuer

Distribution — Labrador to ON and south to CA, NM and the southwest generally, and the Carolinas.

Ecology — Flowing waters and sometimes northern lakes.

Remarks — IRNP specimens from splash zone pools.

Sources — Hirvenoja, 1973; Langton, 1991; Hudson et al., 1990; Epler, 2001; Oliver et al., 1990; LeSage and Harrison, 1980; Simpson and Bode, 1980.

Cricotopus (*Cricotopus*) *bicinctus* (Meigen)

Distribution — Across Canada from YT to Newfoundland and south to CA and the Gulf Coast states.

Ecology — Extremely common in lotic systems, yet adaptable to diverse habitats. Apparently tolerant to environmental stress, including oil wastes.

Remarks — IRNP specimens occupied both zones broadly, reconfirming it as a habitat generalist. Known to become abundant if pollution or toxic conditions exclude other species, *C. bicinctus* would be useful as an indicator of ecological health during oil spill remediation.

Sources — Oliver and Dillon, 1988; Hudson et al., 1990; Hirvenoja, 1973; LeSage and Harrison, 1980; Simpson and Bode, 1980.

Cricotopus (*Cricotopus*) *curtus* Hirvenoja

Distribution — SK, NY and PA.

Ecology — Running and stagnant water.

Remarks — IRNP specimens from the splash zone.

Sources — Oliver et al., 1990; Hirvenoja, 1973; Langton, 1991.

Cricotopus (*Cricotopus*) *cylindraceus* group, Sp. 1

Distribution — Not applicable.

Ecology — Other species in *cylindraceus* group occupy broad habitats, including slow flowing or standing water, shorelines of lakes and small water bodies.

Remarks — IRNP specimens from splash zone pools. Exuviae clearly match the group, but not any species description. Notable traits include lack of especially pale or darkened abdominal segments, and lack of strong accessory tubercles.

Sources — Hirvenoja, 1973; Andersen et al., 2013.

Cricotopus (*Cricotopus*) *fuscus* (Kieffer)

Distribution — ON, PA and Great Smoky Mountains National Park (NC and TN).

Ecology — Lakes, flowing water, springs, and

rarely in ponds.

Remarks — IRNP specimens emerged from opposite zones in different years.

Sources — Oliver et al., 1990; Epler, 2001; Hirvenoja, 1973.

Cricotopus (*Cricotopus*) cf. *magus* Hirvenoja

Distribution — Not recorded from the Nearctic.

Ecology — Lakeshores, rivers and northern streams.

Remarks — IRNP specimens from splash zone pools. *Cricotopus magus* is known in Finland, so possibly a closely related undescribed species. Notable traits include anal macrosetae of similar size, no pedes spurii B, no thoracic horns or frontal setae, and typically with darkened lateral conjunctives.

Sources — Hirvenoja, 1973; Langton, 1991.

Cricotopus (*Cricotopus*) *tremulus* (L)

Distribution — AB, QC and NS, south to OR, OH, GA and eastern and southeastern states generally.

Ecology — Flowing waters, especially with stones and in mosses. Can be tolerant of pollution from urban runoff.

Remarks — One IRNP specimen from the lichen zone.

Sources — Oliver et al., 1990; Hudson et al., 1990; Epler, 2001; Hirvenoja, 1973; Gresens et al., 2007.

Cricotopus (*Cricotopus*) *triannulatus* (Macquart)

Distribution — ON, NY and PA, south to MS and FL.

Ecology — Flowing waters, lakes, and brackish water. Can be tolerant of pollution from urban runoff.

Remarks — IRNP specimens from splash zone pools.

Sources — LeSage and Harrison, 1980; Hudson et al., 1990; Oliver et al., 1990; Hirvenoja, 1973; Gresens et al., 2007.

Cricotopus (*Cricotopus*) *tristis* Hirvenoja

Distribution — YT and NT where range was north of the treeline, but also known from PA.

Ecology — Small, slow-flowing, meandering streams and a lake above rapids.

Remarks — IRNP specimens emerged from splash zone pools.

Sources — Oliver and Dillon, 1988; Oliver et al., 1990; Hirvenoja, 1973.

Cricotopus (*Isocladius*) *intersectus* (Staeger)

Distribution — Widespread in Europe, but only one Nearctic citation from MB. Epler discussed larvae from the southeast that may or may not be this species.

Ecology — Large and medium rivers, sometimes in slow areas with high organic and mild toxic loading, eutrophic and large lakes, and a wide range of dissolved oxygen levels.

Remarks — IRNP specimens from splash zone pools. Specimens fit description and figures in Hirvenoja very well.

Sources — Oliver et al., 1990; Hirvenoja, 1973; Epler, 2001; Simpson and Bode, 1980.

Cricotopus (*Isocladius*) *sylvestris* (F)

Distribution — Wide Nearctic range, from AK to NT, Newfoundland and south to CA, NY, and broadly in the southeast including the Carolinas.

Ecology — Standing or slow flowing water, including low dissolved oxygen and on many substrates, but also rivers with moderate to fast flow. Utilizes widespread habitats south of treeline, but only permanent ponds in the arctic. Also found in marine coastal rock pools above high tide line.

Remarks — Very common at IRNP, clearly a habitat generalist with emergence from a wide range of pool types.

Sources — Oliver and Dillon, 1988; Hudson et al., 1990; Oliver et al., 1990; Colbo, 1996; Epler, 2001; Hirvenoja, 1973; Simpson and Bode, 1980; Simpson et al., 1983.

Eukiefferiella claripennis (Lundbeck)

Distribution — Greenland, BC, AB and NT south to NM, PA and the Carolinas.

Ecology — Northern streams and sometimes lakes. Eurythermic, rheobiontic and mossy areas of swift streams. Known from urban streams. The *claripennis* group probably prefers clean water, but not excluded from moderately polluted water if dissolved oxygen above 5 ppm.

Remarks — IRNP specimens from splash zone pools.

Sources — Hudson et al., 1990; Oliver et al., 1990; Langton, 1991; Lehmann, 1972; Simpson and Bode, 1980; Gresens et al., 2007.

Eukiefferiella coerulescens Kieffer

Distribution — Occurs in Europe and North Africa. Although Hudson et al. listed *coerulescens* for SC, others list Nearctic specimens only as part of the wider *coerulescens* group.

Ecology — Northern and montane lakes, and stones and moss in swift streams.

Remarks — IRNP specimens all from splash zone pools. All key well to *E. coerulescens* in Langton except small, thin, rounded thoracic horns present. Reiss found similar thoracic horns and Langton noted a "small thin-walled sac-like thoracic horn…present in all the examples I have seen since", suggesting this feature had previously been missed. Some Nearctic material may be misidentified and the cryptic thoracic horn should be looked for.

Sources — Lehmann, 1972; Roback, 1985; Bode, 1983; Hudson et al., 1990; Langton, 1991.

Heterotrissocladius changi Saether

Distribution — AB to NT and ON, south to the Great Lakes states and CO.

Ecology — Oligotrophic lakes in the lower littoral and upper profundal zones.

Remarks — IRNP specimens generally emerged from the splash zone.

Sources — Saether, 1975b; Oliver et al., 1990.

Heterotrissocladius oliveri Saether

Distribution — Greenland, NT to BC and ON, south to CA, NY and PA. Populations in large southern lakes, such as Lake Tahoe, Cayuga Lake, and the Great Lakes, occur as relicts.

Ecology. – Strongly cold-stenothermic and ultraoligotrophic.

Remarks — One IRNP specimen from a splash zone pool. Generally an arctic species, emerging through ice-cracks in summer.

Sources — Oliver et al., 1990; Saether, 1975b.

Heterotrissocladius Sp. A Saether

Distribution — Northwest ON and BC, possibly including Vancouver Island.

Ecology — Oligotrophic lakes, with larvae up to 46 m deep. Some species in this genus found in ponds and puddles.

Remarks — IRNP specimens from splash zone pools. The species remains undescribed because only pupae and larvae are known.

Sources — Saether, 1975b; Andersen et al., 2013.

Hydrosmittia ruttneri (Strenzke and Thienemann)

Distribution — AK, NT, YT and MI.

Ecology — Algal growth on stony substrates of northern and montane lakes and rivers.

Remarks — IRNP specimens from splash zone pools. MI populations may not be as disjunct as distribution records suggest, since the 2011 revision created this as a new genus.

Sources — Ferrington and Saether, 2011; Strenzke, 1950.

Hydrosmittia Sp. 1

Distribution — Not applicable.

Ecology — Genus typically in aquatic moss and algae, and often cold-stenothermic.

Remarks — IRNP specimens from splash zone pools. Specimens don't match either *Hydrosmittia* or *Pseudosmittia*, but are a mix that appears to represent an undescribed exuviae of a species in *Hydrosmittia* and possibly closest to *H. virgo* based

on conjunctive patch numbers. Notable features include a large, distinctive patch of thoracic spines above the wing sheath base, many paired tergite spines, posterior tergite spines often larger but not forming distinct banding.

Sources — Andersen et al., 2013; Strenzke, 1950; Ferrington and Saether, 2011.

Limnophyes carolinensis Saether

Distribution — ON, MN, SC and TN.

Ecology — Seeps and wet areas near flowing water.

Remarks — IRNP specimens almost exclusively from lichen zone pools. Wide variation within *Limnophyes*, but IRNP specimens have two distinct morphs and one may be an undescribed species that keys to *carolinensis*.

Sources — Saether, 1990.

Limnophyes minimus Saether

Distribution — Broad Nearctic range, from YT, NT and NS south to NE, SD, MI, TN and SC.

Ecology — Seeps, margins of streams, wet soils, and small rivers. Species is facultatively parthenogenetic.

Remarks — IRNP specimens from lichen zone pools. Specimens key to *minimus* but not all traits fit. Saether notes that *minimus* may represent multiple species.

Sources — Saether, 1990.

Limnophyes natalensis (Kieffer)

Distribution — MB, NS, SD and WI.

Ecology — Rivers, streams, seepages, and sphagnum.

Remarks — One IRNP specimen from the splash zone.

Sources — Saether, 1990; Langton, 1991.

Limnophyes pumilio (Holmgren)

Distribution — Greenland, NT, MB and AB. Generally a northern species, but additional locations include NC, GA and PA.

Ecology — Littoral zone of lakes.

Remarks — One IRNP specimen from the splash zone.

Sources — Saether, 1990; Langton, 1991; Cranston, 1979; Hudson et al., 1990; Oliver et al., 1990.

Limnophyes Sp. 1

Distribution — Not applicable.

Ecology — Genus utilizes broad range of habitat types.

Remarks — IRNP specimens from the lichen zone. Specimens do not key to or match any described *Limnophyes*. Notable traits include five weak (thread-like) and similarly-sized lateral setae on segment eight, and weak shagreen overall.

Sources — Andersen et al., 2013; Saether, 1990.

Metriocnemus ursinus (Holmgren)

Distribution — Greenland, NT, northern QC and PA.

Ecology — Genus has widely variable habitat associations, including coastal rock pools and small habitats like phytotelmata.

Remarks — IRNP specimens from lichen zone pools.

Sources — Oliver et al., 1990; Saether, 1989.

Nanocladius (*Nanocladius*) *speniplenus* Saether

Distribution. – SK, ON and NB, south to OH, AL, GA and FL.

Ecology — Apparantly rheophilous, possibly from creeks and streams.

Remarks — One IRNP specimen from the splash zone.

Sources — Saether, 1977; Hudson et al., 1990; Oliver et al., 1990.

Nanocladius (*Plecopteracoluthus*) cf. *branchiocolus* Saether

Distribution — SK, ON and NY.

Ecology — Generally subgenus phoretic or parasitic on other aquatic insects, so these may emerge from Lake Superior and utilize the abundant

stoneflies.

Remarks — IRNP specimens are from splash zone pools. Saether notes pupae as "easily distinguishable", yet he synonymized similar species that sometimes fit and sometimes contradict IRNP specimens, so determination of *N. branchicolus* is tentative.

Sources — Saether, 1977; Andersen et al., 2013.

Orthocladius (*Eudactylocladius*) *dubitatus* Johannsen

Distribution — From AK, BC, Newfoundland and ON, south to WA, CO, OH and FL.

Ecology — Wide variety of habitats, including marine coastal rock pools above high tide line.

Remarks — One of the most common species from IRNP samples, emerging broadly from both zones. A highly variable species, especially pupae.

Sources — Oliver et al., 1990; Colbo, 1996; Cranston, 1998.

Orthocladius (*Euorthocladius*) *rivicola* Kieffer

Distribution — Widely known from AK, Canada, Greenland and south across the U.S.

Ecology — Generally in lotic systems of various sizes and with wide temperature ranges.

Remarks — IRNP specimens from splash zone pools. Although *rivicola* is variable, IRNP specimens match description well except for presence of frontal warts.

Sources — Soponis, 1990; Hudson et al., 1990; Oliver et al., 1990.

Orthocladius (*Orthocladius*) *dorenus* (Roback)

Distribution — YT, NT, ON and NB, south to OR, CO, NM, MN, PA and the Carolinas.

Ecology — Rivers, creeks and Lake Superior from nearshore at the Gooseberry River.

Remarks — IRNP specimens from splash zone pools.

Sources — Soponis, 1977; Oliver et al., 1990; Roback, 1957.

Orthocladius (*Orthocladius*) *nigritus* Malloch

Distribution — AB, MB, SK, ON, western Great Lakes states and south to UT, VA and the Carolinas.

Ecology — Rivers, creeks and lakes.

Remarks — IRNP specimens from splash zone pools.

Sources — Soponis, 1977; Hudson et al., 1990; Oliver et al., 1990.

Orthocladius (*Orthocladius*) *obumbratus* Johannsen

Distribution — Broad Nearctic distribution south of the arctic.

Ecology — Larvae consume diatoms, detritus and filamentous algae. Generally in streams and creeks. Has been found to be tolerant of urban stormwater runoff, suggesting pollution tolerance.

Remarks — IRNP specimens from splash zone pools.

Sources — Soponis, 1977; Hudson et al., 1990; Simpson and Bode, 1980; Roback, 1957; Gresens et al., 2007.

Orthocladius (*Orthocladius*) *robacki* Soponis

Distribution — SK, PA, NY and NC.

Ecology — Creeks.

Remarks — IRNP specimens from splash zone pools.

Sources — Soponis, 1977; Hudson et al., 1990; Oliver et al., 1990.

Orthocladius (*Pogonocladius*) *consobrinus* Holmgren

Distribution — Greenland, NT, ON and PA.

Ecology — Lakes.

Remarks — One INRP specimen from the splash zone. Specimen fits the monotypic subgenus *Pogonocladius*, but not clearly *consobrinus*. Soponis suggested a review needed, but Saether believed subgenus had no other known species.

Sources — Oliver et al., 1990; Langton, 1991; Soponis, 1977; Saether, 2005.

***Orthocladius* (*Symposiocladius*) *annectens* Saether**

Distribution — NT, BC, ON, MN to NJ and south to MS and FL.

Ecology — Creeks.

Remarks — IRNP specimens from splash zone pools.

Sources — Saether, 2003; Saether, 2005.

***Paracladius alpicola* (Zetterstedt)**

Distribution — Noted as widespread in the Holarctic, but only three Nearctic places listed in Oliver et al.: NT, Labrador, and PA.

Ecology — Northern and montane lakes.

Remarks — One IRNP specimen from the splash zone.

Sources — Fu et al., 2010; Andersen et al., 2013; Oliver et al., 1990; Langton, 1991.

***Paracladius quadrinodosus* Hirvenoja**

Distribution — Holarctic, known in Nearctic from Greenland, AK, NT and PA.

Ecology — Northern lakes.

Remarks — IRNP specimens from splash zone pools.

Sources — Fu et al., 2010; Oliver et al., 1990; Langton, 1991.

***Parakiefferiella* nr. *fennica* Tuiskunen**

Distribution — Not applicable.

Ecology — *Parakiefferiella fennica* favors large oligotrophic northern lakes.

Remarks — IRNP specimens from the splash zone. Based on large abundance in one sample, species may wash in from Lake Superior. Keys to *P. fennica*, but differences from descriptions and at least one consistently distinct feature (circular patch of long spines on sternite two and anterior transverse row of spines on sternites 2-3) suggest it is a similar, undescribed Nearctic species.

Sources — Tuiskunen, 1986; Langton, 1991.

***Parakiefferiella nigra* Brundin**

Distribution — Recorded from an arctic-subarctic range in AK, NT and PA.

Ecology — Oligohumic, northern lakes.

Remarks — IRNP specimens from splash zone pools.

Sources — Tuiskunen, 1986; Oliver et al., 1990; Langton, 1991.

***Parakiefferiella* cf. *scandica* Brundin**

Distribution — Known previously only from Finland and Norway.

Ecology — Standing water, though sometimes lotic in mountain streams, can inhabit barren oligotrophic alpine lakes.

Remarks — IRNP specimens from splash zone pools. Ecological conditions and descriptions of *scandica* match IRNP specimens very well.

Sources — Tuiskunen, 1986; Langton, 1991.

***Parakiefferiella* cf. *smolandica* (Brundin)**

Distribution — Known only from Sweden and Finland.

Ecology — Clear oligotrophic lakes generally, but occasionally mesohumic lakes and brackish water.

Remarks — IRNP specimens from splash zone pools. As with *P. scandica*, ecological conditions and descriptions closely match *smolandica*.

Sources — Tuiskunen, 1986; Langton, 1991.

***Parakiefferiella* Sp. 1**

Distribution — Not applicable.

Ecology — Generally this genus is in lentic systems.

Remarks — One IRNP specimen from splash zone pools. Matches description of *P. pyrenaica* Moubayed, known from a single cold mountain stream in the western Pyrenees, France. IRNP specimen likely an undescribed species. Notable traits include rounded thoracic horn with few apical setae, short anal lobe projections, no pedes-spurii B, and complete and dense anterior point bands on tergites 2-4.

Sources — Andersen et al., 2013; Langton, 1991; Moubayed, 1991.

Parasmittia carinata (Strenzke)

Distribution — Species is somewhat uncertain in reported range. Originally described from Nova Scotia, also noted from PA and Great Smoky Mountains National Park in NC and TN.

Ecology — Humus-rich soil of meadows and forests.

Remarks — IRNP specimens from lichen zone pools, though based on ecology they likely occupied a vegetated hummock near a pool. Specimens match species description well.

Sources — Strenzke, 1950; Oliver et al., 1990; Epler, 2001; Andersen et al., 2013.

Psectrocladius (*Allopsectrocladius*) *pilosus* Roback

Distribution — Broad eastern U.S. range, from ME to FL, also known from SD.

Ecology — Known from meandering streams, likely acidic with bog influence, although genus in broad habitat types.

Remarks — IRNP specimens from lichen zone pools.

Sources — Roback, 1957; Epler, 2001; Oliver et al., 1990; Andersen et al., 2013.

Psectrocladius (*Allopsectrocladius*) Sp. 1

Distribution — Not applicable.

Ecology — Not applicable.

Remarks — IRNP specimens from lichen zone pools. Traits span different species descriptions, between *P. nigrus* and *P. flavus*. Some traits do not match any descriptions, so likely an undescribed species. Notable traits include thoracic horn 0.4-0.5 mm long, 90-97 anal taeniae per side, and posterior tergite spines that are lobed with rounded ends.

Sources — Roback, 1957; Langton, 1991.

Psectrocladius (*Psectrocladius*) *limbatellus* (Holmgren)

Distribution — Greenland, NT, Lake Winnipeg in MB, SD, and PA.

Ecology — Ditches, cattle troughs, ponds in southern areas, and lakes in northern areas.

Remarks — IRNP specimens overwhelmingly from lichen zone pools.

Sources — Oliver et al., 1990; Saether and Langton, 2011; Langton, 1991.

Psectrocladius (*Psectrocladius*) cf. *sensilipes*/*dubius* Saether and Langton

Distribution — Saether and Langton list the Lake Winnipeg area for *sensilipes*, and MB, ON and SC for *dubius*, reflecting the two subspecies' range.

Ecology — Both species known from shallow water bodies, including ditches and slow streams, while *P. dubius* also known from reservoirs.

Remarks — Very common species at IRNP, the large majority emerged from lichen zone pools, and specimens displayed a wide variety of intergrading traits spanning both species. Molecular work probably needed to separate species in this genus.

Sources — Saether and Langton, 2011.

Psectrocladius (*Psectrocladius*) *subsensilis* Saether and Langton

Distribution — ON and MB.

Ecology — An oligotrophic lake in Ontario, and Lake Winnipeg.

Remarks — IRNP specimens from lichen zone pools.

Sources — Saether and Langton, 2011.

Pseudorthocladius (*Pseudorthocladius*) *virgatus* group, Sp. 1

Distribution — Not applicable.

Ecology — Larvae in genus generally occur in moss, hygropetric areas, acidic streams and areas near springs.

Remarks — One IRNP specimen from a lichen zone pool. Specimen does not match any described exuviae, but pupae of many species

remain unknown. Appears to match "*virgatus* group", which is distinct enough that it may warrant subgeneric status. Notable traits include lack of oral spines on tergites, caudal spines present on all tergites and sternites except segment one (with longest spines on tergites two, seven, and eight), sternite three with a distinctive medial patch of elongate and thin spines, anal segments with three robust spines about 12-17 µm long, no anal macrosetae, and total length about 2 mm.

Sources — Andersen et al., 2013; Saether and Sublette, 1983.

***Pseudosmittia* Sp. 1**

Distribution — Not applicable.

Ecology — Generally genus is semiaquatic to semiterrestrial.

Remarks — One IRNP specimen from a lichen zone pool. Could not be determined to species, though possibly near *P. simplex*. Many undescribed pupae in this genus. Notable traits include weak shagreen on tergite one, dense and even shagreen on segments 2-9 with no observable conjunctive spinules, and genital sac without spinules.

Sources — Andersen et al., 2013; Ferrington and Saether, 2011.

***Smittia* Sp. 1**

Distribution — Not applicable.

Ecology — Most *Smittia* larvae in damp soil or decaying vegetation, though some species aquatic. Very few non-adult stages known.

Remarks — One IRNP specimen, but from an uncertain zone. Genus determination difficult for terrestrial chironomid genera. Species cannot be determined with exuviae. Notable traits include smoothly rounded anal lobes, no thoracic horns, tergites 2-8 densely covered in spinules of similar size (per segment) except for muscle marks, and no armament between segments.

Sources — Andersen et al., 2013; Ferrington et al., 2008; Langton, 1991; Ferrington and Saether, 2011.

***Synorthocladius semivirens* (Kieffer)**

Distribution — Widespread in Nearctic, including many southeastern U.S. states.

Ecology — Swiftly flowing water, in gelatinous tubes with sand grains incorporated. Northern and montane streams, lakes, and pools, and streams in southern localities.

Remarks — IRNP specimens from splash zone pools. This is the only described Nearctic *Synorthocladius* species, though an additional undescribed species has been suggested based on reared adults.

Sources — Oliver et al., 1990; Hudson et al., 1990; Simpson and Bode, 1980; Langton, 1991; Liu and Wang, 2005; Andersen et al., 2013.

***Thienemanniella lobapodema* Hestenes and Saether**

Distribution — ON, MB, OH, St. Lawrence River, Lake Erie and surroundings, and south to AL and FL.

Ecology — Typically streams, also rivers, and littoral zone of Lake Winnipeg.

Remarks — Two IRNP specimens from splash zone pools. Genus often abundant when present, suggesting rock pool habitat not ideal.

Sources — Hestenes and Saether, 2000; Epler, 2001.

Subfamily Chironominae

Note on *Chironomus* species: Specimen traits were compared in a spreadsheet, leading to the interpretations reported here. No comprehensive exuviae key exists and there is often much variation in species. Pinder and Reiss (1986) found that subgenera often cannot be separated, while Ashe (1983) noted that this genus is very confused taxonomically.

***Chironomus* (*Chironomus*) *aberratus* Keyl**

Distribution — Species not previously known from the Nearctic.

Ecology — Cold humus-rich montane pools.

Remarks — One IRNP specimen from a lichen

zone pool. Fits habitat and description in Langton in many important ways, though it is possible this is a Nearctic variant of *aberratus.*

Sources — Langton, 1991.

Chironomus (*Chironomus*) *anthracinus* Zetterstedt

Distribution — BC, AB, SK, CA and WI to MA.

Ecology — Moderately eutrophic lakes.

Remarks. – IRNP specimens from lichen zone pools.

Sources — Oliver et al., 1990; Langton, 1991.

Chironomus (*Chironomus*) Sp. 1

Distribution — Not applicable.

Ecology — Chironomus are grazers and filter feeders, usually in sediments of lentic systems, often constructing tubes in or on sediment.

Remarks — Common at IRNP, with most emergence from lichen zone pools. Variations of tergite shagreen within this determination may include more than one species. Traits variable, but include generally rugose thorax (except for an area along the dorsal seam), cephalic tubercles 125 µm long and conical with a subapical hair 60 µm long and in a "pit", segments 5-6 have notable small spines on paratergites, pleura of tergite four with numerous clear spines, shagreen on tergites 2-6 squarish with larger spines posteriorly, tergite eight with large oval patches, segment eight usually with one large spur and 1-4 accessory spurs (can vary on a single specimen), anal lobe with about 80+ taeniae per side (often in double-rows and hard to count), sternite shagreen on segment three laterally and bending sharply to meet anteromedially, and total length about 8-9.5 mm.

Sources — Andersen et al., 2013; Langton, 1991.

Chironomus (*Chironomus*) Sp. 2

Distribution — Not applicable.

Ecology — See *Chironomus* Sp. 1.

Remarks — IRNP specimens from lichen zone pools. This species may be near *C. holomelas* or *annularius*. Notable traits include segment two shagreen in longitudinal rows, segment three shagreen mostly confined to anterolateral corners (though sometimes has an anterior band or slight posterior extension), and general size of tergite shagreen larger and more dense than other collected species.

Sources — Langton, 1991.

Chironomus (*Chironomus*) Sp. 3

Distribution — Not applicable.

Ecology — See *Chironomus* Sp. 1.

Remarks — IRNP specimens from lichen zone pools. These specimens key near Palearctic *C. pseudothummi* or *holomelas*. Notable traits include very weak overall thoracic granulation (often virtually none) that barely reaches muscle marks, weak lateral shagreen on sternites 3-4 (almost absent in some specimens), large spines on pleura of segment four, dark-colored thorax and light abdomen, and frontal tubercles that appear "limp" with rounded lateral expansions on apotome.

Sources — Langton, 1991.

Chironomus (*Chironomus*) Sp. 4

Distribution — Not applicable.

Ecology — See *Chironomus* Sp. 1.

Remarks — One IRNP specimen from a lichen zone pool. Possibly *C. riparius* or similar species. Notable traits include large tracheal patch of thoracic horn (about 120 x 50 µm), strong granulation on thorax, strong uninterrupted posterior sternite shagreen on segment two, pleura of segment four with extensive and strong spinules, parasternite of segment two with strong shagreen, five lateral taeniae on segments 5-8 and four lateral taeniae on segments 3-4, and moderate total length (about 8 mm) for this genus.

Sources — Langton, 1991.

Chironomus (*Chironomus*) Sp. 5

Distribution — Not applicable.

Ecology — See *Chironomus* Sp. 1.

Remarks — IRNP specimens from lichen zone pools. Keys to near Palearctic *C. holomelas*, but is

not that species. Notable traits include distinctly narrow and cylindrical frontal tubercles and small spines on segment four pleurae.

Sources — Langton, 1991.

Chironomus (*Lobochironomus*) *dorsalis* Strenzke

Distribution — ON and PA.

Ecology — Ponds.

Remarks — One IRNP specimen from a splash zone pool. This name has historically complicated use, see Spies and Saether.

Sources — Oliver et al., 1990; Langton, 1991; Spies and Saether, 2004.

Chironomus (*Lobochironomus*) *montuosus* Ryser, Wulker, and Scholl

Distribution — Yosemite National Park in CA.

Ecology — Subgenus in higher altitude lakes and ponds (>1700 m) and arctic areas. Species known in small alpine lakes and ponds up to 2100 m.

Remarks — IRNP specimens from lichen zone pools. Matches Langton description well, and also generally with Ryser et al.

Sources — Ryser et al., 1985; Langton, 1991.

Dicrotendipes fumidus (Johannsen)

Distribution — Known throughout the U.S. and southern Canada.

Ecology — Larvae feed on algae, detritus, and associated microorganisms.

Remarks — IRNP specimens from both splash and lichen zone pools.

Sources — Epler, 1987; Epler, 1988; Oliver et al., 1990; Hudson et al., 1990.

Dicrotendipes modestus (Say)

Distribution — Widespread in the Nearctic, but not in the U.S. southwest.

Ecology — Larvae feed on algae, detritus, and associated microorganisms.

Remarks — IRNP specimens from lichen zone pools. *Dicrotendipes modestus* and *D. neomodestus* share considerable overlapping traits, but IRNP specimen measurements trend closest to *modestus* and one larval exuviae attached to a pupal exuviae also keys to *modestus*.

Sources — Epler, 1987; Oliver et al., 1990; Hudson et al., 1990.

Dicrotendipes nervosus (Staeger)

Distribution — Wide distribution, from AK, NT to NB, Greenland, and south to CA and FL.

Ecology — Larvae feed on algae, detritus, and associated microorganisms. Probably in littoral benthos, especially mud, also in reed stems or on algae covered rocks. Usually in slow currents in eutrophic conditions that may be polluted with sewage and low dissolved oxygen, and usually absent in pristine and swift flowing water.

Remarks — IRNP specimens from both lichen and splash zone pools.

Sources — Epler, 1987; Oliver et al., 1990; Hudson et al., 1990; Simpson and Bode, 1980.

Endochironomus nigricans (Johannsen)

Distribution — NT, BC to NS and NB, and south to CA and FL.

Ecology — Presumably eats algae and diatoms. Generally lentic, sometimes in shallow habitats with vegetation, or found on or in living and dead aquatic macrophyte leaves.

Remarks — One IRNP specimen from a lichen zone pool.

Sources — Grodhaus, 1987; Oliver et al., 1990; Hudson et al., 1990; Andersen et al., 2013.

Glyptotendipes (*Phytotendipes*) nr. *paripes* (Edwards)

Distribution — Not applicable.

Ecology — Generally *Glyptotendipes* species in detritus-rich sediment of standing water.

Remarks — IRNP specimens from lichen zone pools. Specimens key closest to *G. paripes*, but *G. barbipes* also similar. Does not match descriptions of either. Many common Nearctic species are not described as pupae.

Sources — Andersen et al., 2013; Langton, 1991; Contreras-Lichtenberg, 1999; Contreras-

Lichtenberg, 2001.

Micropsectra geminata Oliver and Dillon

Distribution — A few locations in ON, QC and OH.

Ecology — Spring runs and pools.

Remarks — IRNP specimens from lichen zone pools.

Sources — Oliver and Dillon, 1994.

Micropsectra logani (Johannsen)

Distribution — AK, YT, MT, CO, NM, UT, and PA.

Ecology — Varies based on locality, lakes and slow lotic systems, coldwater springs, and profundal areas of lakes.

Remarks — IRNP specimens from splash zone pools.

Sources — Oliver et al., 1990; Stur and Ekrem, 2006.

Micropsectra cf. *nana* (Meigen)

Distribution — Not known from Nearctic. Generally found in Central and Eastern Europe.

Ecology — Cold water habitats, including brooks, pools, small lakes, peat bogs in uplands and mountains.

Remarks — IRNP specimens from lichen zone pools. Specimens fit descriptions in Anderson et al., but cryptic variation occurs in genus and molecular data may be needed to identify these with certainty (A. Anderson, pers. comm., 17 Oct. 2013).

Sources — Gilka and Jazdzweska, 2010; Anderson et al., 2013.

Micropsectra nr. *sedna* Oliver

Distribution — Not applicable.

Ecology — Not applicable.

Remarks — One IRNP specimen from a splash zone pool. Due to the extremely restricted known range of *sedna* (Char Lake, Cornwallis Island, Northwest Territories; oligotrophic with very limited ice-free season) IRNP specimens likely a closely-related species. One key feature (two dorsal taeniae on anal lobe, instead of one in Oliver description) does not agree with reared specimens by Oliver.

Sources — Oliver, 1976; Michelutti et al., 2003.

Micropsectra subletteorum Anderson, Stur, and Ekrem

Distribution — Eastern North America, OH, MN, ON and MB.

Ecology — Small streams fed by groundwater, and other lotic and lentic habitats.

Remarks — IRNP specimens from splash zone pools.

Sources — Anderson et al., 2013.

Micropsectra xantha (Roback)

Distribution — Eastern North America, from QC to FL and west to AB, MN, and MS.

Ecology — Small, cold lotic systems.

Remarks — IRNP specimens from splash zone pools.

Sources — Anderson et al., 2013; Oliver et al., 1990.

Neozavrelia cf. *luteola* (Goetghebuer)

Distribution — Uncertain Nearctic distribution. Appears monotypic in the Nearctic. Recent *Neozavrelia* material from OH, NC and GA.

Ecology — Montane lakes.

Remarks — IRNP specimens from splash zone pools. Specimens fit *N. luteola*, but tergite armament appears distinctive (teardrop-shaped patches that taper anteriorly and with smaller points posteriorly), so may be an undescribed species.

Sources — Epler, 2001; Langton, 1991; Goetghebuer and Thienemann 1942.

Parachironomus Pe. 3 Langton

Distribution — Palearctic.

Ecology — Stagnant and slow-flowing water. Larvae cryptic, frequently live in association with aquatic snails (P. Langton, pers. comm., 31 Oct. 2013).

Remarks — One IRNP specimen from a splash zone pool. Specimen fits Pe. 3 traits in Langton well. Photos of exuviae confirmed by Langton (pers. comm., 31 Oct. 2013).

Sources — Langton, 1991.

***Paratanytarsus dimorphis* Reiss**

Distribution — Not known from the Nearctic. Described from Europe and Mongolia.

Ecology — Lakes.

Remarks — IRNP specimens from splash zone pools. Specimens key very well to *dimorphis* and match the variability described by Reiss.

Sources — Reiss, 1965; Reiss and Sawedal, 1981.

***Paratanytarsus laccophilus* (Edwards)**

Distribution — NC, PA and MB.

Ecology — Shallow water including ponds, pools, ditches, littoral zone of northern and montane lakes. Usually parthenogenetic.

Remarks — IRNP specimens generally from lichen zone pools, but some from splash zone.

Sources — Oliver et al., 1990; Epler, 2001; Langton, 1991; Reiss and Sawedal, 1981.

***Paratanytarsus natvigi* (Goetghebuer)**

Distribution — Northern Canada, Greenland and PA.

Ecology — Shallow freshwater ponds, lakes and brackish water.

Remarks — IRNP specimens from splash zone pools.

Sources — Reiss and Sawedal, 1981; Oliver et al., 1990; Langton, 1991.

***Polypedilum* Sp. 1**

Distribution — Not applicable.

Ecology — Not applicable.

Remarks — IRNP specimens from lichen zone pools. Specimens appear to be in the subgenus *Pentapedilum* (based on lack of frontal and cephalic tubercles, thoracic horn branching, segment eight spur, and lack of dorsal setae on anal lobe) and possibly near the *epleri/tritum* group, but subgenus and species cannot be determined with certainty using pupal exuviae morphology. Variation suggests more than one species may be represented.

Sources — Saether and Sundal, 1998; Maschwitz and Cook, 2000; Oyewo and Saether, 2008; Saether and Oyewo, 2008; Saether et al., 2010.

***Sergentia coracina* (Zetterstedt)**

Distribution — A northern species, from Greenland, NT, AB, SK, ON and south to OR, MT, MN, IN, OH and PA.

Ecology — Large lakes, often oligotrophic. Cold stenotherms probably typical of larvae in this genus.

Remarks — One IRNP specimen from a splash zone pool.

Sources — Townes, 1945; Oliver et al., 1990; Wulker et al., 1998; Andersen et al., 2013.

***Tanytarsus mendax* group Sp. 1**

Distribution — Not applicable.

Ecology — Larvae of this genus known to construct soft tubes on substrate.

Remarks — IRNP specimens from lichen zone pools. Specimens key to *mendax/wirthi* (based on tergite shagreen, lateral taeniae, and frontal setae length), but do not match any species descriptions. Does appear they are in the *mendax* group.

Sources — Ekrem et al., 2003; Andersen et al., 2013.

***Tanytarsus wirthi* Ekrem, Sublette, Sublette**

Distribution — Broad U.S. distribution, from ID to MN to NY and south to CA, TX, LA and FL.

Ecology — Broad habitat use, including dams, ponds, creeks, bayou, estuarine marshes, springs, rivers, bogs, and lakes.

Remarks — One IRNP specimen from a lichen zone pool.

Sources — Ekrem et al., 2003.

DISCUSSION

Sixty-two of the 102 species found at Isle Royale are known from the western Great Lakes region or the Nearctic generally. Nineteen species have not been described as pupal exuviae, although adult males may be described but not associated with exuviae. With statewide or regional accounts documenting approximately 500-600+ species (Bolton, 2012; Epler, 2001) and Nearctic richness estimated at up to 2000 total species (Ferrington, 2008), coastal pools at Isle Royale may contain 20% of regional species richness and at least 5% of Nearctic richness. Records from the University of Minnesota insect museum (UMSP) revealed between 300-400 chironomid species documented in Minnesota as of 2001. The UMSP diversity can be considered a minimum range since it is an estimate from a single collection, not a family-level review. In aquatic studies where chironomids are identified to species, up to 80-100 species typically occur, with over 100 species occasionally collected (Ferrington et al., 2008), suggesting that either many habitats are undersampled or that Isle Royale coastal pools have a relatively high diversity. In comparison, Bouchard and Ferrington (2011) enumerated 261 taxa from streams in southeastern Minnesota. Intensive and focused sampling for chironomids is likely to reveal a much greater richness in many aquatic habitats.

Historically, species descriptions and keys for chironomids have focused on morphological data, although variability within or across species can limit the utility of morphology-based keys. Recent inclusion of DNA barcoding has contributed to several generic revisions (e.g., Anderson et al., 2013; Silva and Wiedenbrug, 2014). For many chironomid genera, morphology is suitable for species-level determinations, although DNA analysis can both strengthen morphological keys or clear-up diverse, plastic, and difficult taxa where morphology was unreliable (Carew et al., 2011). Currently, DNA analyses in chironomid studies are taxonomically limited, so our study was reliant upon traditional keys, and except for the extremely challenging *Chironomus* genus these keys worked well for most of our specimens.

Of the ten species previously known from the Palearctic, two have tentative accounts from North America (*Cricotopus albiforceps* and *Neozavrelia luteola*), but most represent extreme range expansions (*Zavrelimyia melanura, Cricotopus magus, Parakiefferiella scandica, P. smolandica, Chironomus aberratus, Parachironomus* Pe. 3 Langton*, Micropsectra nana,* and *Paratanytarsus dimorphus*). These Palearctic disjuncts match published morphology and habitat descriptions very closely and many are likely Holarctic. Although molecular data may reveal cryptic diversity in these species, many aquatic studies identify chironomids only to family or subfamily level. It is therefore realistic that a great deal of Nearctic diversity has been collected but not identified.

A cold coastal climate at Isle Royale has undoubtedly persisted since the last glacial retreat and the formation of the Great Lakes. Broad occupancy of periglacial localities by cold-stenothermic species, followed by subsequent glacial retreat, creates a refuge-habitat mechanism for retention of these species in disjunct arctic and alpine habitats (Kubow et al., 2010). Seven Isle Royale species fit this description: *Protanypus hamiltoni, Cricotopus tristis, Paracladius alpicola, P. quadrinodosus, Parakiefferiella nigra, Chironomus montuosus* and *Paratanytarsus natvigi*. Outside of far northern localities, a number of these were otherwise only noted from Pennsylvania by Oliver et al. (1990). Disjuncts typical of alpine habitats are represented by *C. montuosus*, known in North America only from California, and *P. hamiltoni*, known from British Columbia and Northwest Territories. Non-disjunct species that appear to be glacial relicts in cold habitats include *Monodiamesa tuberculata* and *Heterotrissocladius oliveri* (Saether 1973).

Ranges that are difficult to interpret include *Corynoneura doriceni*, known from the Russian Far East and Ohio; *Cricotopus intersectus* found in Manitoba; *Eukiefferiella coerulescens* reported in South Carolina; and *Parasmittia carinata*, from Nova Scotia, Pennsylvania, and the Smoky Mountains. Isle Royale represents a broader range in the Nearctic for these species. As previously mentioned, the limited number of studies with species-level chironomid identifications probably

contribute to the lack of biogeographic knowledge regarding these species.

Use of pools by taxa typical of stream habitats was first noticed when Hydropsychidae (Trichoptera) larvae were observed in retreats of silk and pebbles wedged into bedrock cracks of the lowest splash zone pools. High dissolved oxygen and slow current of wave splash in pools closest to Lake Superior probably allows occupancy of species usually associated with lotic systems, particularly cold, low-order streams. These "habitat disjuncts" are well-represented in IRNP splash zone pools by at least 13 rheophilic species: *Parochlus kiefferi, Conchapelopia fasciata, C. cornuticaudata, Pseudodiamesa branickii, Cricotopus intersectus, Limnophyes natalensis, Nanocladius speniplenus, Orthocladius rivicola, O. dorenus, O. robacki, O. annectens, Micropsectra subletteorum,* and *M. xantha*.

Chironomidae identifications and access to primary literature can both be challenging and time consuming, which is probably why many studies report taxa only to the family or subfamily level. Results from the current study of rock pools, along with similarly intensive studies (e.g., Bouchard and Ferrington, 2011), indicate that most aquatic habitats are likely to have much greater chironomid species richness than expected. Similarly, a study in the Bahamas that was limited to a small, remote island and a narrow collection timeframe found 3x greater richness than was previously known from across the entire Bahamian archipelago and all but two species were new to the Bahamas (Anderson et al., 2014). Along with these studies, the current work provides insight into how pupal exuviae can be utilized to determine biodiversity and taxonomic breadth of chironomids in many aquatic habitats.

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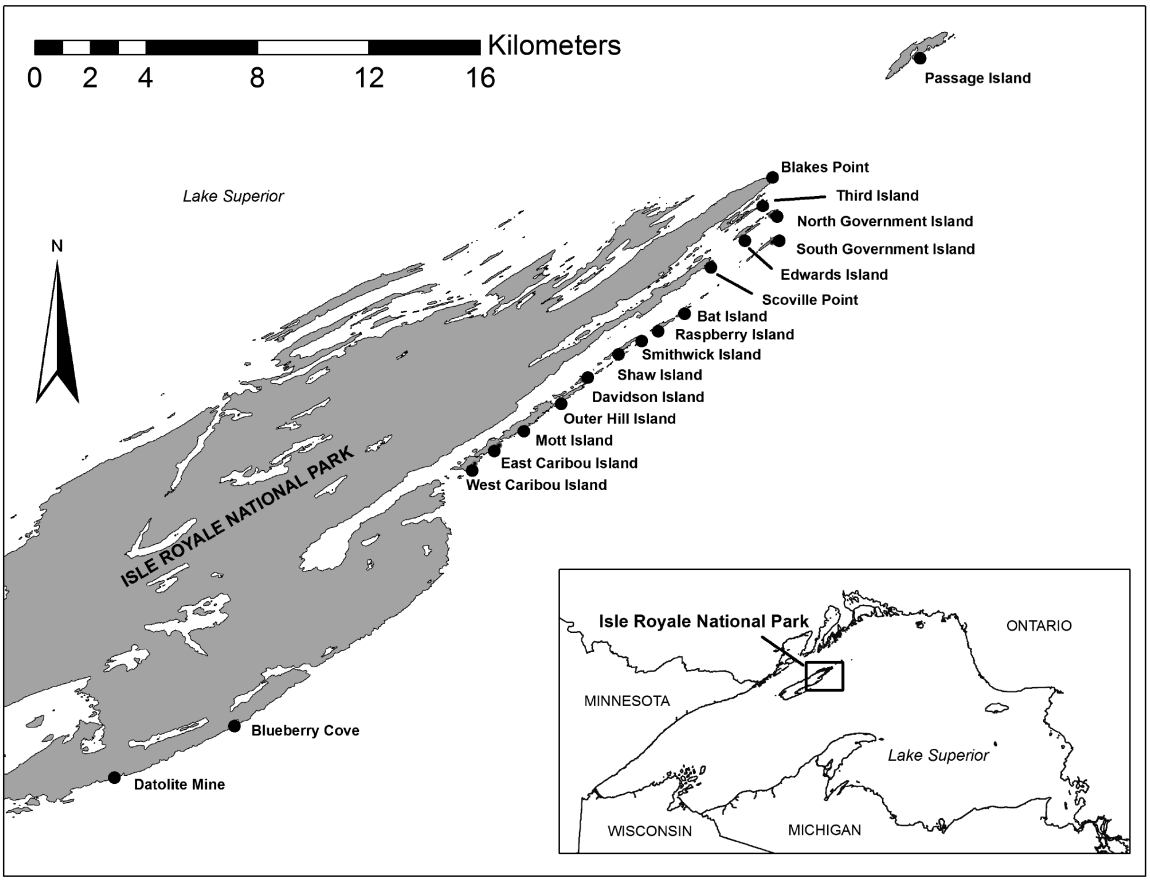

Figure 1. Northeast end of Isle Royale National Park, Michigan, regional context (insert) and locations of sample sites.