New Records of *Eretmoptera* from Washington State, USA: maritime or terrestrial midge?

Barbara Hayford[1], Rebecca Spring[2] and Andrew Fasbender[2]

[1]*Division of Biological Sciences, University of Montana, 32 Campus Dr, Missoula, Montana 59812, USA.*
[2]*Rhithron Associates, Inc., 33 Fort Missoula Rd, Missoula, MT 59804, USA*
E-mail: barbara.hayford@umt.edu, bhayford@gmail.com

Abstract

Washington State, USA has extensive coastal habitats that extend from marine or estuarine ecosystems upstream to the upper mixing zone where tidal surge and freshwater meet. We document a rare maritime chironomid genus, *Eretmoptera* Kellogg, 1900, from these habitats. The larvae of *Eretmoptera* were identified from 21 samples composed of 17 sites in the Puget Lowlands and Coast Range ecoregions based on a total of 1067 samples examined. Larvae were compared to reference material to confirm identification. We document *Eretmoptera* from low order forested streams in urban and private lands. Many sites sampled were near marine habitat and likely experienced saltwater intrusion while at least six sites were far from saltwater intrusion and were likely fully freshwater. We compare larval habitat for *Eretmoptera* in this study to larval habitat of the sub-Antarctic and Antarctic *E. murphyi* Schaeffer, 1914, the only species in the genus for which larvae have been associated. The georeferenced data provided in this study should spur further research to find and associate all life stages for *Eretmoptera* in Washington State to verify the genus identification and to help solve its taxonomic position within maritime and terrestrial Orthocladiinae.

Introduction

Washington State has extensive seashore, estuarine, and tidal surge habitat with 4870 km (3026 miles) of coastline (NOAA 2025). Our faunistic knowledge of benthic invertebrates inhabiting these systems is at best preliminary, with many taxa never thoroughly surveyed in the region. This is particularly true for insects in nearshore marine environments, estuaries, and tidally influenced rivers and streams. Gaps in this knowledge need to be filled, particularly as biodiversity in aquatic ecosystems is declining at a greater rate than terrestrial habitats due to extensive water use by agriculture and industry combined with increasing threats from invasive species and climate change (Strayer and Dudgeon 2010, Fabricius et al. 2014, Reid et al. 2019). Estuarine and nearshore invertebrate diversity is also declining (Worm et al. 2006), a particular problem for understudied invertebrates of these ecosystems such as maritime Chironomidae. Declines in biodiversity necessitate increased publication of georeferenced biodiversity data (e.g., Costello et al. 2013, Costello et al. 2018, Ball-Damerow et al. 2019) either in biodiversity centered research or as appendices related to ecosystem research. The purpose of this paper is to provide detailed range and ecological information for larvae of a rare maritime chironomid taxon, *Eretmoptera* Kellogg, 1900 found in Washington State.

Eretmoptera browni is the only described species of *Eretmoptera* in North America, the sole other described species being *E. murphyi* Schaeffer, 1914 from Antarctic and sub-Antarctic islands. Adults of *E. browni* are brachypterous (Kellogg 1900, Hashimoto 1976), collected in intertidal habitats in California (Kellogg 1900, Wirth 1949); no larvae or pupae have been associated with the adult of *E. browni* (Andersen et al. 2013). Larval descriptions for the genus are based on larvae of *E. murphyi* with the two species placed in the same genus solely based on adult female taxonomy (Andersen et al. 2013). Most recent publications on the genus center on *E. murphyi* as a terrestrial, parthenogenic Antarctic midge, particularly its role as an invasive species in the subantarctic Signy Island, from which the immature stages have been described (Cranston 1985, Convey 1992, Bartlett et al. 2019).

We have long-term, extensive chironomid data for Washington State generated via collaborations of Rhithron Associates, Inc. (RAI) with state, county, city, and non-profit agencies tasked with bioassessment of the state's aquatic resources. Washington's 4870 km of coastline extend from the upper estuary at the mouth of the Columbia River, around Cape Disappointment and north to Cape Flattery along the outer Pacific Coast, then inland along the

Strait of Juan de Fuca and the Salish Sea. Taxonomists at RAI identified *Eretmoptera* from Washington State. Our goals are to:

- Document new distribution records from Washington State of the genus *Eretmoptera* as currently recognized in Holarctic taxonomic keys,

- Provide a georeferenced database for the new chironomid records,

- Use the results to highlight issues in taxonomy and ecology of this rare and unique taxon in Washington State.

Methods

Chironomid specimens were identified from 1067 sites collected from nearly every part of Washington State, USA. Benthic samples were collected in Washington State from 2001-2024 by various organizations, including city, county, and state agencies. All Chironomidae were processed and identified by RAI taxonomists following state and federal protocols. Taxonomic data for this paper were used with permission from: the Cities of Bellevue, Bellingham, Bainbridge Island, Bothell, Federal Way, Issaquah, Kirkland, and Redmond; King County; Pierce County; Seattle Public Utilities; Snohomish County Public Utilities Division; Vashon Nature Center, LLC; and the Washington State Department of Ecology.

Larvae were identified based on a commonly used and widely respective key (Andersen et al. 2013). *Eretmoptera* larvae were identified based on the following combination of characters (Fig. 1): premandible with five teeth, simple SI and SII setae (Fig. 1a), five-segmented antenna (Fig. 1b), procerci and anal tubules absent from the posterior end of the abdomen (Fig. 1c), mentum with median tooth double and with five lateral teeth (Fig. 1d), mandible with four inner teeth (Fig. 1e). Due to the rare nature of the initial find and based on RAI policy, specimens were verified by an outside taxonomic expert (Peter Cranston). Voucher and reference specimens were retained for some projects at client discretion; these specimens are currently housed at RAI. RAI maintains a Microsoft Access database for all project data. Since RAI as a second party identified samples made by the first parties listed above, only latitudes and longitudes were available, thus we had no direct ecosystem data available for this study. Queries were

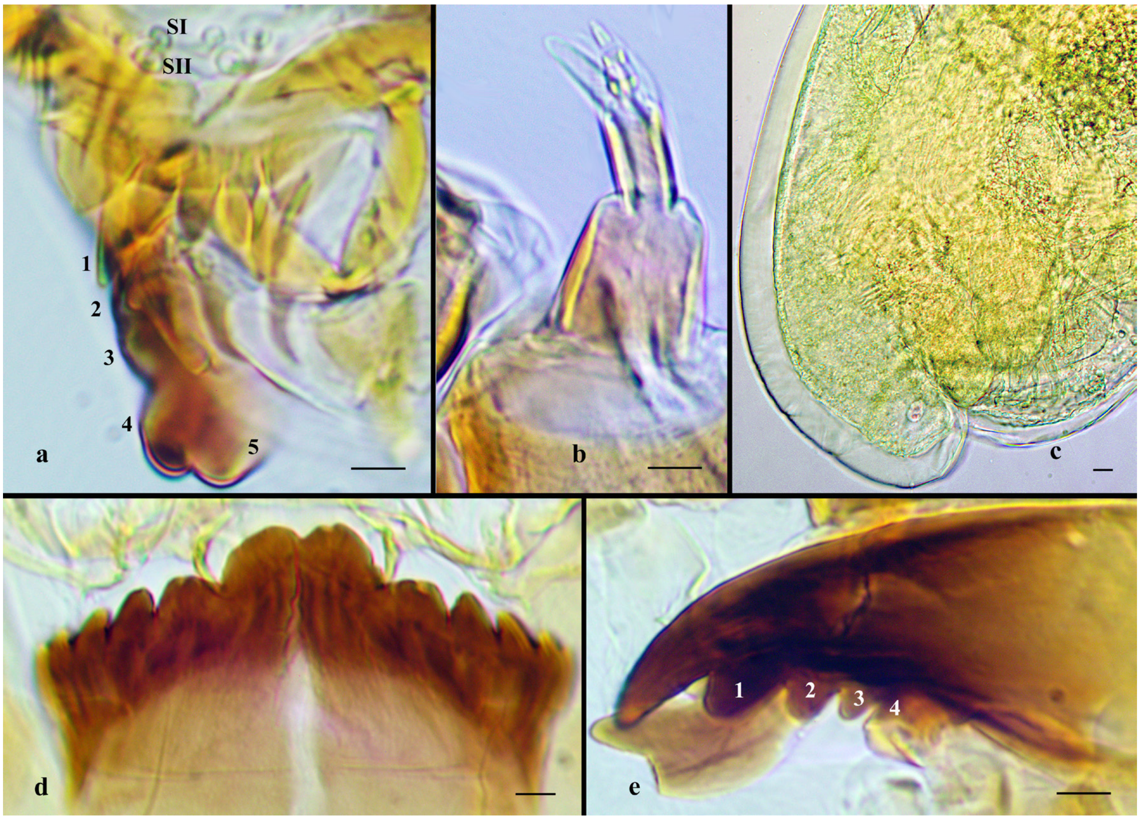

Figure 1. Photomicrograph showing larval head morphology of Eretmopetera from the reference collection at Rhithron Associates, Incorporated: a) premandible with teeth numbered 1-5, and SI and SII setae, b) antenna, c) posterior end of the abdomen, d) mentum, e) mandible with inner teeth numbered 1-4. Scale bar = 100 µm.

conducted to extract location data from records available for publication. Data were exported to Microsoft Excel to create a distribution map generated with SimpleMappr (Shorthouse 2010). We cross-checked latitude and longitude data for all sites retrieved from the RAI database with data for the same sites retrieved from the Washington State Environmental Information Management database (EIM 2021).

To test whether these data represented new records of *Eretmoptera,* literature was retrieved from electronic databases (Web of Science, Google Scholar, PubMed, Bibliography of the Chironomidae) via individual searches or searches through Publish or Perish (Harzing 2007). These databases were reviewed from project inception to the present covering publication dates from 1900 to July 2024 and using keywords such as *Eretmoptera*, *E. browni*, Chironomidae, chironomid, Washington State, Pacific Northwest, Columbia River, and the specific streams, wetlands, and lakes listed below. Distribution of *Eretmoptera* was compared to Nearctic and world catalogs of Chironomidae (Oliver et al. 1990, Oliver and Dillon 1994, Ashe and O'Conner 2012) and then to published literature listing Chironomidae to identify *Eretmoptera* as a new record for the State.

Additional information on larval environments, including estimates of stream width and distance from the marine habitat, was collected. Generalized land use and land cover (i.e. rural or urban, forested or not forested) and estimated size based on estimated stream width were retrieved from Google Earth Pro. Distance of collection sites to marine habitat or freshwater lake was estimated using high resolution aerial imagery from Google Earth Pro (version 7.3.6) and maps of river miles (CBI Data Basin 2025). Estimates of the extent of upstream tidal influence and upstream intrusion of saltwater for tributaries of the Salish Sea (denoted as river kilometer, rkm) were taken from Collins and Sheikh (2005) and Hall et al. (2018). Categories for the Columbia River estuary were taken from Hudson (2014).

Results

We retrieved 195 peer-reviewed research papers from the database searches related to macroinvertebrates in freshwater and estuarine ecosystems in Washington State. Of these, 122 papers contained taxonomic information related to macroinvertebrates, but few papers listed chironomid taxa. Paper publication dates ranged from 1969–2024. Published taxa were found in text or in tabular form within most papers and only one paper included a link to a taxonomic database for their study (Morley et al. 2020). Review of these publications confirmed that *Eretmoptera* represents a new record for Washington State.

Of the 1067 sites in Washington State for which chironomids were identified by RAI taxonomists, *Eretmoptera* larvae were identified from only 17 sites composed of 21 samples. Sites were located in the Puget Lowland and Coast Range level III ecoregions (USEPA 2013) (Fig. 2, Table 1). All Puget Lowland stream sites were small tributaries (~5 m or less in width) of rivers or flowed directly into the Salish Sea (Table 1). These sites flowed through urban, suburban, and exurban locations characterized by riparian forests. Four stream sites were proximal to the Salish Sea with three of these sites located on islands (Table 1). Streams that flowed directly into marine habitat or were tributaries of rivers that flowed into the Salish Sea were located within the estimated historic intrusion of saltwater and within or just above the estimated current intrusion of saltwater in tributaries of the Salish Sea (Table 1). Five of the Puget Lowland sample sites flowed into the freshwater Sammamish Lake (Table 1). Larval habitat was primarily urban forested corridors for all Puget Lowland stream sites (Table 1).

The six Coast Range stream sites were small tributaries (~5 m or less in width) of rivers that flowed into the upper estuary zone of the Columbia River and Willapa Bay (Table 1). These sites flowed through rural areas characterized by sparce to dense forests. One unnamed tributary of the Elochoman River was located above the Columbia River estuary (Table 1). Two stream sites in the Grays River watershed that flow into the Columbia River were at high elevation relative to sea level representing a steep gradient from the Coast Range

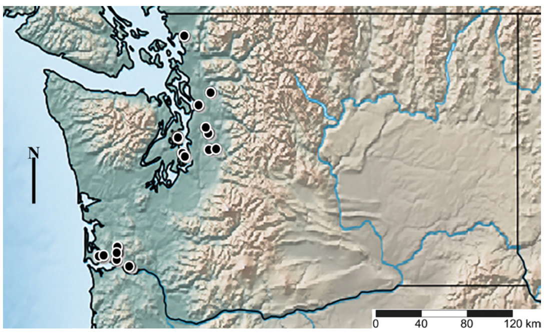

Figure 2. Distribution map of sample site locations where larvae of Eretmoptera were collected in Washington State, USA. Black circles denote sampling locations.

Table 1. Location and watersheds of sites from which *Eretmoptera* were identified and details on site proximity to marine ecosystems and saltwater intrusion.

Number samples/ site	Latitude	Longitude	Distance (rkm)*	Elev (m asl)	Watershed	Receiving aquatic habitat
1	46.4269	-123.5297	37.97	295	Grays R.	Columbia River[1]
1	46.3716	-123.5307	23.92	152	Grays R.	Columbia River[1]
2	46.2902	-123.5541	5.56	32	Harlows Cr.	Columbia River[1]
3	46.2205	-123.3366	8.16	36	Elochoman R.	Columbia River[2]
2	46.3313	-123.8173	27.52	52	Naselle R.	Willapa Bay
1	46.3326	-123.7752	24.58	65	Naselle R.	Willapa Bay
1	47.4763	-122.4815	0.45	10	Vashon Island	Salish Sea
1	47.4537	-122.4442	0.06	3	Vashon Island	Salish Sea
1	47.6653	-122.5679	0.03	10	Bainbridge Island	Salish Sea
1	48.7522	-122.4528	3.34	20	Whatcom Cr.	Salish Sea
1	48.0015	-122.2215	0.37	10	Snohomish R.	Salish Sea
1	48.1445	-122.0254	39.7	60	Stillaguamish R.	Salish Sea
1	47.5195	-122.0386	7.05	58	Issaquah Cr.	L. Sammamish
1	47.6955	-122.0561	11.55	158	Mackey Cr.	L. Sammamish
1	47.7580	-122.1063	15.72	91	Bear Cr.	L. Sammamish
1	47.5259	-121.9405	12.48	179	Issaquah Cr.	L. Sammamish
1	47.6955	-122.0561	8.88	158	Bear Cr.	L. Sammamish

* Indicates distance to receiving aquatic habitat in river kilometers (rkm) based on estimated historic saltwater intrusion upstream for Puget Lowland river (27 rkm, Collins & Sheikh 2005), current estimates (15.9 rkm, Hall et al. 2018). [1]Upper estuary of the Columbia River. [2]Above the upper estuary of the Columbia River. In general, L. = lake, R. = River, Cr. = Creek.

mountains to the Columbia River (Table 1). Larval habitat was primarily forested, located on private forestry lands and other private lands. Tidal influence on the Naselle River reaches nearly to the town of Naselle, 14.5 rkm upstream from Willapa Bay where the river exhibits a drastic decrease in size (Fig. 3). Stream sites in the Naselle River watershed were all low elevation (Table 1). We could not find salinity intrusion studies for the Willapa Bay rivers and so use the upstream estimates for the Salish Sea. Streams sites located in the Naselle River watershed were within the estimated historic intrusion of saltwater and within or just above the estimated current intrusion of saltwater in tributaries of the Salish Sea (Table 1).

Figure 3. Examples of stream sites for this study: a) Naselle River ~15 rkm upstream of the tidal surge plain; b) tidal surge plain for the Naselle River; c) an example of mossy banks typical of streams in Western Washington, USA.

Discussion

Our results highlight the need for publishing biodiversity data. The dearth of published studies that include taxonomic information for Chironomidae from Washington State does not indicate that *Eretmoptera* have not been collected prior to this study, but rather that Chironomidae are not identified or reported at a fine taxonomic resolution (e.g. genus or species). Studies on fish, amphibian, and shorebird diets typically refer to Chironomidae only at the family level (e.g. Wilson 1994, Tyler et al. 1998, Champion et al. 2018). Some research focusing on macroinvertebrates take many taxa to genus or species but leave Chironomidae at subfamily or tribe (e.g. Foster et al. 2020, Claeson et al. 2021). Food web analyses may not include taxa identified to finer resolutions (Wootton 2012). Finally, in some cases taxa were identified to the genus or species level, but only aggregated taxa, metrics, indices and/or functional traits are included in the publication without inclusion of taxa in the text or as supplemental material (Marshalonis & Larson 2018, Larson et al. 2019). In publications that do list chironomid genera and lower-level taxonomic resolution in Washington State (Gaines et al. 1992, Danehy et al. 2021, Morley et al. 2020), *Eretmoptera* was absent.

One of the goals of this study was to characterize larval habitat to examine whether *Eretmoptera* is truly a maritime midge, but our results warrant further investigation. All study sites were connected to marine ecosystems presently or in the past. For example, Lake Sammamish is part of the Lake Washington watershed and Lake Washington had anthropomorphic saltwater intrusions in the 1940s and 1950s (Edmondson 1994), though it seems unlikely that saltwater would have intruded as far upstream as the study sites in the Lake Sammamish watershed (Table 1). Other study streams may represent the upper intrusion of saltwater into freshwater tributaries of marine ecosystems, but the extent of saltwater intrusions used in our research were based on only one river tributary of the Salish Sea (Collins & Sheikh 2005, Hall et al. 2018). It is no coincidence that many study sites were located above the tidal zone since lower reaches or tidal streams were excluded from some of the studies for which chironomids were identified (e.g. Larson et al. 2019). It is possible that more *Eretmoptera* will be found along the tidal reaches of the study streams, if sampled, particularly since the genus was identified for projects that sampled small tidal streams (e.g. Bainbridge and Vashon Islands, Table 1). Salinity concentrations vary greatly in bays and estuaries, so predicting the percent salinity moving upriver proves challenging. Willapa Bay salinity patterns vary based on a suite of physical processes such as wind and wave intensity, currents, and river discharge (Banas et al. 2004, Banas and Hickey 2005). The Columbia River estuaries have even greater variation in salinity than Willapa Bay and the Salish Sea given the profound discharge volume of the lower Columbia River (Hudson 2014). Thus, even if saltwater characterizes some of the sites in this study, salinity varies seasonally based on flows and tides and salinity intrusion has changed significantly over time due to alterations such as diversions, diking, shipping canals, and impoundments (Edmondson 1994, Collins & Sheikh 2005, Hall et al. 2018).

These habitats are far different from the expected larval habitats of *Eretmoptera* based on previous studies of adults associated with California tidal pools (Kellogg 1900, Wirth 1949). Larvae of *E. murphyi* are terrestrial to semi-aquatic in the sub-Antarctic and Arctic regions (Cranston 1985, Convey 1992, Bartlett et al. 2019). Larvae of *E. murphyi* inhabit wet mosses and lichens, peat, soil, and leaf litter; egg-masses seem to be resistant to desiccation (Convey 1992, Bartlett et al. 2019, Bartlett et al. 2020). Possibly, larvae of *Eretmoptera* from Western Washington State inhabit wet moss and peat soils, common habitats along shady and forested streams (Fig. 3). Terrestrial and semi-aquatic larvae are often found in Washington stream samples, especially low order streams. Rather than indicating nearshore or tidal pool larval habitats the results of this study provide ecological evidence supporting phylogenetic analyses placing *Eretmoptera* and some other maritime midge genera in a group of Orthocladiinae "varia" *sensu* Tang *et al.* 2023. Several "maritime" genera group with semi-aquatic/terrestrial orthoclads instead of the marine *Clunio* Haliday and relatives (Cranston *et al.* 2011, Tang et al. 2023). If the *Eretmoptera* documented in this study are *E. browni*, then adults found associated with tidal pools in California may emerge from nearby terrestrial or semiterrestrial substrates such as mosses or lichen like *E. murphyi*, which may explain the lack of success locating larvae in tidal pool habitats.

Since *Eretmoptera* is monotypic for North America, it is tempting to determine the specimens in this study as *E. browni*. However, when it often becomes "known" that a particular genus is monotypic in a region, taxonomists may neglect to assess the species diversity of that group and overlook contradicting information, such as novel habitats or range extensions of preexisting taxa (i.e. *Parochlus kiefferi*, Hayford 2012) or subtle morphological characters. Assumptions of monotypy can change once taxonomists are able to analyze specimens in greater detail and from a range of sites (i.e. *Doncricotopus*, Namayandeh and Beresford 2021), but using presumed monotypy to ascribe a species epithet is particularly common when the specimens being identified lack the characters needed to assess their species level placement. In Chironomidae, most species descriptions are based on adult males, and for many species the immature stages are undescribed. Furthermore, research based on molecular analysis has shown that cryptic species may be found in one and sometimes multiple life stages of Chironomidae (i.e. Anderson et al. 2013). Lack of associated material for *E. browni* has hampered understanding of the taxonomy and systematic placement of the species and genus (Tang et al. 2023). As the immatures have yet to be described for *E. browni* and our material does not have associated adults, we believe it would be inappropriate to assign the Washington specimens to the described species as it is possible the California adults and our Washington larvae are not conspecific. Furthermore, given that the larval description for *Eretmoptera* in widely used Holarctic identification keys (i.e. Andersen et al. 2013) is based on specimens from the far southern reaches of the Southern Hemisphere, a more conclusive identification of specimens as *Eretmoptera* will require DNA analysis and further taxonomic work.

Several taxa in Chironomidae inhabit marine environments (Hashimoto 1976, Tang et al. 2022) and chironomids have been documented from marine and estuarine habitats in Washington State (e.g. Wootton et al 1996). Focusing on these habitats and ecoregions while working to improve our taxonomic understanding of Chironomidae will yield a wealth of biodiversity data for the Pacific Northwest region of North America. Furthermore, sampling that targets specific taxa vastly increases known biodiversity for a region (e.g. Borkent et al., 2018). Although limited, the distribution data in this study (Table 1) is shared to aid in future targeted surveys for adults and pupae of *Eretmoptera* with the goal of finding all three life stages so that the genus' taxonomic placement may be solved. With additional sampling, we hope to further explore whether Washington *Eretmoptera* are marine or terrestrial.

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Disclosure Statement

No potential conflict of interest was reported by the authors.

Author Contributions

BH, paper conceptualization, literature review and analysis, natural history and ecology comments; AF, taxonomic comments; RS, data retrieval, mapping; all authors contributed to writing the manuscript.

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