Chironomid (Diptera) species recorded from UK lakes as pupal exuviae

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Abstract

An inventory of chironomid species (Diptera, Chironomidae) data collected from 221 lake basins or reservoirs is detailed together with major physical and chemical characteristics of these waterbodies. Aquatic species of Chironomidae must rise to the water surface for adult emergence. Floating exuviae are transported by wind and water currents to lakeshores. Species data were obtained by collecting lake marginal floating pupal exuviae representing juvenile stages dwelling from across the lake. Among the 450 species found, several were new records for the British Isles.

Introduction

From 1998 the author has gathered chironomid species and environmental data from inland waterbodies across England, Wales and Scotland for the purpose of developing methods to assess ecological status for the water framework directive (WFD) (European Regulation, 1999). The chironomid pupal exuviae technique (CPET) (Wilson & Ruse, 2005) was used to obtain representative biotic samples from large waterbodies. CPET exploits the easy collection and identification of pupal exuviae (skins) discarded by emerging adults. Pupae of all aquatic chironomid species rise to the water surface for the adults to emerge (Langton, 1995). CPET proved to be a simple and effective sampling method for implementing WFD ecological assessment of lake anthropogenic nutrient impact (Ruse, 2010) and acidification (Ruse, 2011).

The Chironomidae are the most species-rich of aquatic macroinvertebrate families and provide an excellent surrogate for benthic invertebrates, representing all their major feeding modes (Berg, 1995). From Britain 615 chironomid species could be listed from pupal exuviae collections (Wilson & Ruse, 2005; Langton & Ruse, 2005a, 2005b, 2010a, 2010b) although 591 species can be identified using the adult key by Langton & Pinder (2007). In either case, this exceeds the combined number of species of non-dipteran aquatic macroinvertebrates found in the British Isles. Raunio *et al.* (2007) demonstrated that marginal CPET samples provided more profundal species than had profundal grab samples and was the only method found to detect land use impacts among mesohumic Finnish lakes. The collection of floating chironomid pupal exuviae at the leeward shore of standing water bodies provides a simple and safe means of obtaining abundant macroinvertebrate data representative of at least a large part of the lake. The sample is passively collected by wind and water currents, integrating adult chironomid emergence over the previous day or two (Coffmann, 1973; McGill, 1980). There are none of the difficulties associated with separating benthic invertebrates from silt and macrophytes (Moss *et al.,* 1996) or requirement for numerous stratified samples (Resh, 1979). Ferrington *et al.* (1991) has quantitatively demonstrated the efficiency and economy of CPET compared with direct sampling of larvae. The ease of obtaining representative lake chironomid species by collecting their floating exuviae was first suggested by Thienemann (1910) who began the trophic classification of lakes in Europe from that period. There is a European Standard guidance on sampling and processing chironomid pupal exuviae for ecological assessment (CEN, 2006).

Up to 203 of the lake surveys provided in this paper were used to calculate the sensitivity of chironomid species to anthropogenic nutrient enrichment and acidification (Ruse, 2010, 2011). The observed sensitivity score of a lake was compared with the lake's reference score modeled from impact-independent characteristics of that lake. A modified observed to reference ratio provided the ecological quality ratio (EQR) required by the WFD (Anonymous, 2003). The EQR was used to classify the ecological status of each lake as defined by the WFD (European Regulation, 1999, Annex V); boundaries were defined by the relative proportion of sensitive to tolerant species.

The research of most of these data and the development of two WFD methods for assessing lake ecological status have already been published (Ruse, 2010, 2011) so it is the purpose of this publication to provide the raw data as a resource for others to investigate further and to compare with, and augment, their own data. Ultimately, the objective is to further improve our understanding of lake ecology and measurement of lake functioning.

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Materials and methods

Floating debris containing chironomid pupal skins was collected at the lake shore, to which the wind blew, using a 250 μm mesh net attached to an extendable lightweight pole. The netted sample was passed through a 4 mm and a 250 μm mesh sieve, and then the residue of the coarse sieve was refloated and passed again through the sieve stack before repeating at least once more. Finally, the residue on the fine sieve was preserved in a small pot by adding 100% denatured ethanol. In the laboratory, the residue was resuspended in water, stirred and small aliquots removed. A subsample was placed in a Petri dish and all chironomid pupal skins removed while viewed through a low-power (x60–300) microscope. Approximately 200 skins were subsampled randomly from each collection. This provided an unbiased, representative subsample of the whole collection (Wilson & McGill, 1979; Ruse, 1993). Occasionally it would be necessary to sort the entire sample to obtain sufficient skins. Exuviae were mounted temporarily in 70% alcohol, or permanently in Euparal, on a microscope slide and identified to species (Langton & Visser, 2003) under high magnification (x400). Each survey comprised four CPET samples from different months between April and October. This strategy yielded 80-90% of the species obtained when sampling every month (Ruse, 2002, 2006) comparable with the 91-100% found by Rufer & Ferrington (2008) taking four CPET samples.

Chironomid data from 243 lake surveys (221 different lakes or basins; Figure 1) reported here were collected from 1998 to 2012 apart from three of these lakes, which were also surveyed during the 1980's (Shearwater, Blagdon and Chew Valley). Six lakes near Maidenhead that were surveyed twice, in 2000 and 2001, were temporary gravel lakes created during the construction of a flood-relief anabranch of the River Thames (Ruse, 2012). All the existing waterbodies surveyed have a unique waterbody identification number (WBID) within the UK lakes database (http://www.uklakes.net). Lake surface area and catchment area, if not already reported, were measured from 1:25,000 or larger scale maps using a planimeter. Catchment area excluded lake surface area. Mean depth was calculated from lake volume/surface area. Mean retention time (days) was calculated from:

$$[\text{volume } (10^6\,\text{m}^3)/\text{catchment area } (\text{km}^2)]\times [365/\text{net precipitation } (\text{m yr}^{-1})]$$

Net precipitation is mean annual rainfall – mean annual evaporation.

The age of artificial lakes at the end of a survey was normally obtained from the managing authorities while natural lakes formed at the end of the last glacial period were given a default value of 9999 years. Kenfig Pool, Little Sea, Slapton Ley and Loe Pool have formed more recently through land/sea interactions. Conductivity and pH were metered and supplemented by data from relevant regulatory agencies or water companies who also provided alkalinity and nutrient data. Other sources are acknowledged in Ruse (2002). For each lake survey, chemical data were averages of measurements taken over a minimum period of one year up to the date of the last CPET sample. For the following tables, lakes have been ordered in terms of their mean conductivity, from lowest to highest. In a canonical correspondence analysis, conductivity was the most influential supplied variable explaining chironomid species compositional turnover across the lake data set. For this dataset it was the best available surrogate for geological change across the Britain.

Chironomid pupal exuviae were identified using the CD-ROM key of Langton & Visser (2003) and followed its nomenclature unless subsequently changed and recorded in Fauna Europaea (version 2.6., 2013; http://www.faunaeur.org). The CD-ROM version of the key is currently being replaced by an online *Next Generation* version (http://www.eti.uva.nl). Chironomid data for each survey were amalgamated and species abundance recorded as a percentage of the total number of skins collected. Species were ordered according to their tribe and subfamily.

Results

Species

Supplementary Table 1 records the relative percentages of species found in each of the 243 surveys of lakes and reservoirs. The total count of individual exuviae identified from each survey is recorded at the bottom of each table. Waterbodies have been ordered from lowest to highest mean conductivity. Species author names may be abbreviated after first use. In the nomenclature of Langton & Visser (2003) pupal species without an associated adult are given a *Pe* number. At that time they considered *Microtendipes chloris* (Meigen) and *M. pedellus* (De Geer) as the same species. Only after many of these surveys had been completed was it possible to distinguish two species and therefore the practice of continuing to name all of them as *M. chloris* was retained. On the contrary, *Tanytarsus lestagei* Goetghebuer and *T. palmeni* Lindeberg are identified separately in Langton & Visser (2003) but have since been synonymized.

Environmental data

Compilation of environmental characteristics of each waterbody has been explained under methods. The recorded year is that of the final CPET sample in a survey. The WBID will uniquely identify the location of each waterbody from the UK lakes database. The Maidenhead lakes no longer exist after becoming a flood-relief channel of the River Thames. Instead of WBID, their approximate location is provided within the table by a numerical ordinance survey grid reference. Waterbodies are ordered by their mean conductivity, as in the species tables. Alkalinity data were not available for Elterwater.

The same lake names are given in the Supplementary Tables 1 and 2, except that Maidenhead lakes sampled in 2001 with the prefix '1' are differentiated from the same Maidenhead lakes sampled in 2000.

Remarks

The provision of these species and environmental data can supplement other researchers' data to improve understanding chironomid distribution and lake ecology. From 243 lake surveys 450 species of Chironomidae were collected. Several species were recorded for the first time in the British Isles during these surveys and published in following papers or are *in press*. Langton & Ruse (2005a) reported the first British records of *Cryptochironomus defectus* and *Paratanytarsus dimorphis*. Langton & Ruse (2005b) refer to further records of the following species: *Chironomus crassimanus* (now named *acerbiphilus*), *C. entis*, *C. holomelas*, *C. carbonarius*, *Cladopelma bicarinata*, *Glyptotendipes salinus*, *Rheotanytarsus rioensis*, *Tanytarsus anderseni*, *T. mancospinosus* and *Limnophyes spinigus* as well as a first record of *Glyptotendipes signatus*. Langton & Ruse (2010a) report the first record of *Hydrobaenus distylus* while Langton & Ruse (2010b) record *Limnophyes angelicae* occurring in Britain. The previously circum-Mediterranean distribution of *Chaetocladius algericus* (Moubayed, 1989) was greatly extended northwards by its occurrence at Sowley Pond in August 2010 subsequent to the lake's original surveillance (Ruse & Moubayed-Breil, 2013).

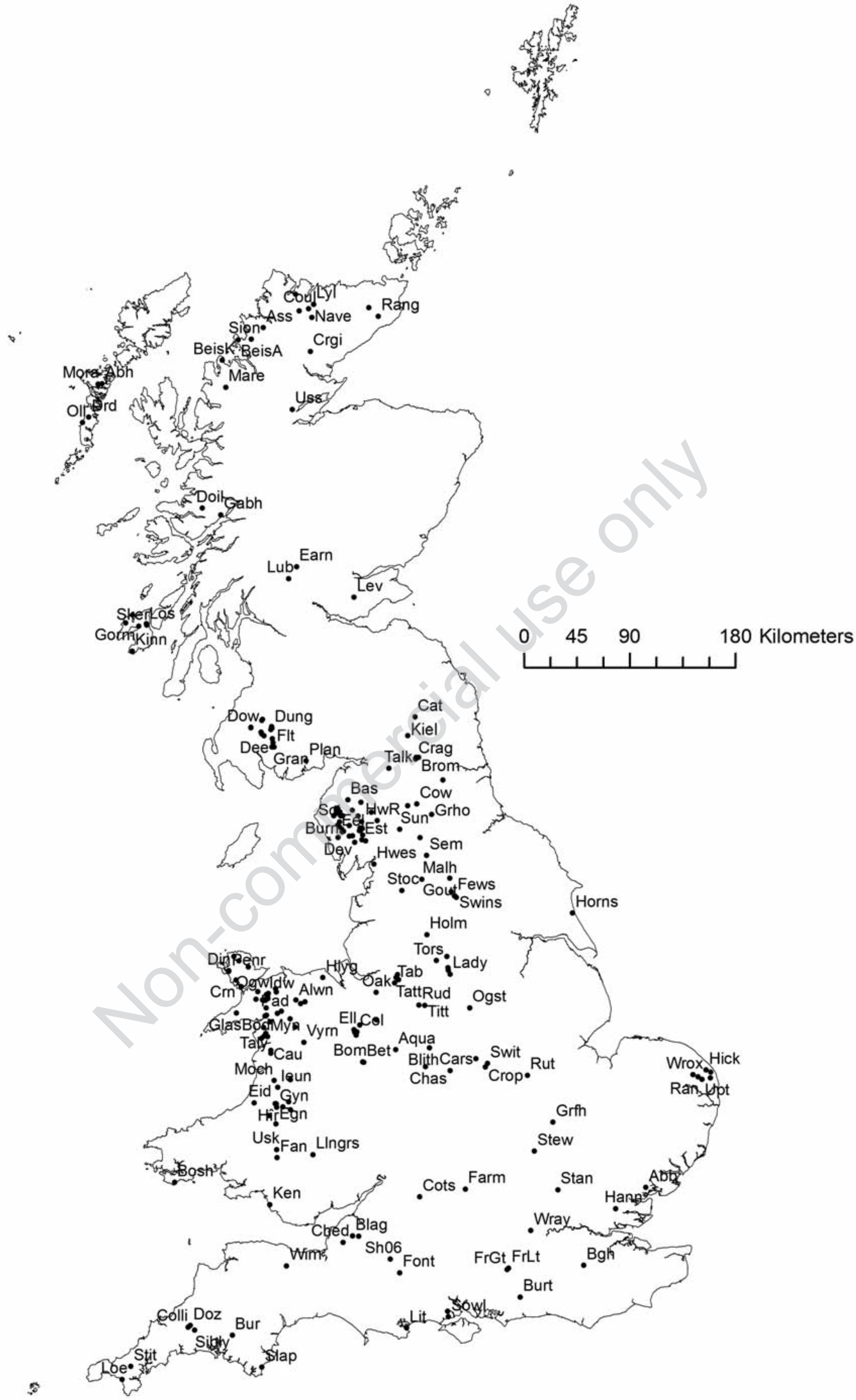

Figure 1. Location of waterbodies indicated by dots. Names abbreviated or missing due to congestion.

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