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Northern Russian chironomid-based modern summer temperature data set and inference models

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ABSTRACT

West and East Siberian data sets and 55 new sites were merged based on the high taxonomic similarity, and the strong relationship between mean July air temperature and the distribution of chironomid taxa in both data sets compared with other environmental parameters. Multivariate statistical analysis of chironomid and environmental data from the combined data set consisting of 268 lakes, located in northern Russia, suggests that mean July air temperature explains the greatest amount of variance in chironomid distribution compared with other measured variables (latitude, longitude, altitude, water depth, lake surface area, pH, conductivity, mean January air temperature, mean July air temperature, and continentality). We established two robust inference models to reconstruct mean summer air temperatures from subfossil chironomids based on ecological and geographical approaches. The North Russian 2-component WA-PLS model ($RMSEP_{Jack}$ = 1.35 °C, r^2_{Jack} = 0.87) can be recommended for application in palaeoclimatic studies in northern Russia. Based on distinctive chironomid fauna and climatic regimes of Kamchatka the Far East 2-component WAPLS model ($RMSEP_{Jack}$ = 1.3 °C, r^2_{Jack} = 0.81) has potentially better applicability in Kamchatka.

1. Introduction

Biotic proxies from lake sediments provide a powerful means of quantifying past climate change in terrestrial contexts. In addition, analysis of biotic remains from lake sediments provides an indication of the rate and magnitude of the response of animals and plants to past climate change and how they may respond in the future. Climatic inferences from palaeorecords are based on modern or near-modern analogues (training sets) from which the empirical reconstruction models (i.e. the transfer function) are established. By using inference models, which link the present distribution and abundance of chironomids to contemporary climate, past climates can be quantified from fossil chironomid assemblages (Kienast et al., 2011; Self et al., 2011). Chironomids (Insecta: Diptera) are well-proven to be among the most reliable quantitative proxies of mean July air temperature (Brooks, 2006). They are a diverse and nearly ubiquitous family of holometabolous two-winged flies and play vital roles in freshwater ecosystems as primary consumers (Coffman and Ferrington, 1996). The abundance and distribution of most chironomid taxa are temperature-dependent (Walker et al., 1991), reflecting the effect of air and water temperatures on all stages of their life cycles (Oliver, 1971) and they respond rapidly to climate change by virtue of the winged adult stage. The larval head capsules preserve well in lake sediment deposits and the subfossils are readily identifiable in most cases at least to species morphotype (Brooks et al., 2007).

Chironomid based inference models for reconstructing mean July air temperature have been developed successfully for Western Europe (Olander et al., 1999; Brooks and Birks, 2001), North America (Walker et al., 1997; Barley et al., 2006), Africa (Eggermont et al., 2007), New Zealand (Woodward and Shulmeister, 2006) and Tasmania (Rees et al., 2008).

Recently, data on the distribution and abundance of chironomids in lakes along environmental gradients in eastern and western Siberia were used to develop modern chironomid-based calibration data sets (training sets) and quantitative transfer functions for reconstructing mean July air temperature (T July), water depth (WD) and continentality (CI) in eastern (ES) and western Siberia (WS) (Nazarova et al., 2011; Self et al., 2011). Numerical analysis showed that T July is the most significant variable explaining contemporary chironomid distribution and abundance in both data sets. These data sets and transfer functions

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