CURRENT RESEARCH

SHORT COMMENT ON CHIRONOMID ASSEMBLAGES AND STRATIGRAPHY OF HIGH ALTITUDE LAKES FROM TIBET

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Abstract

A recent chironomid record of three shallow, high altitude lakes in southern Tibet, as well as a short palaeolimnological history of one lake, are presented. The recent chironomid assemblages consisted of 13 taxa; one of the Orthocladiinae taxa recorded most likely represents a new species. In spite of the low head capsule concentration in the sediment core of Lake Karuugema, probably due to physical disturbance, redistribution and outwash of head capsules, there was a trend from assemblages composed of stenothermal/rheophilic taxa to eurythermal/limnophilic taxa. This shift in assemblage structure suggests that changes in monsoon precipitation and catchment hydrology may have influenced the habitat conditions of the chironomids.

Introduction

Our knowledge of chironomids of Tibetan Plateau, whether recent or subfossil, is fairly limited. In this short note, we aim to report the composition of recent chironomid assemblages of three shallow, high altitude lakes in southern Tibet, and to investigate a short palaeolimnological history of one of

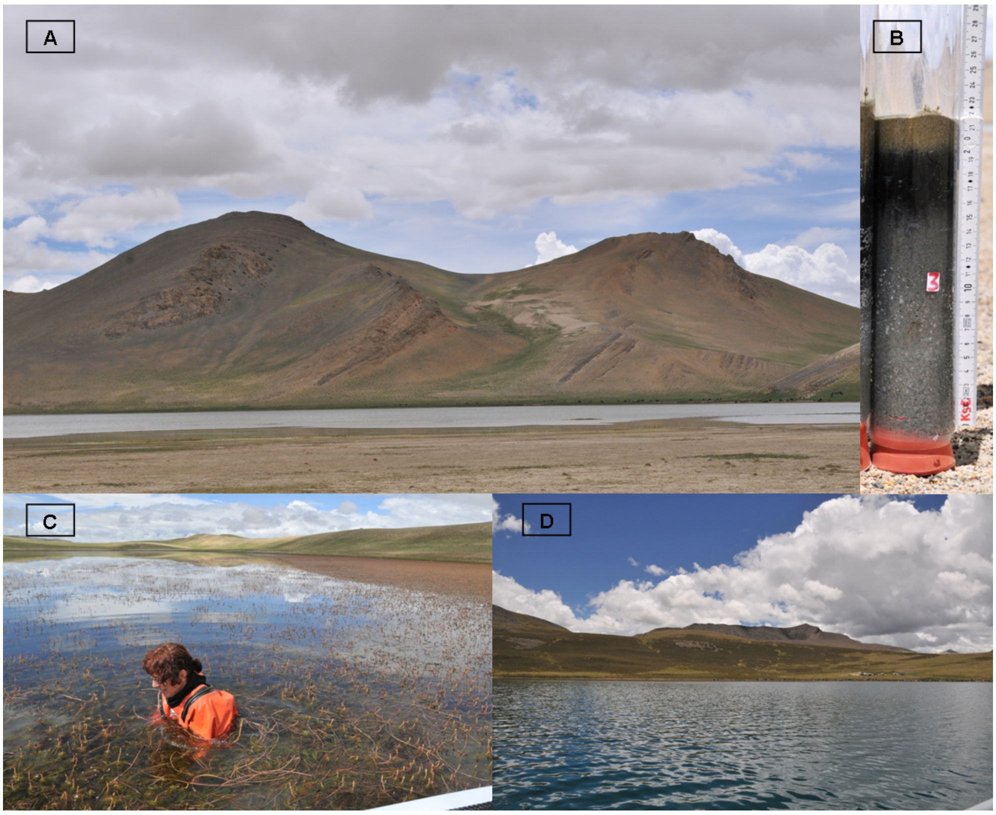

Figure 1. Photography of Lake Karuugema (A) and the sediment core (B) that was used for the chironomid analysis. The two other lakes, Sharmar tso (C) and Sijing la tso (D) are also pictured. Photo: K. S. Christoffersen.

Table 1. Basic parameters of the lakes surveyed.

Parameter	Karuugema	Sharmar tso	Sijing la tso
Coordinates	28º42.793'N 85º53.441'E	30º02.056'N 90º24.355'E	29º46.613'N 82º22.887'E
Altitude (m asl)	4,654	4,401	4,925
Average depth (m)	0.4	4.6	6.5
Conductivity (µS/cm)	855	220	18
O_2 (mg/L) (top/bottom)	8.2	9.3/7.2	2.3/2.1
pH	9.1	8.9	7.2

the lakes as it is situated in an area with extreme climate (cold winters and hot summers).

Material and methods

Three shallow lakes (Fig. 1A, C, D) located on the Tibetan Plateau were surveyed during July 2009. The basic lake parameters were measured using a multiprobe (YSI-556) and are presented in Table 1. The sediment cores were retrieved from the middle part of the lakes with a Kajak corer by hand and sectioned on site into 1 cm slices using standard equipment. Samples were collected in zip lock bags and stored cold for transportation to the laboratory.

To assess the recent chironomid assemblages, the uppermost 4 cm layers of the sediment cores were used. Furthermore, a 19 cm long sediment core of Lake Karuugema was used to carry out a palaeoecological reconstruction (Fig. 1A, B). Lake Karuugema is situated on a large plateau with small moraine hills surrounded by larger mountains. The surrounding bedrock consists of carbonate and clastic deposits of Triassic-Jurassic age. The area is seasonally frozen and the catchment is characterized by sparse, high–altitude desert vegetation. The lake is permanent but undergoes seasonal changes in water level. At the time of visit the max depth was approx. 1.2 m and the mean lake depth was estimated to be ~40 cm. The bottom consists of sandy sediment with very sparse vegetation. Calcium precipitation was observed on the plants. Given the low lake depth, wind exposure, physical disturbance and winter freezing will influence the biota directly, but also indirect influence through in-lake processes will occur.

The samples were processed for chironomid analysis according to standard methods: freeze-dried sub-samples were deflocculated for 10–20 min in 10% KOH heated to 75 ºC (Walker & Paterson 1985). The sediment was passed through a 90 µm mesh sieve. The chironomid head capsules were hand picked under a binocular microscope (40×), dehydrated in 99% ethanol and mounted in Euparal®. Identification was performed under a compound microscope at 400× magnification, with reference to Wiederholm (1983), Roback & Coffman (1987) and Brooks et al. (2007). Most of the specimens were identified to genus level, and, in some cases, to species-morphotype level. Fragments that consisted of more than half the mentum were counted as a whole head capsule, fragments that consisted of half the mentum were counted as half a head capsule and smaller fragments were

Table 2. Relative abundances of chironomid taxa recorded in the uppermost 4 cm of the lake sediments.

Taxon	Karuugema (%)	Sharmar tso (%)	Sijing la tso (%)
Procladius (H.) sp.	8	-	-
Orthocladiinae indet.	7	-	5
Paracladius sp.	8	-	-
Psectrocladius sordidellus-type	-	-	12
Smittia/Parasmittia sp.	-	11	-
Tvetenia discoloripes gr.	1	-	-
Rheocricotopus sp.	-	11	-
Chironomus plumosus-type	4	-	2
Chironomus anthracinus-type	3	67	5
Corynocera oliveri-type	1	-	-
Micropsectra sp.	66	11	29
Paratanytarsus sp.	1	-	48
Tanytarsus sp.	2	-	-

excluded. β-diversity of the sediment sequence was expressed as DCA gradient-length in SD (ter Braak & Šmilauer 2002).

Results and discussion

Recent chironomid assemblages

Altogether, 13 taxa were recorded in the uppermost 4 cm sediment layers of the three lakes sampled (Table 2). The most frequent were *Chironomus anthracinus* type and *Micropsectra* sp. occurring in all three lakes, followed by Orthocladiinae indet., *Chironomus plumosus* type and *Paratanytarsus* sp. Taxa of the subfamily Chironominae (such as *Micropsectra* sp., *C. anthracinus* type and *Paratanytarsus* sp.) dominated numerically in all three lakes.

According to Williams (1991), *Chironomus reductus* (as *Tendipes reductus*) was the most important chironomid and formed a significant part of the total benthic biomass of the high altitude saline lakes of Quinghai region (China).

During the investigation of 42 lakes of the Tibetan Plateau, species of the *Psectrocladius* genera (especially *P. sordidellus* type), *Cricotopus/Orthocladius* sp., *Paratanytarsus* sp., *Tanytarsus* spp. and *Chironomus* spp. were the dominating taxa (Zhang et al. 2007). Surprisingly, species of *Cricotopus/Orthocladius* genera were not recorded and both *Tanytarsus* sp. and *P. sordidellus* type were relatively rare in our samples. Moreover, the most abundant taxon of the present study, *Micropsectra* sp., was not recorded by Zhang et al. (2007). However, the genus *Micropsectra* is the dominant Tanytarsini in Nepalese Himalayas, especially above 2000 m asl (Roback & Coffman 1987). According to the head capsule characteristics, (dark brown head and first two antennal segments, very short spur on the antennal pedestals and short pedicels of Lauterborn organs) the morpho-type dominating in our sediment cores seems to be the same as described in Roback & Coffman (1987) and also found widespread in the lakes of the Nepalese Himalayas by Manca et al. (1998). According to the imagos found by Manca et al. (1998), this larva type could belong to a species close to *Micropsectra nepalensis* Säwedal.

One taxa of the Orthocladiinae subfamily was recorded which did not resemble known genera and which most likely represents a new species. The morpho-type called Orthocladiinae indet. (Fig. 2) has also been recorded from other lakes in Tibet (Tang, pers. comm.). The head capsule has plumose S1 setae, 5-segmented antenna and simple premandibles. Mandibles bear 3 inner teeth and 2 robust dorsal teeth, partially obscuring the inner teeth. The mentum is very characteristic with 3 pale median teeth and markedly darker lateral teeth, which are folded back (resembling e.g. *Corynocera ambigua*); there is also a little rounded basolateral tooth on the mentum, which is characteristic for *Limnophyes* and relative species. The shape of the mandibles and the mentum suggests that this species is most likely a collector-gatherer, feeding on fine organic particles of the detritus. This combination of the head capsule characteristics did not allow us to place this type to the existing genera with certainty. However, some characteristics indicate that it might be a species close to *Limnophyes* or *Thienemannia* (Cranston, pers. comm.).

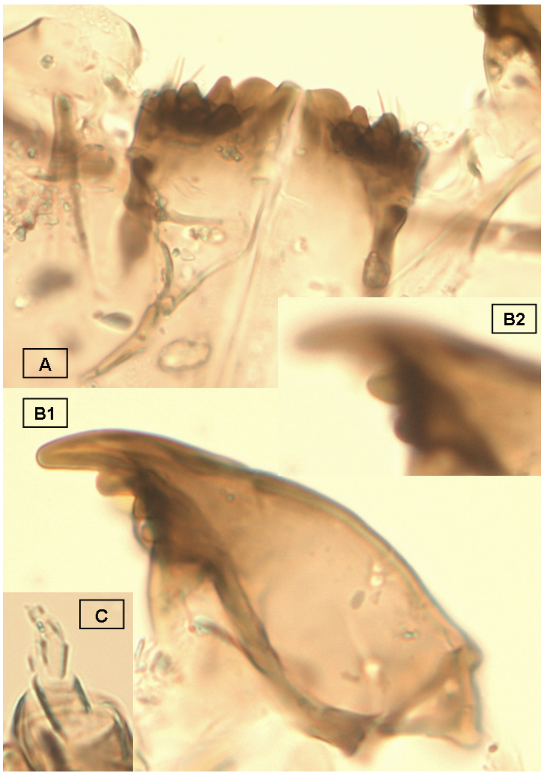

Figure 2. Photographs of the mentum (A), inner (B1) and dorsal teeth (B2) of the mandible, and the 5-segmented antenna (C) of the unidentified specimen (Orthocladiinae indet.) found in the sediment core.

Chironomid stratigraphy of Lake Karuugema

The age of the 19 cm long sediment core was not identified; however, given the high altitude of the lake and the very low amount of the fine organic accumulation in the sediment, the sedimentation rate of the lake is most likely similar to that of other arctic and/or high altitude lakes and is consequently very low. In our estimation, the sediment core may represent several hundred years. There was a great amount of fine mineral sediments, such as sand, mica and quartz throughout the sediment

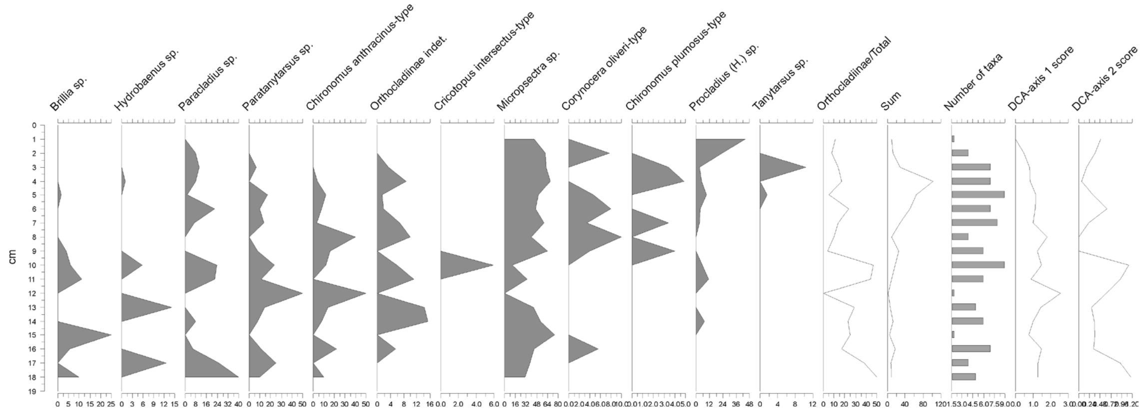

Figure 3. Chironomid stratigraphy of Lake Karuugema. Chironomid taxa are given as percentages of the total number of head capsules; sum represents the total number of head capsules per sample. Taxa are ordered according to weighed average score.

core. It is probably originated from soils and bedrock as well as from the surrounding glaciers and is transferred to the lake through its intense inlets.

In total, 13 chironomid taxa of 3 subfamilies were recorded (Fig. 3). Besides the head capsules, also the larva of *Tvetenia discoloripes* group was found in the uppermost sediment layer, however, given the only occurrence of this taxon, it was excluded from the analysis. Generally, the sediment core was fairly poor in chironomid head capsules and their density varied markedly from layer to layer. A maximum of 100 head capsules was counted per sample, however, at some layers only 10 head capsules were found. From the bottom up to 7 cm, the abundance was constantly low, without obvious oscillations. From the 7-8 cm layer, however, the abundance increased rapidly to 3-4 cm, where it reached the maximum and started to decrease to the same low abundance level as before. Taking the whole core into account, the most abundant taxa were *Micropsectra* sp. (54% of all head capsules), *Paracladius* sp. (9.5%), *Paratanytarsus* sp (8.7%), *Chironomus anthracinus*-type (8.3%), *Procladius* (*H.*) sp. (5.9%) and Orthocladiinae indet. (4.9%). These taxa were also the most constant along the sediment core, occurring at least in the half of all samples. Despite of its low total abundance, also *Brillia* sp. had high frequency occurring in 40% of all samples. Most of the above taxa have been found previously in lakes of the Tibetan Plateau (Zhang et al. 2007, Chen et al. 2009).

The species turn-over was relatively high (DCA gradient length 2.5 SD) and there was a gradual but obvious shift in taxonomic composition. Most of the taxa were represented throughout the sediment core, however, some taxa were characteristic at the base, while others for its upper, most recent portion. Orthocladiinae *Brillia* sp. and *Hydrobaenus* sp. occurred mainly towards the base, for which also very low abundance was characteristic. Species of the genus *Hydrobaenus* are mainly cold stenothermal, but ecologically rather diverse, dwelling the littoral of oligotrophic lakes, ponds, puddles, rivers and streams. Some species aestivate during the summer season (Sæther 1976). Species of the genus *Brillia* are considered to be primarily rheophilic, but also occur in littoral and hygropetric zones of lakes (Wiederholm, 1983). High frequency of both taxa mentioned in the bottom layers linked with low total abundance could be an indicator of strong influence of inlet streams.

On the contrary, taxa only occurring in the upper portion of the core were Chironominae and Tanypodinae, such as *Corynocera oliveri* type, *Chironomus plumosus* type, *Tanytarsus* sp. and *Procladius* (*H.*) sp. Moreover, in these layers, the proportion of Orthocladiinae was lower then in the deeper layers. Appearance of Chironominae (especially *C. plumosus* type) and Tanypodinae preferring fine sediments, linked with increasing abundance suggests lower intensity of inlet streams, higher sedimentation rate, more stable environment, supporting higher abundance and occurrence of taxa preferring fine sediments. There is likely to be a linkage of inflow intensity and the amount of monsoon precipitation, found by Morrill et al. (2006) in another Central Tibetan lake. They found significant differences in monsoon precipitation linked with lake depth since early Holocene, with recently increased precipitation following a late Holocene dry period, which is in accordance with our results.

Conclusion

The new records of chironomids from the three studied lakes extend the taxa-list of the region and will be valuable for taxonomists and limnologists aiming for future studies in high altitude lakes in

Tibet. In spite of the low head capsule concentration in the sediment core of Lake Karuugema, probably due to physical disturbance, redistribution and outwash of head capsules, there was a trend from assemblages composed of stenothermal/rheophilic taxa to eurythermal/limnophilic taxa. This shift in assemblage structure suggests that changes in monsoon precipitation and catchment hydrology may have influenced the habitat conditions of the chironomids.

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References

Brooks, S.J., Langdon P.G & Heiri O. 2007. *The Identification and Use of Palaearctic Chironomidae Larvae in Palaeoecology*. QRA Technical Guide No. 10. - Quaternary Research Association, London, pp. 276.

Chen, J., Chen, F., Zhang E., Brooks, S., Zhou, A. & Zhang J. 2009. A 1000-year chironomid-based salinity reconstruction from varved sediments of Sugan Lake, Qaidam Basin, arid Northwest China, and its palaeoclimatic significance. - *Chinese Sci. Bull.* 54(20): 3749-3759.

Manca, M., Ruggiu, D., Panzani, P., Asioli, A., Mura, G. & Nocentini, A.M. 1998. Report on a collection of aquatic organisms from high mountain lakes in the Khumbu Valley (Nepalese Himalayas). In Lami A. and Giussani G. (Eds) Limnology of high altitude lakes in the Mt Everest Region (Nepal). - *Mem. Ist. Ital. Idrobiol.* 57: 77-98.

Morrill, C., Overpeck, J.T., Cole, J.E., Liu, K., Shen, C. & Tang, L. 2006. Holocene variations in the Asian monsoon inferred from the geochemistry of lake sediments in central Tibet. - *Quat. Res.* 65: 232-243.

Roback, S.S. & Coffman, W.P. 1987. Results of the Nepal Alpine Zone Research Project, Chironomidae (Diptera). - *Proc. Acad. Nat. Sci. Phil.* 139: 87-158.

Sæther, O.A. 1976. Revision of Hydrobaenus, Trissocladius, Zalutchia, Paratrissocladius, and some related genera (Diptera: Chironomidae). - *Bull. Fish. Res. Bd Can*. 195: 1-287.

ter Braak, C.J.F. & Šmilauer, P. 2002. CANOCO *Reference Manual and Users Guide to Canoco for Windows*. Software for Canonical Community Ordination (version 4), Wageningen: Centre of Biometry.

Walker, I.R. & Paterson, C.G. 1985. Efficient separation of subfossil Chironomidae from lake sediments. - *Hydrobiologia* 122: 189-192.

Wiederholm, T. (ed.) 1983. Chironomidae of the Holarctic region Keys and diagnoses. Part I Larvae. - *Ent. Scand., Suppl*. 19: 1-457.

Williams, W.D. 1991. Chinese and Mongolian saline lakes: a limnological overview. - *Hydrobiologia* 210: 39-66.

Zhang, E., Jones, R., Bedford, A., Langdon, P. & Tang., H. 2007. A chironomid-based salinity inference model from lakes on the Tibetan Pateau. - *J. Paleolimn.* 38: 477-491.