

Discovery of *Nymphomyia* larval remains (Insecta: Diptera: Nymphomyiidae) in five hundred year-old bottom sediments of Oron lake (Eastern Siberia, Russia)

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ABSTRACT: Finding of larval remnants belonging to archaic Diptera from the family Nymphomyiidae in Oron lake (Irkutsk Area, Bodaibinskiy District) bottom sediments is indicated for the first time. Remains of the larval head capsules are related to the recent group of species *Nymphomyia* gr. *rohndendorfi*, distributed mostly in the Russian Far East, as well as in south-eastern Asia and North America. A brief characterization of the location and morphological description of Nymphomyiidae remnants of the larval head are given and illustrated. The approximate period of time at which Nymphomyiidae inhabited Oron lake is established.

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KEY WORDS: *Nymphomyia*, fossils, Kodar ridge, Minor Ice Age, paleolimnology.

Находка макроостатков личинок *Nymphomyia* (Insecta: Diptera: Nymphomyiidae) в 500-летних донных осадках озера Орон (Восточная Сибирь, Россия)

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РЕЗЮМЕ: Впервые отмечена находка макроостатков личинок, принадлежащих к архаичным двукрылым из семейства Nymphomyiidae в донных отложениях озера Орон (Иркутская область, Бодайбинский район). Останки обнаруженных головных капсул личинок близки современной группе видов *Nymphomyia* gr. *rohndendorfi*, распространенных в основном на Дальнем Востоке России, а также в юго-восточной Азии и Северной Америке. Приведены и проиллюстрированы краткая характеристика места обнаружения макроостатков головных капсул личинок

Nymphomyiidae и их морфологическое описание. Установлен приблизительный период времени, в который Nymphomyiidae обитали в озере Орон.

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КЛЮЧЕВЫЕ СЛОВА: *Nymphomyia*, осадки, Кодарский хребет, Малый ледниковый период, палеолимнология.

Introduction

The archaic dipteran family Nymphomyiidae is identified by the Japanese dipterologist M. Tokunaga (1932) on the basis of *Nymphomyia alba* Tokunaga, 1932, described by himself from the Kyoto University Botanic Garden (Honshu Island, Japan). These peculiar, minute and little-known flies are one of the most distinctive families of Diptera. They are easily recognized as larvae, pupae and adults (Courtney, 1994; Courtney, Jedlicka, 1997).

At present the world fauna of Nymphomyiidae includes only the genus *Nymphomyia*, including 9 species, 5 of which dwell in piedmont and montane watercourses of the Russian Far East — *N. alba*, *N. kaluginae* Makarchenko 2013, *N. kannasatoi* Makarchenko et Gunderina 2014, *N. levanidovae* Rohdendorf et Kalugina, 1974, and *N. rohdendorfi* Makarchenko, 1979 (Fig. 1). The species *N. alba* and *N. kannasatoi* inhabit Japanese streams, too (Makarchenko, 1996; Makarchenko *et al.*, 2014; Saigusa, 2014). *N. walkeri* (Ide, 1965) inhabits North American streams (Back, Wood, 1979; Ide, 1964, 1965; Kevan, Cutten, 1975; Mingo, Gibbs, 1976; Smith *et al.*, 1989) and *N. dolichopeza* Courtney, 1994 (USA) also occurs in North America; *N. brundini* (Kevan, 1970) inhabits India (West Bengal); and *N. holoptica* Courtney, 1994 (Saigusa, 2014) inhabits Hong Kong and possibly Japan. In addition, unidentified pupae of *Nymphomyia* sp. are found within the Northern Altai of Mongolia (Hayford, Bouchard, 2012). One species of fossil Nymphomyiidae — *N. succina* — is described based on remains of adults from Baltic and Bitterfeld amber (Wagner, Hoffeins et Hoffeins 2000).

Nymphomyiidae dwell in cold submontane and montane streams with rapid currents and high oxygen content in the water, low electric conductivity, and pH from weakly acid to weakly alkaline. Some species apparently can tolerate only a narrow range of environmental conditions; however, other species have been recorded from a variety of stream types, from small, clear, closed-canopy headwaters to large, brown-water rivers. Larvae typically settle on stony and gravel-pebble grounds which are frequently covered with algae in May and June. They often are found on moss-covered rocks. After emergence the Nymphomyiidae imago swarm at a height of 1–5 m creating swarms of some hundred individuals. Copulating midges land on damp stones in current or on a water surface, lose wings, submerge and for some time they live on the water body bottom or on inshore stones. Then females oviposit and frequently the female glues the eggs on the male abdomen end (Makarchenko, Gunderina 2019). Nymphomyiidae swarming occurs in the evening, often at sunset and in calm weather. Currently, the species biology is studied best for North American *N. walkeri* (Cutten, Kevan, 1970; Kevan, Cutten, 1975; Mingo, Gibbs, 1976; Back, Wood, 1979; Adler *et al.*, 1985; Harper, Lauzon, 1989) and north-eastern palaeartic *N. levanidovae* (Makarchenko, Makarchenko, 1983), *N. kannasatoi* (Makarchenko *et al.*, 2014) and *N. rohdendorfi* (Yarovskaya, Makarchenko, 2015), and to a lesser degree for *N. alba* (Takemon, Tanida, 1994; Saigusa *et al.*, 2009).

Data on the larval morphology of different Nymphomyiidae species are published in several papers (Cutten, Kevan, 1970; Courtney, 1994; Takemon, Tanida, 1994; Courtney, Jedlicka,



Fig. 1. Distributions of Palearctic and Oriental species of *Nymphomyia*: *N. alba* (black triangle); *N. kaluginae* (inverted triangle); *N. kannasaroi* (cross); *N. levanidovae* (square); *N. rohdendorfi* (circle); *N. brundini* (star); *N. holoptica* (diamond) (Courtney, 1994; Makarchenko 2013; Makarchenko, Gunderina, 2019). Location, where remains of the *Nymphomyia* sp. larvae were found is marked by a circle with a cross.
 Рис. 1. Распространение видов *Nymphomyia* Палеарктики и Ориентальной области: *N. alba* (черный треугольник); *N. kaluginae* (перевернутый треугольник); *N. kannasaroi* (крест); *N. levanidovae* (квадрат); *N. rohdendorfi* (круг); *N. brundini* (звезда); *N. holoptica* (ромб) (Courtney, 1994; Макаренко 2013; Макаренко, Гундерина, 2019). Место, где в озере Орон были обнаружены макроостатки личинок *Nymphomyia* sp., обозначено крестом в круге.

1997; Makarchenko, 2006). Larvae are vermiform, their body is composed of 13 well distinguishable segments. Abdominal segments I–VII and IX bear pairs of long pseudopodia at the apex of which a claw and crochets. The head is egg-shaped, pale-yellow; it bears a pair of larval eyelets near a posterior end. Antennae are shorter than half of the head length; the basal joint is

erect, cylindrical, the distal series is composed of 4 short flat adnexa. The head bears a sharply protruding front projection formed by the clypeus, labrum and premandibles. The mandibles are in the form of a scoop with 7 teeth on the edge. The pamprodactylous mentum edge is dentate: the medial tooth is three- or five-lobed, there are five teeth on each side. Hypopharynx

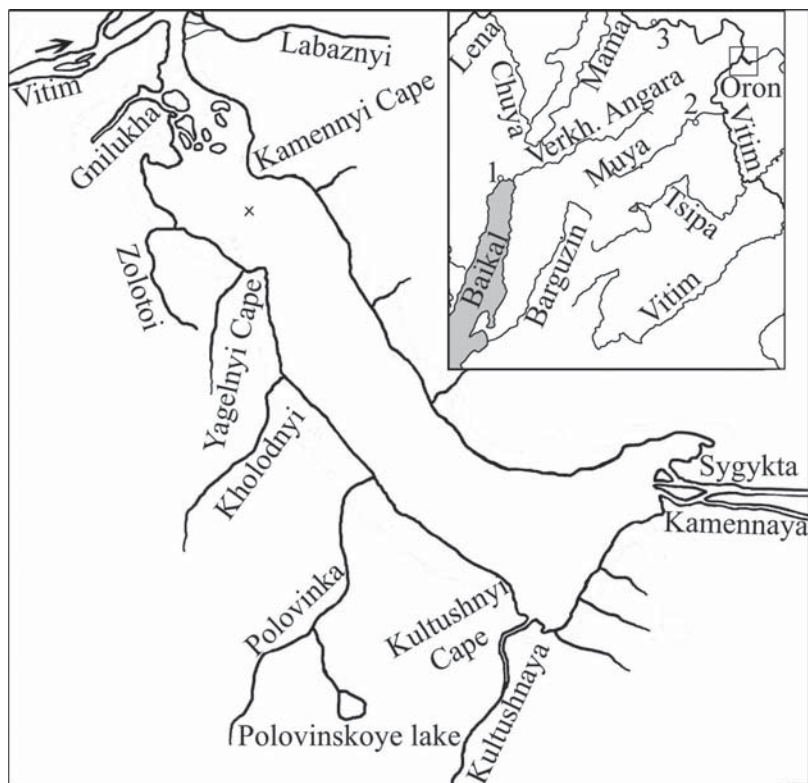


Fig. 2. Geographic location of Oron lake; position of analyzed core with *Nymphoiya* sp. larvae remains marked by cross. 1 — Nizhneangarsk; 2 — Taksim; 3 — Bodaibo.

Рис. 2. Географическое положение озера Орон; место отбора керн, в котором были обнаружены макроостатки личинок *Nymphoiya* sp. обозначено крестом. 1 — Нижнеангарск; 2 — Таксимо; 3 — Бодайбо.

is on apex with crest of narrow long dens. Larvae are mobile; they move over rocks using the abdominal pseudopodia, and sometimes use caddisfly cases (Trichoptera). Nymphomyiidae of several species in the larval stages can be situated in substreamflow; they go into the current just before pupation (Makarchenko, Gunderina, 2019). They eat diatoms, bacteria and fine organic material which they scrape off the stone surface. Pupae and adults do not eat.

As to internal anatomic features of Nymphomyiidae they are the following: the presence of a closed tracheal system and 8 free thoracic ganglia and a very large supraesophageal ganglion in the adult. Karyological studies were made only for *N. levanidovae*. The diploid number of this species is $2n=8$ (Makarchenko, 2006).

During core treatment of the Oron lake bottom sediments (Or-02/13), we found the remains of head capsules of Nymphomyiidae larvae. Up to the present the finding of fossil remains of the Nymphomyiidae preimago stage of development has not been mentioned.

Materials and methods

The Oron lake is situated in the northern part of the Baikal rift zone at a height of 353 meters above sea level, about 450 km from Lake Baikal (Fig. 2). The lake is bordered in the south and east by the Olekma-Vitim upland and in the west and north it is bounded by branches of the Kodar ridge which ranges in altitude from 1400–1800 m.

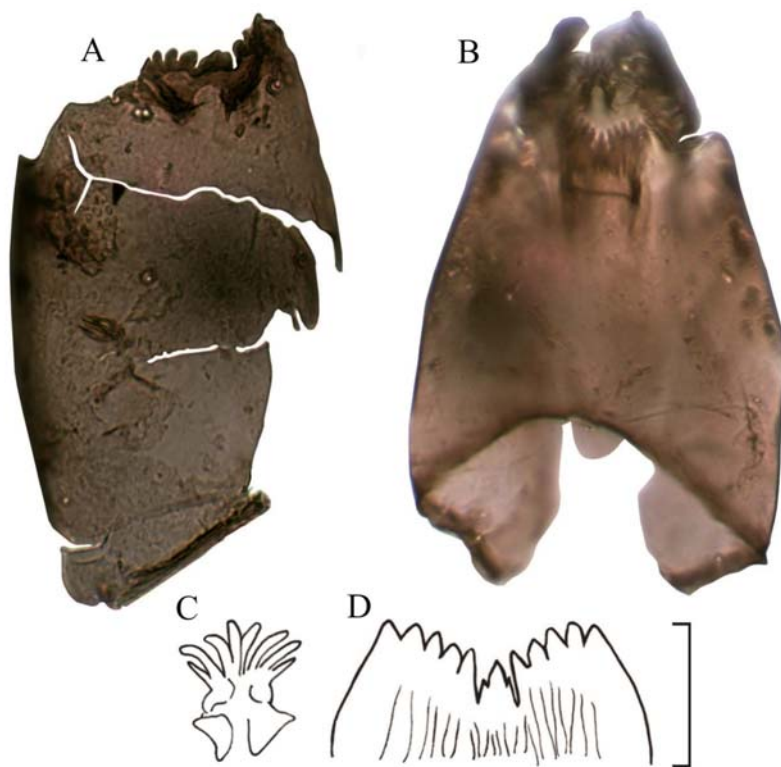


Fig. 3. Remains of *Nymphomyia* sp. larvae from Oron lake bottom sediments (A, B) and details of larvae head capsules (C, D). A — head capsule from horizon 13–14 cm; B — head capsule from horizon 26–27 cm; C — hypopharynx; D — mentum. Scale bar 0.2 mm.

Рис. 3. Макроостатки личинок *Nymphomyia* sp. из донных осадков озера Орон (A, B) и детали головных капсул личинок (C, D). А — головная капсула из горизонта 13–14 см; В — головная капсула из горизонта 26–27 см; С — гипофаринкс; D — ментум. Линейка 0,2 мм.

The lake is of tectonic origin. Its length is 24 km; width is 6.5 km and maximum depth is 184 m. The lake area is about 51.3 km²; its catchment basin area is 3570 km² (Matveev *et al.*, 2006). The Sygykta, Kultushnaya and Kamennaya Rivers, which spring from the Kodar ridge, are the main tributaries. In addition, more than 100 small rivers and rivulets flow into the lake.

In March 2013 the first author (as a member of the Limnological institute of the SB RAS (Irkutsk) expedition) sampled bottom sediments. Sampling was realized in a cross-section of the Kamennyi cape (N 57°09'14"; E 116°27'59") by the benthos sampler Uwitec-Corer from the depth of 9 m. The taken core length was 73 cm. The core upper part (0–2 aleuropelites 9 cm) is

generally presented by fine-grained olive green-brown aleuropelites. The rest is composed of pale brown aleuropelites with abundant inclusions of phytodetritus (Fedotov *et al.*, 2016), which indicates the different sedimentation rates at different time intervals. The depth-age model was developed on the basis of the isotope activity distribution of ²¹⁰Pb, ³⁷Cs (Vorobyeva *et al.*, 2015; Fedotov *et al.*, 2016). CRS (Central Rate of Supply) the accumulation model of ²¹⁰Pb (Binford, 1990) was used for the age calculation.

Only two head capsules of Nymphomyiidae larvae were found: in 13–14 and 26–27 cm of the Or-02/13 core. Their short description is below.

Results and discussion

The recovered head capsules with a form typical for the Nymphomyiidae larvae are brown (Fig. 3A, B). The hypopharynx is wide at the base with crest of 8 long and narrow teeth on the apex (Fig. 3C). Mentum with triple median tooth and five pairs of lateral teeth, roughly of the same size; the first lateral teeth almost of the same height with the rest of lateral teeth (Fig. 3D).

According to isotopic dating the core upper 9 cm were formed after 1870. If you extrapolate the depth-age model to the core horizons from which the Nymphomyiidae larvae remains were extracted, it turns out that these horizons were formed around 1780 and 1500, respectively. That is it happened during so-called Minor Ice Age which ended in the second half of the 19th century. Then, the period of Recent Warming started, and it continues up to present. However, judging by the core lithologic structure character in this interval, these horizons are probably more ancient. Unfortunately, the discovered remains are not enough to a detailed comparison of fossil larvae with recent species; however, according to the hypopharynx and mentum texture they are suggested to be close to the larvae of recent species *Nymphomyia* gr. *rhodendorfi*, which are abundant in the Russian Far East (Yavorskaya, Makarchenko, 2015). It is possible that the archaic dipteran Nymphomyiidae currently inhabit the Oron lake basin which may be detected during more detailed hydrobiologic surveys of streams falling into the lake.

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