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Cnidarian fauna of relict Lakes Baikal, Biwa and Khubsugul

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Abstract

In relict Lakes Baikal, Biwa and Khubsugul three orders: Hydrida, Athecata and Limnomedusa (?) of the class Hydrozoa were found. In Lake Baikal, only representatives of Hydrida, such as *Pelmathohydra baikalensis* (endemic of Lake Baikal), *P. oligactis* and *Hydra circumcincta* were found (the last two species had not been found there before. Recent studies of the phylum Cnidaria in Lake Biwa showed the presence of *Pelmatohydra oligactis* and a representative of the family Clavidae which has been treated as a new species, *Pachycordyle kubotai*. In Lake Khubsugul a single representative of Hydrida has been found so far which is suggested to represent a new species of *Pelmatohydra*. According to techniques described earlier air-dried chromosome slides were prepared. The karyotype of *P. kubotai* were studied using conventional chromosome staining (by 6–10% Giemsa in the Sørensen's buffer, pH 6.8), whereas karyotype of *P. baikalensis* was studied using conventional and C-banding techniques. C-banding to reveal highly repeated DNA followed the protocol by Sumner (1972).

Introduction

According to the literature, representatives of Hydrozoa (subphylum Medusozoa), one of five known classes of the phylum Cnidaria, occur in continental water bodies (Stepanjants, 1994; Holstein, 1995). Of known Hydrozoa, the orders Hydrida, Athecata and Limnomedusa inhabit freshwaters. Evidently, between cnidarians, from the standpoint of species diversity and in terms of quantity, hydrids play the major role in continental water bodies. However, representatives of the family Olindiidae (Limnomedusa), more frequently Craspedacusta, less frequently Limnocnida (in India) and also representatives of the family Clavidae (*Cordylophora* and *Pachycordyle* – Athecata) are also quite common. Polyps of species *Velkovrhia enigmatica* (Bougainvilliidae, Athecata) have been found so far within a narrow distribution range. It should be noted that species of *Craspedacusta*, particularly *Craspedacusta sowerbii*, are widespread and are frequently found in artificial water bodies. It is difficult to explain observed peaks of abundance of medusae of this species in a reservoir and their abrupt disappearance; polyps of *Craspedacusta* are known only in laboratory conditions.

Until now, data on the Cnidaria of Lakes Baikal, Biwa and Khubsugul were scanty. *Hydra baikalensis* described by Swarczewsky in 1923 and described independently by Schulze in 1927 as *Pelmatohydra baicalensis* was not discovered for more than 50 years. Another allegedly new Baikalian species of hydra described in 1927 by Schulze as *Hydra oxycnidoides* has not been discovered again, and its existence in Baikal is subject to doubt (Anokhin, 2002). In relation to Lake Biwa, the Atlas of its pelagic inhabitants (Negoro, 1982) contains an obscure description and drawing of medusa, identification of which is impossible. Information on cnidarians of Mongolian Lake Khubsugul was absent.

The present paper contains results of research on Cnidaria in Lakes Baikal, Biwa and Khubsugul for the past 10 years.

Materials and methods

For Cnidaria of relict Lakes Baikal, Biwa and Khubsugul, collections of the Zoological Institute of the Russian Academy of Sciences were used: *P. baikalensis*, Catalogue Nos. 2–7, *P. oligactis* Nos. 15, 22–24. The work was based upon living and fixed material collected from Baikal by O. Timoshkin & T. Sitnikova (Limnological Institute, RAS, Irkutsk) in 1980–1990, by A. Yankovsky in 1997 and B. Anokhin in 2000 (Zoological Institute, RAS, St. Petersburg); from Lake Khubsugul, collected by T. Sitnikova in 1997; from Lake Biwa collected by O. Timoshkin in 1994 and 1997. We also used living material from tanks of Lake Biwa Museum kindly sent to the Zoological Institute by Dr. M. Grygier in 2001. Material collected during the past years in Lake Baikal and in Lake Biwa was cultivated in the laboratory to study characteristics of ontogenesis, morphology of living specimens, including thin structures such as nematocysts (stinging or adhesive organelles unique for the phyllum Cnidaria) and karyotypes (chromosome number, their morphology and molecular composition). Structure of nematocysts in the form of discharged and undischarged threads of capsules was studied on living or fixed material using light microscope with objective $\times 100$.

Following Anokhin & Kuznetsova (1999), air-dried chromosome slides of *Pelmatohydra baikalensis* and *Pachycordyle kubotai* were prepared. Slides of both species were stained by 6–10% Giemsa in Sørensen's buffer (pH 6.8). Some slides of *P. baikalensis* were stained using C-banding to reveal highly repeated DNA, following protocol by Sumner (1972) with minor modifications (Anokhin & Kuznetsova, 1999).

Results

For over 10 years we studied Cnidaria of continental water bodies, including fauna Hydrozoa of various relict lakes of Asia, such as Baikal, Biwa, and Khubsugul, represented by the orders: Hydrida, Athecata and Limnomedusa (?). Representatives of all three orders were not found in each of these lakes, and it may be assumed this is merely because of insufficient knowledge of each water body. Nevertheless, our studies have extended knowledge of Cnidaria as compared to the past century.

Faunal composition of hydroids in three relict lakes of Asia

Only Hydrida have been noted in Lake Baikal, and only two species both regarded as endemics: *Pelmatohydra baikalensis*, (Swarczewsky, 1923) (= *Pelmatohydra baicalensis*, Schulze, 1927) and *Hydra oxycnidoides* Schulze, 1927). Our research also showed *Pelmatohydra oligactis* to be present. *Elodea* was introduced into Lake Baikal relatively recently, and it can be assumed *Pelmatohydra oligactis* was introduced into Lake Baikal with that plant (Stepanjants & Anokhin, 2001). *Hydra oxycniodoides* has not been found in Baikal after its description, indicating its exceptional rarity in the lake, or the doubtful validity of this species (Holstein, 1995). Our studies have shown the presence *Hydra circumcincta* in Lake Baikal (Stepanjants & Anokhin, 2001).

In Lake Biwa only one species of hydra, *Pelmatohydra oligactis* and a representative of the family Clavidae (Athecata) described as a new species *Pachycordyle kubotai* (Stepanjants et al., 2000b) are known. In the Atlas "The Plankton of Lake Biwa" (Negoro, 1982) an indistinct photo of a medusa is given, but identification from this is impossible. The medusa might be referred to the genus *Craspedacusta* (Limnomedusa), but may also be a free medusoid stage of *Pachycordyle kubotai* (Stepanjants et al., 2000b).

The hydroids of Lake Khubsugul are the least examined. We examined 30 polyps of hydras, the morphology of which, including structure of nematocysts, suggests a number of differences from other known species. Perhaps additional materials will establish this as a new species of *Pelmatohydra*.

We note that in these relict Asian lakes, species of the genus *Pelmatohydra* were predominant among hydras. One species is endemic of Baikal, and another apparently endemic of Khubsugul.

P. oligactis was introduced in Baikal and formed a viable population.

Ecological characteristics of hydroid fauna of these Asian lakes

Typically, hydras are benthic littoral organisms. In Baikal, Khubsugul and Biwa, large accumulations of hydras occur at depths from several centimeters to 2–3 m, mostly on macrophytes, but not infrequently also on stone, snags and piles. The same is true of *Pachycordyle kubotai* in Lake Biwa. Evidently, abundance of food (mostly small planktonic crustaceans) in the warm time of year and presence of suitable substrata lead to rapid asexual reproduction of polyps. Discoveries of hydras at somewhat greater depths are not rare: for example, *P. oligactis* in Baikal at 10 m depth (collections of T. Sitnikova and O. Timoshkin in 1997), and in Biwa at 5 m (collections of O. Timoshkin in 1994). Hydras survive unfavourable conditions in the form of zygotes covered by a dense protective cover – embryotheca, and *Pachycordyle kubotai* probably in the form of colony fragments. Considerable accumulations of *Pelmatohydra* sp. are noted on *Ulothrix* in the coastal zone of Khubsugul (T. Sitnikova, personal communication), as well as *P. baikalensis* on *Elodea* in Baikal (depth 0–3 m) (Yankovsky & Anokhin, personal communication).

Taxonomy

As has been mentioned above Cnidaria are represented in lakes Baikal, Biwa, and Khubsugul by four or five species of hydras, one species of athecate hydroids and possibly by one species of limnomedusae. These are *Hydra circumcincta*, *Pelmatohydra oligactis*, *P. baikalensis*, very doubtful *H. oxycnidoides* and possibly *Pelmatohydra* sp. nov.; *Pachycordyle kubotai* and possibly *Craspedacusta* sp.

Order Hydrida
Family Hydridae
Genus Hydra

The major characteristics of the genus are the lack of polyp stalk, simultaneous formation of tentacles on buds, and peculiarities of the packing of undischarged thread in capsules of nematocysts, holotrichous isorhizas, packed in its upper part by several transverse or oblique spires.

Hydra circumcincta Schulze, 1914 (Fig. 1a)

Number of tentacles normally 6, seldom 5 or 7. They are shorter than polyp body, if they exceed body size the difference is very slight. Holotrichous isorhizas are broadly oval (Fig. 2c).

Hermaphroditic

Measurements (mm): in living specimens body length 1–10, in fixed ones 1–5; living body diameter 0.4–0.8, tentacle length of living polyps 5–8; tentacle length of fixed polyps 0.8–1.5.

Nematocysts (μm): Stenoteles 15.0–16.0 × 12.0–13.0 and 20.0–22.0 × 16.5–18.0, holotrichous isorhizas 8.5–11.0 × 5.5–5.7, atrichous isorhizas 7.0–8.0 × 3.0–4.0, desmonemes 7.0–7.7 × 4.5–5.0.

Karyotypes (known from Byelarus and North-West Russia; Anokhin & Kuznetsova (1999): $2n = 30$, FN (number of chromosome arms) = 56 (two chromosome pairs are acrocentric), NOR in one of middle pairs of chromosomes, index $X_{1/15}$ (ratio of lengths of the 1st and 15th pairs of chromosomes) = 2.23 ± 0.38 ($p < 0.05$). Sex chromosomes are not distinguished. Data on karyotype of the Baikal population are absent.

Until recently it was believed that distribution range of the species was the Holarctic (Eurasia, North America).

Hydra oxycnidoides Schulze, 1927
(Fig. 1b, after Schulze, 1927)

The major distinctive feature (after Schulze, 1927) is a strongly elongated shape of capsules of stenoteles (Fig. 2c).

Measurements (fixed polyps measured in mm after Schulze drawing): Body length 2.4, body diameter 1.8, length of tentacles 1–1.2.

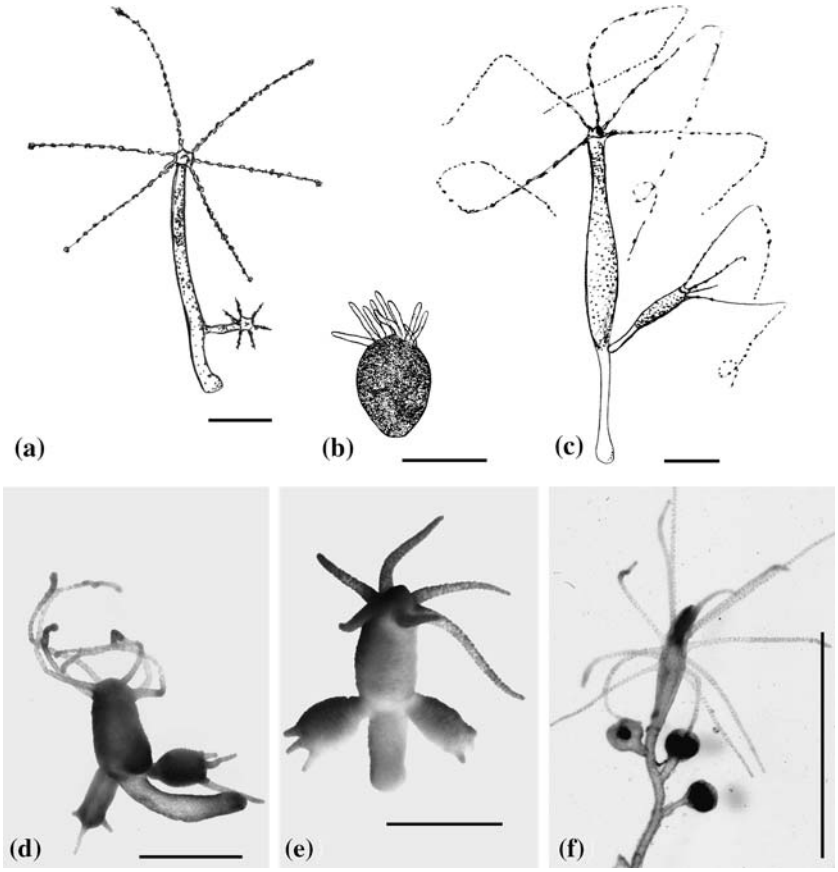

Figure 1. Outward appearance of hydras and *Pachycordyle*. Bar equals 2 mm. (a) *Hydra circumcincta*, typical posture of living polyp. (b) *H. oxycnidoides* (after Schulze, 1927). (c) *Pelmatohydra oligactis*, typical posture of living polyp. (d) *P. baikalensis*, fixed polyp. (e) *Pelmatohydra* sp., fixed polyp. (f) *Pachycordyle kubotai*, living hydranth with gonophores.

Nematocysts (in μm after Schulze drawing): Stenoteles 19.5×10.0, holotrichous isorhizas 10.5×4.0, atrichous isorhizas 10.5×4.3, desmonemes 4.3×3.3.

Data on karyotype absent

Lack of findings of *H. oxycnidoides* in Lake Baikal after 1925 implies that this species is in all probability very rare in this lake, or its identification for Lake Baikal is erroneous.

Genus Pelmatohydra

Validity of this genus was substantiated as a result of our earlier studies (Stepanjants et al., 2000a; Anokhin, 2002). Characteristic features are presence of stalk in living polyps and non-simultaneous formation of tentacles on lateral buds of the polyp. Undischarged thread of holotrichous isorhizas is packed in longitudinal spires only.

Pelmatohydra oligactis (Pallas, 1766) (Fig. 1c)

Number of tentacles 3–9: Length of tentacles in stretched state in starved polyp is 3–6 times the body length. Holotrichous isorhizas are oval (length is 2.3–2.8 times its width) (Fig. 2f).

Detailed description of representatives of Baikalian population of this species is given by Anokhin (2002).

Dioecious polyps

Measurements (in mm): Body length: living specimens 10–20 (relaxed state), fixed ones 7–9; body diameter: living specimens up to 1.5; stalk length 2–10; tentacles length: living specimens 70–80, fixed ones 1–6.

Nematocysts (μm): Stenoteles $10.0–13.0 \times 7.5–10.0$ and $8.0–8.5 \times 6.0–6.5$, holotrichous isorhizas

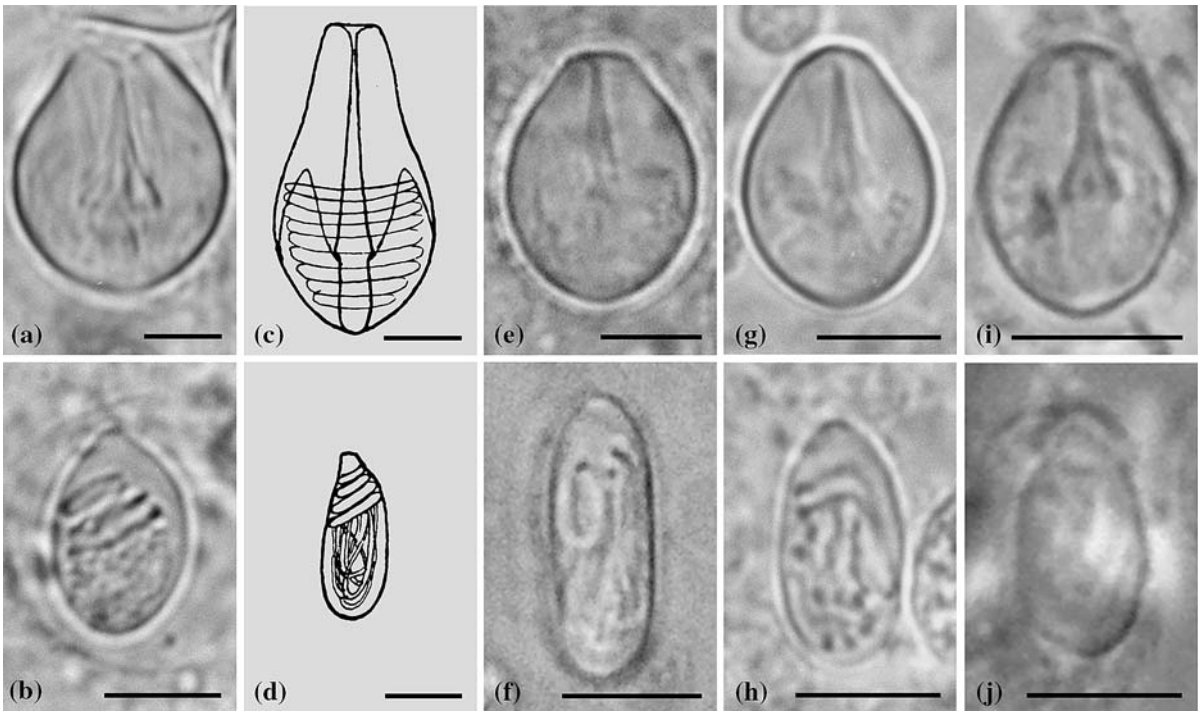

Figure 2. Hydras nematocysts (above – stenoteles, below – holotrichous isorhizas). Bar equals 5 μm. (a, b) *Hydra circumcincta* (c, d) *H. oxycnidoides* (after Schulze, 1927) (e, f) *Pelmatohydra oligactis* (g, h) *P. baikalensis* (i, j) *Pelmatohydra* sp.

8.0–11.5 × 3.0–4.5, atrichous isorhizas 6.0–9.0 × 3.0–5.0, desmonemes 4.0–7.0 × 3.0–4.5.

Karyotype (known before from Primorski Krai and North-West Russia; Anokhin & Kuznetsova (1999)): $2n = 30$, NF = 60 (meta-submetacentic chromosomes), index $X_{1/15} = 1.95 \pm 0.20$ ($p < 0.05$). Each chromosome of the 2nd or the 3rd pair carries a distinct negatively heteropycnotic region. Sex chromosomes are not distinguished (no data available on the Baikal and Biwa populations). Data on karyotype of *P. oligactis* from Baikal and Biwa are absent.

Boreal species of the Northern Hemisphere (Campbel, 1999).

Discovered for the first time in Lakes Baikal and Biwa.

Pelmatohydra baikalensis
(Swarczewsky, 1923) (Fig. 1d)

Number of tentacles 6, very seldom 5 or 7: Length of stretched tentacles of starved polyp 3–5 times body length. Holotrichous isorhizas capsules are broad and oval (length 1.8–2 times the width) (Fig. 2h).

Measurements (mm): Body length of living specimens 8–20 (relaxed state), fixed 3–7; body diameter of living specimens up to 1.5; stalk up to 7; tentacle length: living specimens up to 50, fixed ones 1–5.

Nematocysts (μm): Stenoteles 9.0–10.0 × 7.0–8.0 and 7.5 × 6.0, holotrichous isorhizas 7.0–9.0 × 3.5–4.5, atrichous isorhizas 7.0 × 3.0, desmonemes 4.0–6.0 × 4.0–5.0.

Karyotype: $2n = 30$, FN = 60 (meta-submetacentric chromosomes), index $X_{1/15} = 2.50 \pm 0.20$ ($p < 0.05$). Sex chromosomes are not distinguished. One of the larger chromosome pairs, indistinguishable in size (the 1st or the 2nd), bears a secondary constriction as an achromatic gap in every homologue (Fig. 3a). C-blocks (area) are localized in the centromeric regions of the chromosomes (Anokhin, 2002) (Fig. Ba).

A detailed description of the species (from new discoveries) and comparative characterization are given by Anokhin (2002).

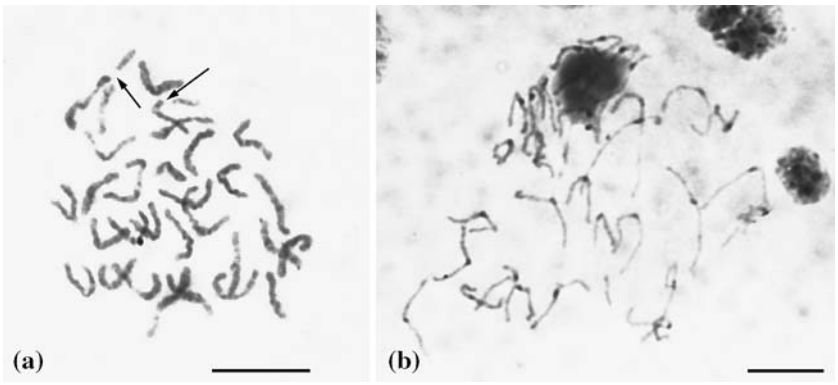

Figure 3. Mitotic chromosomes of *Pelmatohydra baikalensis*. Bar equals 10 μm. (a) Mitotic metaphases, $2n = 30$, arrows indicate achromatic gaps. (b) C-banded mitotic metaphase with C-blocks in the centromere region of each chromosome.

Endemic of Lake Baikal
Pelmatohydra sp. (Fig. 1e)

Major characters: Number of tentacles 5–6. On a bud, the first 3–5 tentacles are formed simultaneously (Fig. 1e) and grow at a similar rate, the rest in all probability arise somewhat later unlike *P. oligactis* and *P. baikalensis*, in which formation and growth of the first tentacles do not occur simultaneously (Fig. 1c, d). Holotrichous isorhizas have a more broadly oval shape (length 1.6–1.9 the width) than those in *P. baikalensis* and *P. oligactis* (Fig. 2f, h, j).

Measurements (in mm): In fixed polyps body length 0.7–5.0, body diameter 0.2–0.8, length of tentacles 0.2–2.0.

Nematocysts (μm): Stenoteles 7.5–8.0 × 6.0, holotrichous isorhizas 6.0–7.5 × 3.5–4.5, atrichous isorhizas (no data), desmonemes 5.0–5.5 × 3.5–4.0.

Data on karyotype absent.

If this is established as a new species it will be endemic to Khubsugul.

Order Athecata
Family Clavidae
Genus *Pachycordyle*

Validity of this genus was supported by our findings (Stepanjants et al., 2000b).

The major distinctive characters (observed on living organisms): colonies not branching or weakly branching; perisarc annulate completely or partially; continuous filiform tentacles are arranged in several rows in the upper part of the head of polyp; gonophores are eumedusoids, zone of their budding is on the stem or branches beneath the head of the polyp.

Pachycordyle kubotai Stepanjants et al. (2000b) (Fig. 1f)

Weakly branching stems; each branch terminates by polyp and beneath it a zone of budding of 1–2 gonophores-eumedusoids; up to 17 filiform tentacles, arranged in 3–4 rows in the upper part of polyp head around hypostome.

Measurements (in mm): Stem length 9–10; stem diameter 0.05–0.12; length of the polyp head 0.6–1.0; length of the developed gonophores with pedicel 0.32–0.33; diameter of the developed gonophores 0.30–0.40.

Nematocysts (μm). Microbasic euryteles 6.5–7.0 × 3.0–3.5, desmonemes 4.5 × 3.0–3.2.

Karyotype: $2n = 30$, chromosome morphology unknown, index $X_{1/15} = 2.70 \pm 0.50$ ($p < 0.05$). Sex chromosomes are not distinguished. Every homologue of the pair 4 carries the distinct negatively heteropycnotic region, probably NOR (Stepanjants et al., 2000a, b) (Fig. 4).

Order Limnomedusa
Family Olindiidae
Genus Craspedacusta

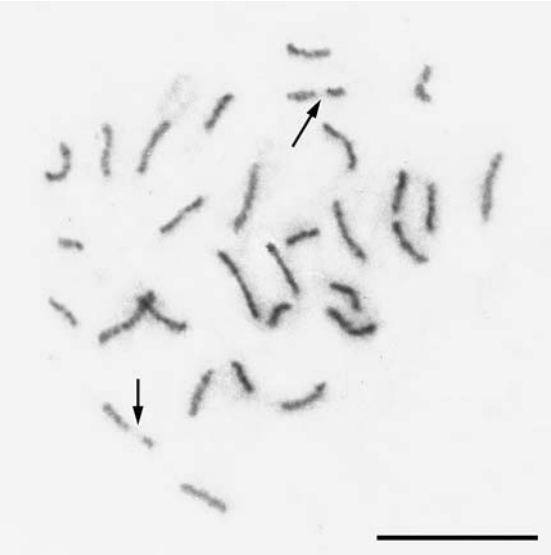

Figure 4. Mitotic chromosomes of *Pachycordyle kubotai*, $2n = 30$, arrows indicate achromatic gaps. Bar equals 10 μm.

The medusae shown in the Atlas of planktonic organisms in Lake Biwa (Negoro, 1982) as belonging to this genus is doubtful. As mentioned, these medusae may belong to *Pachycordyle kubotai*.

Conclusion

1. As a result of research in relict lakes of Asia (Baikal, Biwa and Khubsugul) four species of hydras have been discovered: *Hydra circumcincta*, *Pelmatohydra oligactis*, *P. baikalensis*, *Pelmatohydra* sp. (validity of the fifth species – *Hydra oxycnidoides* is doubtful); one species of the family Clavidae – *Pachycordyle kubotai*. A single medusa identitified as a species of the genus *Craspedacusta* is doubtful.
2. Genera *Pelmatohydra* and *Pachycordyle* are regarded as valid.
3. Among representatives of the order Hydrida, fauna of the genus *Pelmatohydra* is particularly rich.
4. The above species are not distinguished in chromosome number ($2n = 30$). The hydras are similar in the C-bands localization (in the centromeric region) but differ from one another in NOR localization and karyotype structure.

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