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Original Article

A new species of *Metadiaptomus* Wang & Wang, 2024 from the Qinghai-Tibetan Plateau, China (Copepoda, Calanoida, Diaptomidae)

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ABSTRACT

A new copepod species *Metadiaptomus aliensis* sp. nov., collected from lakes in the Qinghai-Tibetan Plateau, is described. *M. aliensis* sp. nov. is differentiated by total length, the fifth leg of both sexes, and the right antennule of the male, compared with the similar species *M. asiaticus* Ul'yanin, 1875 and *M. chevreuxi* Guerne & Richard, 1894. The low temperature species *M. aliensis* sp. nov. survives in a wide salinity range from fresh to polyhaline water, and a wide alkalinity range from 6.12 to 40.39 mmol/L. The first generic record of *M. aliensis* sp. nov. in the Qinghai-Tibetan Plateau contributes to our understanding of the global biogeography of the subfamily *Paradiaptominae*.

Introduction

Many specialized crustaceans develop well in high-elevation lakes (Liss et al. 1998, Jersabek et al. 2001). Expeditions to discover the distribution of crustaceans in high-altitude areas had been carried out over the world in the 20th century, e.g., the Rocky Mountains in North America (Anderson 1971, 1974), Central America (Löffler 1972), and the Himalayan region (Manca et al. 1994). The Qinghai-Tibetan Plateau (QTP), located in the center of Asia, is one of the highest plateaus of the world. It contains a large number of lakes with different water types (Zheng and Liu 2009; Zhu et al. 2020). Daday (1908), Stewart (1911), and Kiefer (1939) initiated planktonic crustacean research in the QTP at the beginning of the 20th century. This was followed by a scientific survey by the Chinese Academy of Sciences (CAS) in the mid-20th century (Shen and Song 1963, 1964, 1965; Shen 1979). The Chinese Academy of Geological Sciences (CAGS) carried out a plankton investigation in lakes in northern Tibet and reported 13 planktonic crustaceans (Zhao et al. 2005). Recently, Zhao et al. (2010) researched the annual succession of the planktonic community in Namuka Co, Bange County, northern QTP and found seasonal changes in total biomass and abundance of zooplankton and phytoplankton in saline lakes in northern Tibet. In 2006, a biological expedition was initiated by CAGS focusing on lakes in the Ali district, Tibet. Seven planktonic crustacean species were identified (Yuan et al. 2007).

As a fraction of the Gondwanian origin, the *Paradiaptominae* (Copepoda, Calanoida) is a part of the family Diaptomidae. It consists of 24 species, most of which are restricted in temporary or semi-permanent waters of arid areas. *Metadiaptomus* Methuen, 1910, with ten described species, is the largest genus of the subfamily. The second largest genus is *Paradiaptomus* Sars, 1895, consisting of nine species.

Rayner and Heeg (1994) concluded that subfamily *Paradiaptominae* is endemic to Africa. However, several *Paradiaptominae* species are reported to appear outside Africa: *Neolovenula alluaudi* Guerne and Richard, 1890 and *M. chevreuxi* Guerne and Richard, 1894 occur in Europe (Jaume 1989; Dussart and Defaye 2002).

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Metadiaptomus asiaticus Ul'yanin, 1875 was recorded in Asia, i.e., in China, Turkey, Iran, Ukraine, Mongolia, and Russia (Gurney 1929; Vasilyeva and Smirnov 1995; Rayner 1999, 2000; Sinev et al. 2009; Samchyshyna 2011; Gorlacheva et al. 2014; Federico et al. 2015). Yuan et al. (2007) reported the first record of *Metadiaptomus asiaticus* in the QTP.

In this paper, we present a new species belonging to the genus *Metadiaptomus*: *M. aliensis* sp. nov. appearing in the QTP. The aims are to (1) determine the taxonomic characteristics of the new species; (2) identify the difference between the new species and the similar species; and (3) clarify the distribution and ecological features of the new species.

Material and methods

Field work

All the sampled lakes during the autumn expedition on Ali district, the QTP, 2006, are shown in Figure 1. In this region, the annual average temperature falls below 0 °C, the annual average precipitation is approximately 50 mm, and the annual average evaporation is more than 2000 mm. Zooplankton samples were collected by filtering 20 liters lake water, which contains zooplankton community, through a plankton net (200 μm mesh). The samples were preserved in 5% formalin to fix biological specimens. Water chemistry analysis was conducted at the same place. Water temperature, pH, and salinity were measured *in situ* with the method described by Yuan et al. (2007).

Analysis and identification

Copepoda individuals were taken from samples. Three adult females and three adult males were examined. The appendages were dissected and photographed under a dissecting microscope Nikon SME 1500 and Nikon 90i with NIS-Element BR 3.1. The body structures were drawn. The descriptive terminology for the body parts followed Huys and Boxshall (1991).

Hydrochemistry analysis

Cl^-, SO_4^{2-}, HCO_3^-, CO_3^{2-}, Na^+, K^+, Ca^{2+}, and Mg^{2+} were conducted in the MNR Key Laboratory of Saline Lake Resources and Environment by conventional methods in Analysis Department of Qinghai Institute of Salt Lakes, CAS (1988). Alkalinity was calculated based on hydrochemistry data. According to Li et al. (2016) and Wang et al. (2021b), water types could be classified as SO_4·Cl-Ca·Mg, SO_4·Cl-Na, HCO_3-Na, and HCO_3-Ca·Mg. The dominant ion could be categorized as calcium, magnesium, sodium, bicarbonate, sulfate, chloride, and no dominant ion.

Material examined

Holotype comprises an adult female 1.2 mm and paratype series comprise two adult females and two adult males from Tai Co and Zhaxi Co on Ali district of the QTP. The holotype and paratype series are deposited in the Key Laboratory of Saline Lake Resources and Environment, Institute of Mineral Resources, Chinese Academy of Geological Sciences, Beijing, China (CAGS).

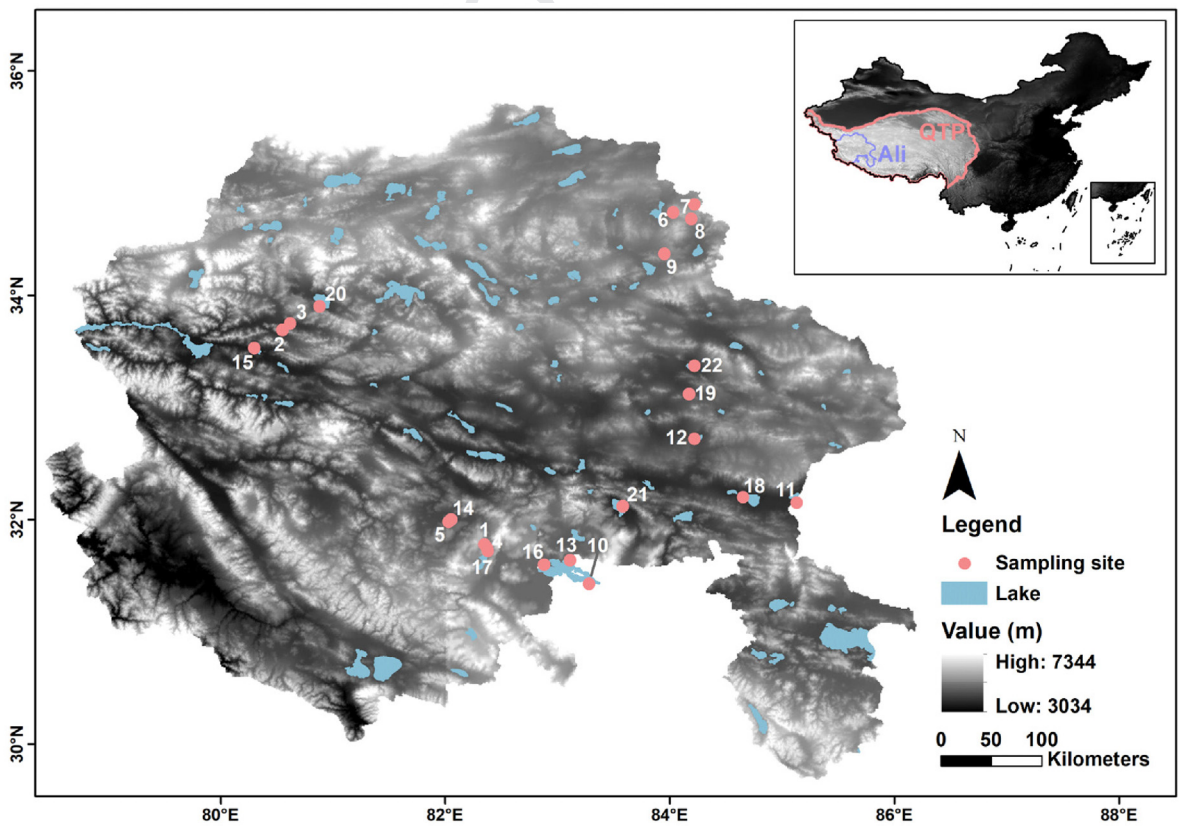

Figure 1. Map showing the location of sampled lakes. The new species *Metadiaptomus aliensis* sp. nov. was collected from Tai Co I, Tai Co II, and Zhaxi Co, marked by 2, 3, and 11, respectively, in the map. QTP, Qinghai-Tibet Plateau; Ali, Ali district.

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Results

Environmental habitat

Metadiaptomus aliensis n. sp. was found both in Tai Co I, Tai Co II, and Zhaxi Co. The three lakes are located in Ali district, northwest of the QTP (Figure 1). Tai Co I and Tai Co II are two small lakes separated by a levee at 4514 m a.s.l. No permanent surface water feeds the two lakes, and the main water supply is from precipitation and groundwater. Zhaxi Co covers a drainage basin of 50 km^2 with an elevation of 4400 m a.s.l.

The results of water parameters of Tai Co I, Tai Co II, and Zhaxi Co are shown in Tables 1 and 2. The piper diagram of the three lakes is presented in Figure 2. The water type of the studied water is SO_4·Cl-Na. The dominant cation is Na in Tai Co I, Tai Co II, and Zhaxi Co. Differences exist in the dominant anion of the three lakes. Cl is the main anion in Tai Co I, where no dominant anion is exhibited in Tai Co II. The dominant anion of Zhaxi Co is SO_4.

Taxonomy

The female antennule is symmetrical and 25-segmented, while the male antennule is asymmetrical, i.e., left antennule is similar to that of the female but the specialized grasping limb of the right antennule is 22-segmented. In both sexes, endopodite exists on legs I–IV, with two segments in the first leg and three segments in legs II–IV. The endopodite occurs on the fifth leg of females but only on the right fifth leg of males. In females, the urosome has three somites and a genital double-somite that expands laterally. Therefore, the species in the specimen belongs to Calanoida, Diaptomidae, *Paradiaptominae*, *Metadiatomus*.

Table 2. Hydrochemical parameters of the lakes where *Metadiaptomus aliensis* was found.

Lake	Ionic concentration (mg/L)								Alkalinity (mmol/L)
	Cl^-	SO_4^{2-}	HCO_3^-	CO_3^{2-}	Na^+	K^+	Ca^{2+}	Mg^{2+}	
Tai Co I	0.68	0.28	0.18	0.38	0.67	0.05	0.01	0.12	6.12
Tai Co II	0.7	0.2	0.05	0.38	0.62	0.05	0.01	0.1	3.99
Zhaxi Co	1.99	8.79	1.62	1.66	6.78	0.65	0.01	0.26	40.39

Order Calanoida Sars, 1903
Family Diaptomidae Baird, 1850
Genus *Metadiaptomus* Methuen, 1910
Metadiaptomus aliensis Wang & Wang, sp. nov.

Description. Female total length 1.1–1.3 mm (excluding caudal setae) (Figure 3A, B; Figure 4A). Prosome with six somites: cephalon distinct from first pediger; fourth and fifth pedigers partly fused; fifth pediger wings small and symmetrical. Proportional lengths of prosome somites: 50:7:12:10:11:10. Ratio of prosome-to-urosome including furcal rami 2.6:1. Prosome 2.5 × longer than wide. Urosome with four somites. Proportional lengths of urosome somites: 60:8:16:16. Genital double-somite approximately 2 × as long as wide; genital area asymmetrical, one extension located proximal-ventrally, another extension located distally (Figure 3C; Figure 4A). Furcal rami symmetrical, ~ 4 × longer than wide. Each ramus with six setae, five setae well developed, one seta short, and terminal on inner margin (Figure 3D; Figure 4A). Antennule (Figure 5A, B) symmetrical, 25-segmented, length ~ 1 mm. Armature of segments as follows: segment II with three setae; segment IV one seta; segment VI two seta; segment VIII one seta;

Table 1. Data on hydrological characteristics and appeared copepods of all sampled lakes during the autumn expedition in 2006 (modified after Yuan et al. 2007). Abbreviations used in appeared copepod: *A. salinus-Arctodiaptomus salinus*; *C. deitersi-Clelocamptus deitersi*; *C. feei-Cletocamptus feei*; *C. retrogressus-Cletocamptus retrogressus*; *C. ladakanus-Cyclops ladakanus*; *C. strenuous-Cyclops strenuous*; *M. asiaticus-Metadiaptomus asiaticus*; *M. aliensis* sp. nov.-*Metadiaptomus aliensis* sp. nov.

Lake number	Name	Temperature (°C)	pH	Salinity (g/L)	Altitude (m)	Appeared copepods
1	Degae Co	13.0	7.3	0.31	4811	–
2	Tai Co II	11.0	8.0	2.17	4514	*A. salinus* *M. aliensis* sp. nov.
3	Tai Co I	11.0	8.5	2.36	4514	*A. salinus* *M. aliensis* sp. nov.
4	Delage Co	16.0	8.5	6.95	4806	*C. deitersi* *C. strenuus*
5	Sekazhi I	17.0	9.6	8.47	4586	–
6	Yanshan L3	4.0.	7.0	8.69	~5040	–
7	Yanshan L2	6.0	7.0	12.69	~5040	–
8	Yanshan L4	6.0	7.0	17.25	~5040	–
9	Xiaoquan Lake	1.0	9.0	18.63	4850	–
10	Anglaren Co	16.0	8.8	21.28	4728	*C. ladakanus*
11	Zhaxi Co	10.0	9.0	21.59	4400	*A. salinus* *C. feei* *M. asiaticus* *M. aliensis* sp. nov.
12	Rena Co	6.8	9.0	26.70	4608	*C. feei*
13	Ruijiangmi Co	16.0	9.0	31.50	4710	*C. deitersi*
14	Sekazhi II	18.0	–	37.82	4586	–
15	Changmu Co	13.0	9.0	43.68	4432	*C. retrogressus* *C. feei*
16	Anglicaga	14.0	9.0	53.77	4724	–
17	Chaqin Co	11.0	9.0	73.79	4805	–
18	Dong Co	6.0	9.0	96.00	4416	–
19	Duoma Co	9.0	7.5	98.45	4687	–
20	Jiezechaka	11.0	8.5	128.53	4548	–
21	Mami Co	21.0	7.5	128.75	4333	–
22	Chabu Co	10.0	–	300.71	4534	–

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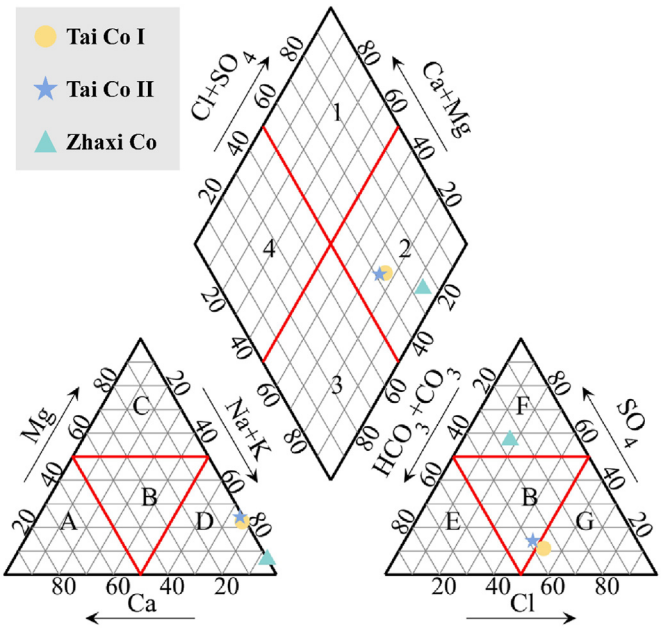

Figure 2. Piper diagram of the water samples from Tai Co I, Tai Co II, and Zhaxi Co. 1, SO_4·Cl-Ca·Mg type; 2, SO_4·Cl-Na type; 3, HCO_3-Na type; 4, HCO_3-Ca·Mg type. A, calcium type; B, no dominant type; C, magnesium type; D, sodium type; E, bicarbonate type; F, sulfate type; G, chloride type (Li et al. 2016; Wang et al. 2021b).

segment IX two setae; segments X–XVII and XIX–XXI one seta each; segment XXII–XXIV two setae; segment XXV with four setae. Antenna (Figure 6A) biramous. Coxa unarmed, basis with two setae on inner margin. Endopodite is 3-segmented, equal in length with exopodite; first endopodite segment ornamented with two setae medially on inner margin and spinules in outer posterior positions, second endopodite segment shorter with one seta posteriorly and seven setae at tip, third endopodite segment shortest with five setae terminally. Exopodite 8-segmented; armature as follows: 2, 1, 1, 1, 2, 1, 2, 4. Mandible (Figure 6B) coxa sickle-shaped, unarmed, gnathobase cutting edge with one isolated tooth and eight teeth. Basis longer than wide with one seta on inner medial margin, two setae on inner posterior margin, and three setae terminally. Endopodite 2-segmented; first endopodite segment not ornamented, and second endopodite segment with nine setae. Exopodite 5-segmented, with setal formula 1, 1, 1, 2, 2. Maxillule (Figure 6C) is coxa armed with seven plumose setae and seven stout spines. Basis armed with six setae. Endopodite 2-segmented; first endopodite segment armed with two proximal setae and one distal seta, second endopodite segment with ten setae. Exopodite is 2-segmented; first exopodite segment with one seta distally, second exopodite segment with four lateral setae and two distal setae. Maxilla (Figure 6D) 4-segmented. Praecoxa with four setae. Coxa with three setae proximally and two setae distally. Basis ornamented with two setae proximally. Endopodite is 2-segmented; first endopodite segment with three setae and second endopodite segment with three setae. Exopodite is 1-segmented and armed

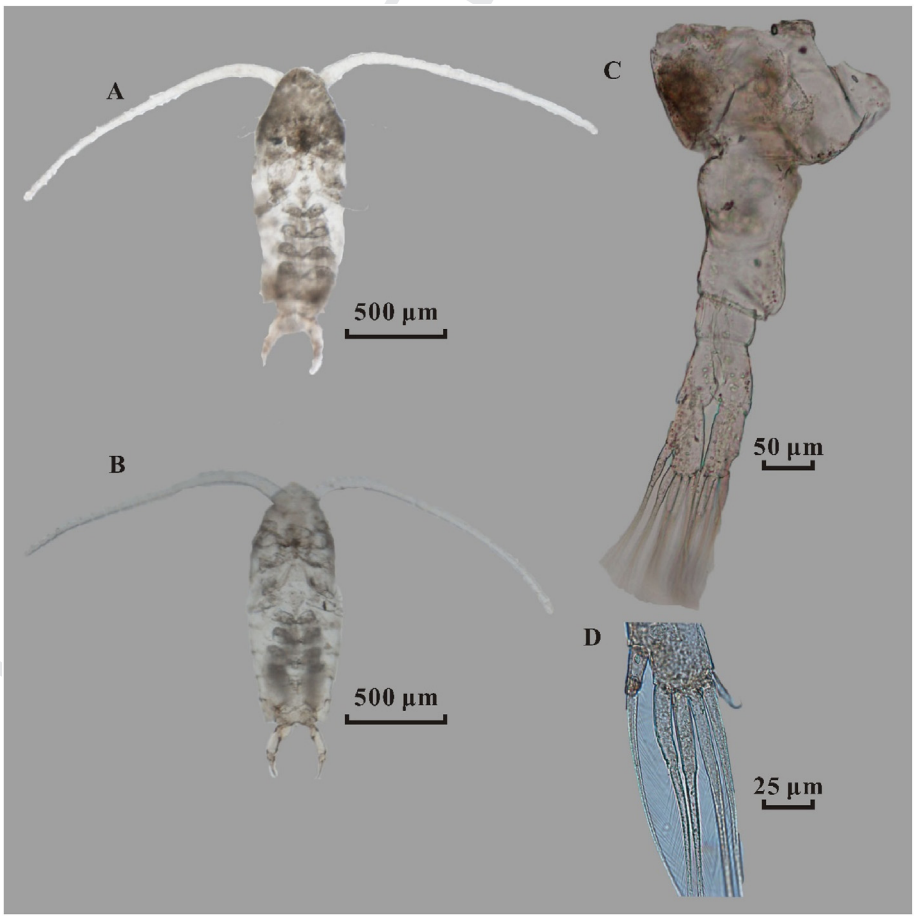

Figure 3. Female. A: prosome and antennule, dorsal view; B: prosome and antennule, ventral view; C: somite 6 and urosome (including furcal rami), ventral view; D: right furcal rami and setae.

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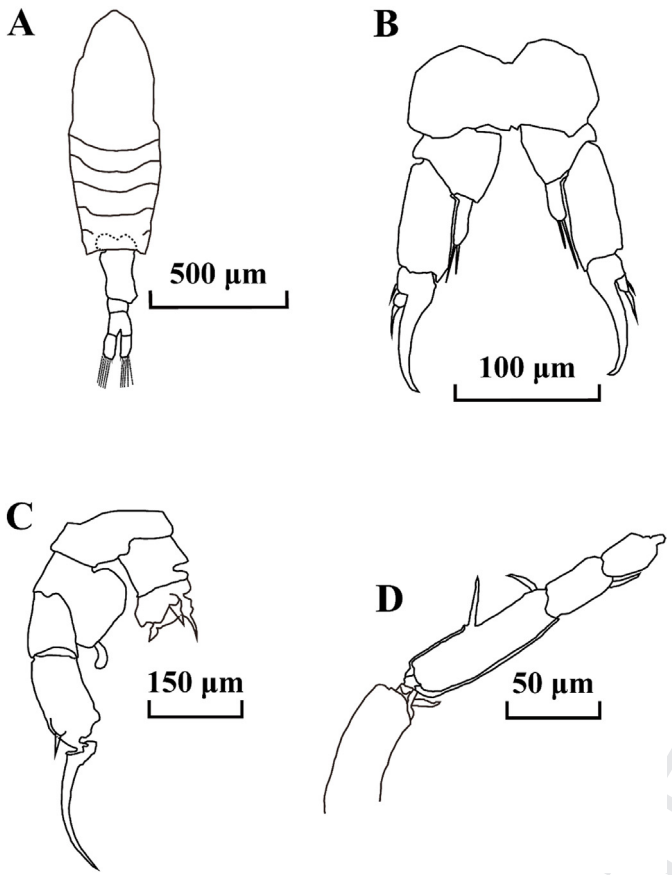

Figure 4. Drawing of *Metadiaptomus aliensis*. A: prosome and urosome (including furcal rami), female, dorsal view; B: fifth leg, female, ventral view; C: fifth leg, male, ventral view; D: right antennule, male, segments XIX–XXII.

with three setae. Maxilliped (Figure 6E) 7-segmented. Coxa incorporated into segment, setal formula 1, 2, 2, 1, 3, and spinules on inner distal margin. Basis semilunar with spinules in inner proximal position, inner posterior margin ornamented with three setae. Endopodite armature formula 5, 4, 3, 4, 4; each endopodite segment gradually shorter, with last endopodite segment shortest. Swimming legs I–IV (Figure 7A–D; Table 3) armature formula is as follows: first leg shorter than other swimming legs; exopodite 3-segmented, endopodite 2-segmented. Legs II–IV exopodites are 3-segmented, endopodites 3-segmented. Fifth leg (Figure 4B; Figure 8A, B) symmetrical, biramous, coxa unarmed, basis is shorter than coxa. Exopodite 3-segmented. First exopodite-segment length 72 μm, longer than basis, ~ 2 × longer than wide, no ornamentation. Second exopodite-segment is armed with a claw-shaped spine on inner margin and one small naked spine on outer margin, length 91 μm (including clawed-shaped spine), claw-shaped spine almost equal to first exopodite segment in length, with a row of small denticles along inner margin. Third exopodite-segment has a length of 13 μm, with a naked spine. Endopodite length 38 μm, not segmented, armed with two strong naked spines, half the length of the first exopodite segment, ~ 2/3 of first exopodite segment including spines. Male total length is 0.9–1.0 mm (excluding caudal setae). Prosome is 2.3 × as long as wide. Cephalon and pedigerous somites are similar to those of adult female. Ratio of prosome: urosome including furcal rami is ~ 2:1. Urosome is with five somites. Proportional lengths of urosome somites: 19:24:19:17:21. Genital double-somite (Figure 9D) is asymmetrical, length slightly shorter than width, with expanded protuberance on right side. Furcal rami and setae are as in female. Antennule (Figure 4D; Figure 9A–C) asymmetrical, left antennule similar to female. Right antennule is specialized grasping limb, 22-segmented. Proportional lengths of right antennule segments: 4:5:3:2:3:3:3:2:3:2:3:4:4:6:7:7:5:9:11:9:4:4. Armature of segments are as follows: segment XIII one seta; segment XIV one seta; segment XV one seta; segment XVI one seta; segment XX two setae. Spiniform processes on segments VIII, X–XI, XIII, XV–XVII, XVIV, XXI; processes on segments VIII, X–XI long and all the same length, processes on segment XIII, XV–XVII, XVIV, XXI ~ 1/2 length of other processes; segments XIII–XVII expanded, segment XIII firstly enlarged; segment XV reached maximum width. Swimming legs I–IV are as in female. Fifth leg is (Figure 4C; Figure 10A, B) biramous, asymmetrical. Right and left coxa unarmed. Basis is longer than coxa. Right basis is ornamented with small spinules in ventral view, remarkably larger than left basis. Right leg is 4-segmented. Exopodite is 2-segmented, first exopodite-segment length 97 μm, no ornamentation; second exopodite-segment length 113 μm, armed with a short naked spine mid-distally on outer margin, and a hook-shaped claw. The claw (Figure 10B) longer than second exopodite segment, prominently curved proximally in outer margin. Endopodite is 1-segmented, terminal equal to tip of proximal segment, and no ornamentation. Left leg is 4-segmented. Exopodite length 57 μm, 1-segmented, with two short naked spines distally on outer margin and a small process at tip; endopodite lacking.

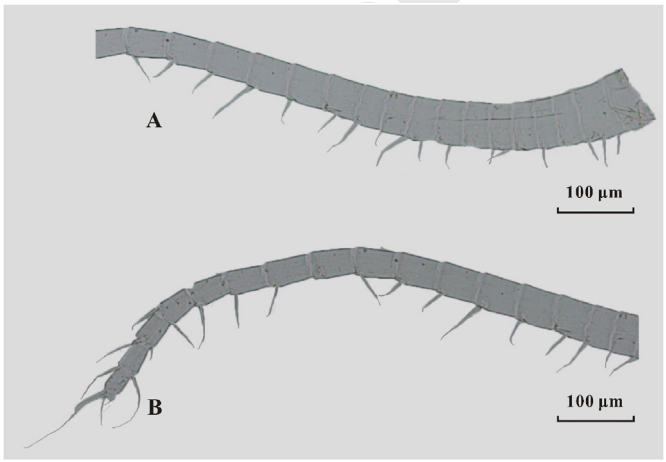

Figure 5. Female. A: left antennule, segments I–XVIII; B: left antennule, segments IX–XXV.

Discussion

Unique taxonomy features of Metadiaptomus aliensis

The new species *Metadiaptomus aliensis* was compared with the most similar species *M. asiaticus* based on Rayner (1999). Differences mainly occur in total length and the fifth leg of both sexes, and the right antennule of the male. Firstly, the total length of the female of *M. aliensis* is 1.1–1.3 mm and the total length of the male is 0.9–1.0 mm, while in *M. asiaticus*, female total length is 1.92 mm and male total length is 1.70 mm. Then, in the endopodite of the fifth leg on females of *M. aliensis*, two strong naked spines are almost equal in length to the endopodite (Figure 4B; Figure 8A, B), while in *M. asiaticus*, the two spines are half the length of the endopodite. In addition, the endopodite on the left fifth leg of the male differs in ornamentation. In *M. aliensis*, the left fifth leg is

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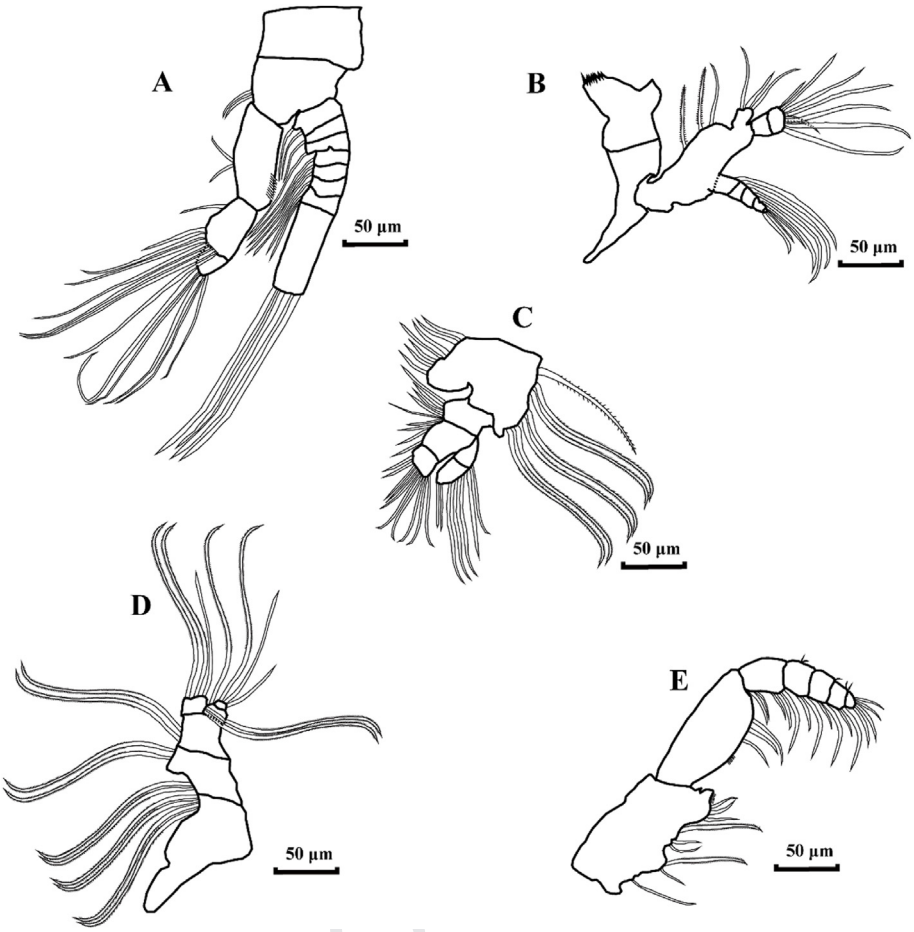

Figure 6. Drawing of *Metadiaptomus aliensis*. Female. A: antenna; B: mandible; C: maxillule; D: maxilla; E: maxilliped.

armed with two lateral spines and one very short distal process (Figure 4C; Figure 10A, B), evidently contrasted with the left fifth leg being armed with only two small adjacent lateral processes lying in parallel in *M. asiaticus*. Additionally, a key difference exists in the right fifth leg of the male between the two species: the claw on the right fifth leg of the male *M. aliensis* is prominently proximally curved in the outer margin (Figure 10B), while in *M. asiaticus*, the proximal part of the claw is smooth in the outer margin.

Difference also occurs on the right antennule of the male. In the new species, the right antennule is 22-segmented and armed with spiniform processes on segments VIII, X–XI, XIII, XV–XVII, XVIV, XXI (Figure 9A–C). Processes on VIII, X–XI are long and all the same length, while the process on segment XIII, XV–XVII, XVIV, XXI is ~ half the length of other processes. However, in *M. asiaticus*, the antennule is 18-segmented and armed with spiniform processes on segments VIII, X, XI, XIII. Processes on VIII, X, XI are long and all of the same length, while process on XIII is half the length of other processes.

The new species is also distinguished from other species in the genus *Metadiaptomus*: e.g., somite number of the urosome on the female, the genital double-somite of the female, total length of the male, and ornament of the exopodite of the left fifth leg on the male as noted by Rayner (1999). Here the differences between *M. chevreuxi* (Rayner, 1999, Marrone and Naselli-Flores, 2005) and *M. aliensis* sp. nov. are as follows. On the female of *M. aliensis*, the urosome comprises two somites and the genital double-somite features proximal and distal extensions (Figure 3A–C; Figure 4A), while in *M. chevreuxi*, the urosome comprises three somites and a large round expansion lies on the right side of the genital double-somite. On the male of *M. aliensis*, total length is 0.9–1.0 mm and the exopodite of the left fifth leg is armed with two lateral spines and one very short process distally (Figure 4C; Figure 10A), prominently differing with the total length of *M. chevreuxi* being more than twice, longer than 2 mm, and having an unarmed exopodite of the left fifth leg.

The unique taxonomy features of *Metadiaptomus aliensis* are likely to be reduced by special choice of life history strategies, when the reproduction, parenting, and growth of *M. aliensis* populations are challenged by the host water environment. Life history strategies posit that organisms decide how to allocate resources to maintain and develop populations, when resources are limited in the living environment (Wang et al. 2021c). Several studies have demonstrated that the different body size of *Limnocythere inopinata* Baird, 1843 (Crustacea, Ostracoda), populations represent the adaptive response to variable environment (Yin et al. 2001; Wang et al. 2021a). As a species of crustacea, the taxonomy characteristics of *M. aliensis*, especially the special total length, may contribute to maintain fitness confronting with high-mountain lake environment.

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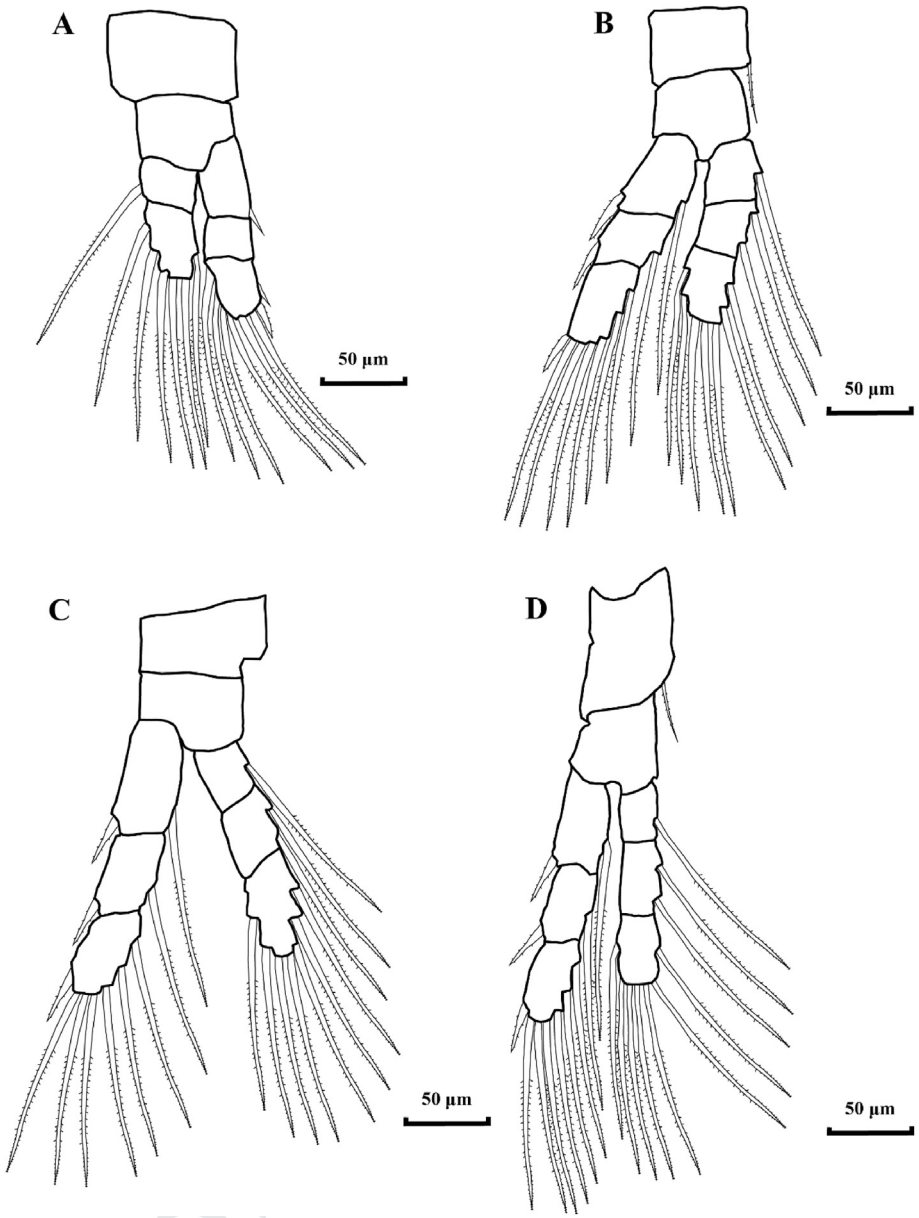

Figure 7. Drawing of *Metadiaptomus aliensis*. Female. A: leg I; B: leg II; C: leg III; D: leg IV.

Distribution and ecology

Rayner and Heeg (1994) studied the distribution modes of Diaptomidae in southern Africa, and concluded that its subfamily *Paradiaptominae* is narrowly distributed in Africa. But several *Paradiaptominae* species are also recorded in other regions. For example, *M. asiaticus* was found in Asia (Gurney 1929; Vasilyeva and Smirnov 1995; Rayner 1999, 2000; Yuan et al. 2007; Sinev et al. 2009; Samchyshyna 2011; Gorlacheva et al. 2014; Federico et al. 2015). The new species, *M. aliensis*, lives in the Qinghai-Tibetan Plateau, suggesting that it may be a Palearctic species. Additional studies on more regions are necessary to complete the distribution modes of *Paradiaptominae*.

Hydrochemical characteristics will greatly influence the distribution and abundance of copepod (Sprules 1975; Byron et al. 1984; Stoddard 1987). Studies of diaptomid copepods living in high-altitude lakes at America also show that the abundance of these species is affected by water depth, trout density, and nutrient concentration (Liss et al. 1998). *Metadiaptomus aliensis* sp. nov. can survive in a wide salinity range from fresh water (2.36 g/L in Tai Co I) to polyhaline water (21.59 g/L in Zhaxi Co), and in an alkalinity range from 6.12 mmol/L in Tai Co I to 40.39 mmol/L in Zhaxi Co. This species prefers relatively high salinity and alkalinity of host

Table 3. Swimming legs I–IV armature formula. Arabic numbers-number of setae; roman numbers refer to numbers of spines.

Swimming leg	Coxa	Basis	Endopodite	Exopodite
Leg I	0-0	0-0	0-1; 1, 2, 3	*I*-0; 0-0; *II*, 1, 1, 1, 3
Leg II	0-1	0-0	0-1; 0-2; 2, 2, 3	*I*-1; *I*-1; *I*, 1, 1, 1, 3
Leg III	0-0	0-0	0-1; 0-2; 2, 2, 3	*I*-1; *I*-1; *I*, 1, 1, 1, 3
Leg IV	0-1	0-0	0-1; 0-2; 2, 2, 3	*I*-1; *I*-1; *I*, 1, 1, 1, 3

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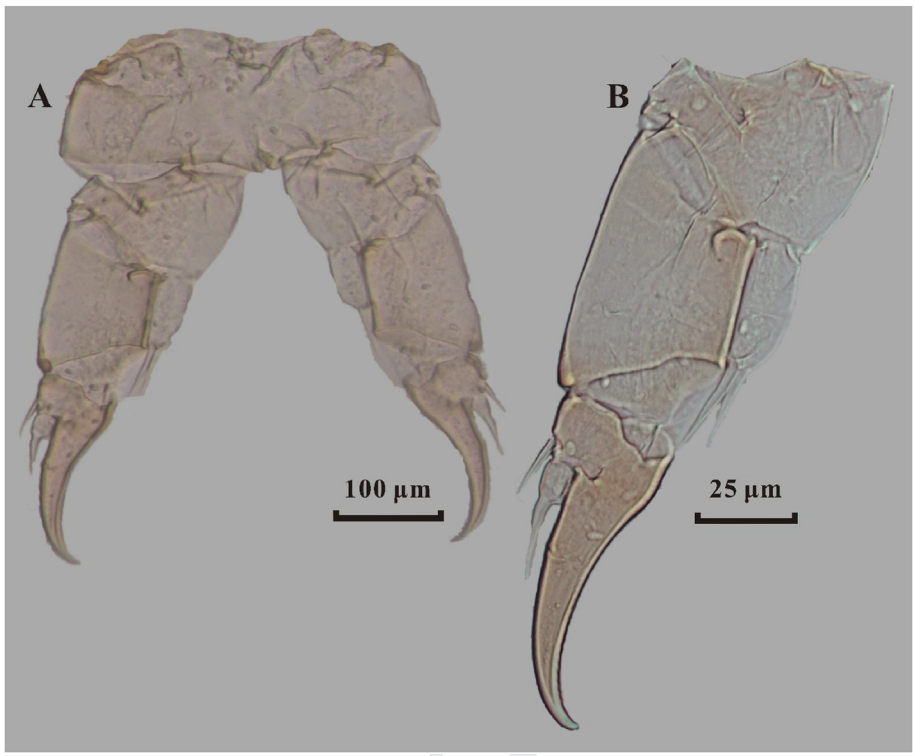

Figure 8. Female. A: fifth leg, ventral view; B: right leg, ventral view.

water as indicated by comparing the high density of 17 ind./L in Zhaxi Co with that of less than 1 ind./L in Tai Co I (ind./L means the biomass per liter). The biological expedition by Zhao et al. (2005) suggested that no *M. aliensis* exists in host water with water temperature of 16 °C during the summer, while in autumn it occurs with water temperature of 11 °C, and well develops in 10 °C. These evidences demonstrate that *M. aliensis* is a low temperature species.

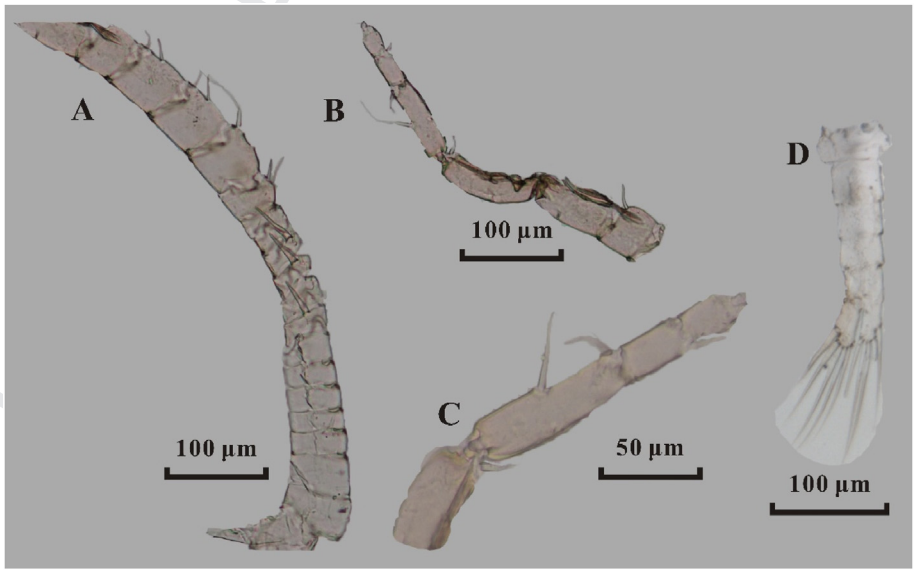

Figure 9. Male. A: right antennule, segments I–XVII; B: right antennule, segments XVII–XXII; C: right antennule, segments XIX–XXII; D: urosome (including furcal rami), ventral view.

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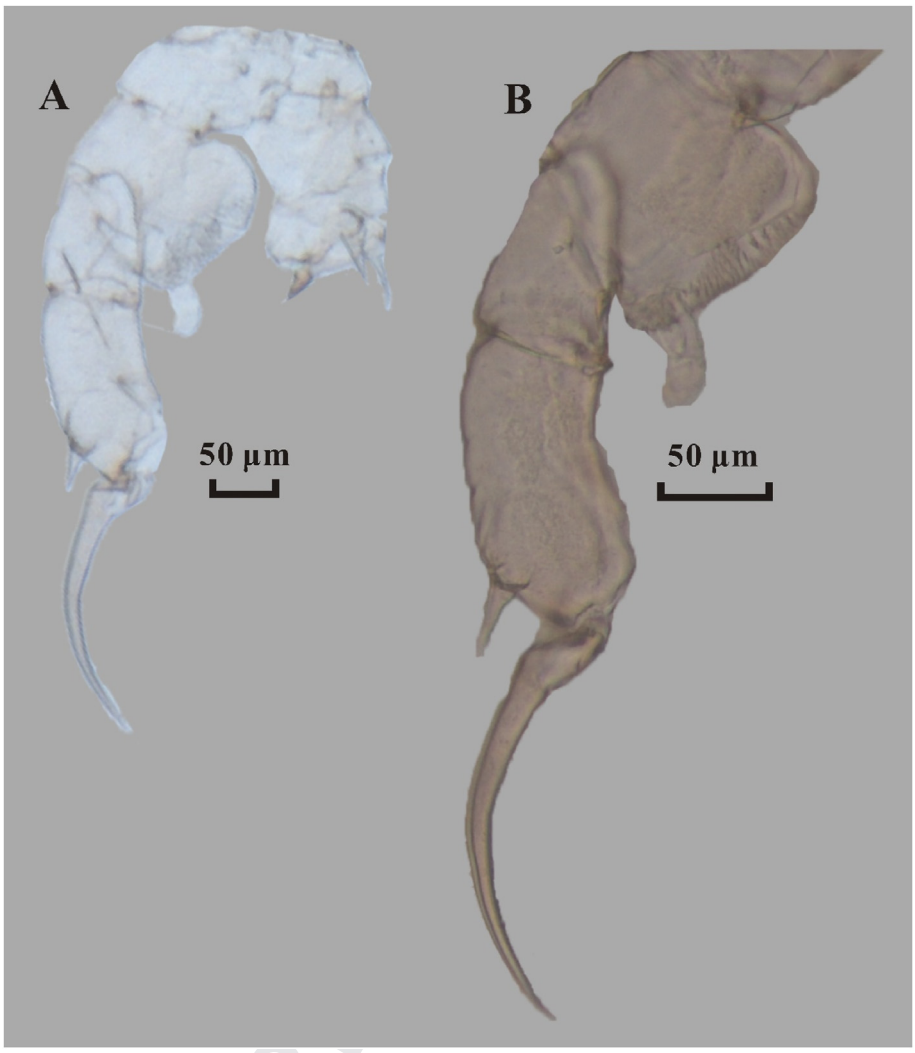

Figure 10. Male. A: fifth leg, ventral view; B: right leg, ventral view showing the curved proximal claw on the outer margin.

Conclusions

A new copepod species *Metadiaptomus aliensis* sp. nov., collected from lakes in the Qinghai-Tibetan Plateau, is described. Presentations of taxonomy, distribution, and ecology characteristics allow us to conclude as follows.

1. *M. aliensis* sp. nov. is differentiated by total length, the fifth leg of both sexes, and the right antennule of the male, compared with the similar species *M. asiaticus* Ul'yanin, 1875 and *M. chevreuxi* Guerne & Richard, 1894.
2. The low temperature species *M. aliensis* sp. nov. survives in a wide salinity range from fresh to polyhaline water, and a wide alkalinity range from 6.12 to 40.39 mmol/L.
3. The first generic record of *M. aliensis* sp. nov. in the Qinghai-Tibetan Plateau contributes to our understanding of the global biogeography of the subfamily *Paradiaptominae*.

Uncited references

Defaye et al., 2000; Marrone et al., 2015; He et al., 1989; He et al., 1993; He et al., 1995; Shen and Zhang, 1966; Zhao et al., 1996; Zhao et al., 1998.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Can Wang: Data curation, Formal analysis, Investigation, Methodology, Writing – original draft. **Hailei Wang:** Funding acquisition, Project administration, Supervision, Writing – review & editing. **Xingxing Kuang:** Funding acquisition, Project administration, Writing – review & editing. **Xianchun Yuan:** Data curation, Investigation, Writing – review & editing. **Ganlin Guo:** Data curation, Writing – review & editing.

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References

Analysis Department of Qinghai Institute of Salt Lakes, CAS. 1988. *Analysis methods for brine and salt*. Beijing: Science Press. p. 469 (in Chinese).

Anderson RS. 1971. Crustacean plankton of 146 alpine and subalpine lakes and ponds in western Canada. *Journal of the Fisheries Research Board of Canada* 28: 311–321.

Anderson RS. 1974. Crustacean plankton communities of 340 lakes and ponds in and near the National Parks of the Canadian Rocky Mountains. *Journal of the Fisheries Research Board of Canada* 31:855–869.

Byron ER, Folt CL, et al. 1984. Copepod and cladoceran success in an oligotrophic lake. *Journal of Plankton Research* 6:45–65.

Daday EV. 1908. Entomostraca et Hydrachindae e Tibet. *Records of the Indian Museum* 2:323–341.

Defaye D, Cuoc C, Brunet M. 2000. Genital structures and spermatophore placement in female Paradiaptominae (Copepoda, Calanoida, Diaptomidae). *Journal of Crustacean Biology* 20:245–261.

Gorlacheva EP, Tsybekmitova GTS, et al. 2014. Lake-margin ecosystems of saline lakes of the Borzya group (Zabaikalsky Krai, Russia) during the initial filling phase. *Chinese Journal of Oceanology and Limnology* 32:871–878.

Gurney R. 1929. LXIX.-Notes on the Diaptomidae of South Africa. *Annals and Magazine of Natural History* 4:572–584.

He ZH, Qin JG, Wang HQ, et al. 1989. Studies on the saline and hypersaline zooplanktons from Jinnan and Yinchuan regions. *Acta Hydrobiologica Sinica* 13:24–37 (in Chinese with English abstract).

He ZH, Qin KJ, Wang Y, et al. 1993. Biological resources in inland saline waters from southern Shanxi, China, Part I. Lake Xiaochi. *Journal of Dalian Fisheries College* 8: 1–16 (in Chinese with English abstract).

He ZH, Qin KJ, Wang Y, et al. 1995. Biological resources in inland saline waters from southern Shanxi, China, Part II. Pool Beimentan. *Journal of Dalian Fisheries College* 10:1–11 (in Chinese with English abstract).

Jersabek CD, Brancelj A, Stoch F, et al. 2001. Distribution and ecology of copepods in mountainous regions of the Eastern Alps. *Hydrobiologia* 453:309–324.

Kiefer F. 1939. Freilebende Ruderfusskrbse (Crustacea Copepoda) aus Northwest und Sudindien (Pandschab, Kaschmir, Ladak, Nilgirigebirge). *Memoirs of the Indian Museum, Calcutta* 13:83–203.

Li P, Li X, Meng X, et al. 2016. Appraising groundwater quality and health risks from contamination in a semiarid region of Northwest China. *Exposure and Health* 8: 361–379.

Liss WJ, Larson GL, Deimling EA, et al. 1998. Factors influencing the distribution and abundance of diaptomid copepods in high-elevation lakes in the Pacific Northwest, USA. *Hydrobiologia* 379:63–75.

Löffler H. 1972. Contribution to the limnology of high mountain lakes in Central America. *Internationale Revue der gesamten Hydrobiologie und Hydrographie* 57: 397–408.

Manca M, Cammarano P, Spagnuolo T. 1994. Notes on Cladocera and Copepoda from high-altitude lakes in the Mount Everest region (Nepal). *Hydrobiologia* 287: 225–231.

Marrone F, Naselli-Flores L. 2005. First record of a representative of the subfamily Paradiaptominae (Copepoda Calanoida Diaptomidae) in Italy: *Metadiaptomus chevreuxi* (Guerne & Richard, 1894). *Journal of Limnology* 64:89–92.

Marrone F, Miguel A, Valentina P, et al. 2015. The crustacean fauna of Bayan Onjuul area (Tôv Province, Mongolia) (Crustacea: Branchiopoda, Copepoda, Ostracoda). *North-Western Journal of Zoology* 11:288–295.

Rayner NA. 1999. Copepoda: Calanoida Diaptomidae Paradiaptominae. In: *Guides to the identification of the microinvertebrates of the continental waters of the world*, vol. 15. Leiden: Backhuys Publishers. pp. 1–71.

Rayner NA. 2000. Distribution and biogeography of the paradiaptominae (Copepoda: Calanoida: Diaptomidae). *African Journal of Aquatic Science* 25:93–97.

Rayner NA, Heeg J. 1994. Distribution patterns of the Diaptomidae (Calanoida: Copepoda) in southern Africa. *Hydrobiologia* 272:47–75.

Samchyshyna L. 2011. Faunistical overview of calanoid copepods (Crustacea) from continental waters of Ukraine. *Vestnik Zoologii* 45:9–15.

Shen JR, Song DX. 1963. Copepods in Shigatse and Gyangze regions. *Acta Zoologica Sinica* 15:79–97 (in Chinese).

Shen JR, Song DX. 1964. *Copepods in the southern part of Tibet. The proceedings on the comprehensive survey in Tibet (aquatic organisms and insects)*. Beijing: Science Press. pp. 51–71 (in Chinese).

Shen JR, Song DX. 1965. Crustacean planktons in the North Tibet. *Acta Zoologica Sinica* 17:298–308 (in Chinese).

Shen JR, Zhang CZ. 1966. On copepods of Inner Mongolia and Ning-Hsia, north China. *Acta Zoologica Sinica* 18:209–219 (in Chinese).

Shen JR. 1979. *Fresh water copepods, Crustacea, Arthropoda, China animal*. Beijing: Science Press. p. 450 (in Chinese).

Sinev AY, Alonso M, Sheveleva NG. 2009. New species of *Alona* from south-east Russia and Mongolia related to *Alona salina* Alonso, 1996 (Cladocera: Anomopoda: Chydoridae). *Zootaxa* 2326:1–23.

Sprules WG. 1975. Midsummer crustacean zooplankton communities in acid-stressed lakes. *Journal of the Fisheries Research Board of Canada* 32:389–395.

Stewart FH. 1911. List of the aquatic animals hitherto recorded from the provinces of Tsang and Ü in central Tibet, with a table showing their geographical distribution. *Records of the Indian Museum* 6:67–72.

Stoddard JL. 1987. Microcrustacean communities of high elevation lakes in the Sierra Nevada, California. *Journal of Plankton Research* 9:631–650.

Vasilyeva II, Smirnov NN. 1995. The biota of lake Abalakh (Yakutia, eastern Siberia, Russian Federation). *International Journal of Salt Lake Research* 4:57–63.

Wang C, Wang H, Kuang X, et al. 2021a. Life stages and morphological variations of *Limnocythere inopinata* (Crustacea, Ostracoda) from Lake Jiang-Co (northern Tibet): a bioculture experiment. *ZooKeys* 1011:25–40.

Wang C, Zhou H, Kuang X, et al. 2021b. Water quality and health risk assessment of the water bodies in the Yamdrok-tso basin, southern Tibetan Plateau. *Journal of Environmental Management* 300:113740.

Wang IM, Michalak NM, Ackerman JM. 2021c. Life history strategies. In: Shackelford TK, Weekes-Shackelford VA, editors. *Encyclopedia of Evolutionary Psychological Science*. Cham: Springer.

Yin Y, Li W, Yang X, et al. 2001. Morphological response of *Limnocythere inopinata* to hydrochemical environmental factors. *Science in China (Series D)* 31:252–257 (in Chinese).

Yuan XC, Zheng MP, Zhao W, et al. 2007. Plankton and ecology investigation of some saline lakes in Ali region, Tibet. *Acta Geologica Sinica* 81 (12):1754–1763 (in Chinese with English abstract).

Zhao W, Jiang H, He ZH. 1996. Planktonic crustaceans of inland saline waters in Sanbei district, northern China. *Journal of Dalian Fisheries College* 11:1–13 (in Chinese with English abstract).

Zhao W, Wang Y, Qin KJ, et al. 1998. Biological resources in inland saline waters from southern Shanxi, China, Part III. Lake Yanchi. *Journal of Dalian Fisheries College* 13:9–18 (in Chinese with English abstract).

Zhao W, Zheng MP, Xu XZ, et al. 2005. Biological and ecological features of saline lakes in northern Tibet, China. *Hydrobiologia* 541:189–203.

Zhao W, Zhao YY, Wang QH, et al. 2010. Spatial and temporal patterns of plankton assemblage structure in a high-altitude saline lake, Namuka Co in northern Tibet, China. *CLEAN-Soil, Air, Water* 38:960–968.

Zheng MP, Liu XF. 2009. Hydrochemistry of salt lakes of the Qinghai-Tibet Plateau, China. *Aquatic Geochemistry* 15:293–320.

Zhu LP, Peng P, Zhang GQ, et al. 2020. The role of Tibetan Plateau lakes in surface water cycle under global changes. *Journal of Lake Sciences* 32:597–608.

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