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Winter-Spring fauna of Cladocera of Dali Bai Autonomous Prefecture, Yunnan Province, China

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ABSTRACT

Winter-Spring fauna of Cladocera of Dali Bai Autonomous Prefecture, Yunnan Province, China

The Cladoceran fauna of Dali Bai Autonomous Prefecture, Yunnan Province, China was investigated in January 2015 and April 2016. Water bodies studied include Lake Erhai, second largest lake in Yunnan, several large lakes and reservoirs, and numerous smaller water bodies, located at 1800-2000 m above sea level. The winter-spring fauna of the area included 34 species, most of them Palearctic or widely distributed species, with plus five predominantly Paleotropical taxa. Thirty-one species occurred in Lake Erhai, while species richness in other water bodies not exceeded 14 species. Only parthenogenetic females were found in the majority of species, suggesting that Dali area climate is mild enough to allow Palearctic species to overwinter as active populations. *Ilyocryptus cuneatus* Štifter, 1988 is recorded for China for the first time; *Alona kotovi* Sinev, 2012, *Camptocercus uncinatus* Smirnov, 1971 and *Disparalona ikarus* Sinev & Kotov, 2011, are also first records for continental China.

Key words: Cladocera, zoogeography, morphology, China, Yunnan

RESUMEN

Fauna invernal y primaveral de cladóceros de la prefectura autónoma de Dali Bai, provincial de Yunnan, China

Durante enero de 2015 y abril de 2016 se investigó la fauna de cladóceros de la prefectura autónoma de Dali Bai, provincia de Yunnan, China. Las masas de agua estudiadas incluyeron el lago Erhai, segundo en tamaño de Yunnan, varios lagos grandes y embalses, y numerosos pequeños cuerpos de agua, situados a una altitud de 1800 – 2000 msnm. La fauna invernal y primaveral de cladóceros incluye 34 especies, muchas de ellas de distribución Paleartica o ubiquistas, con sólo cinco taxones encontrados de predominancia Paleotropical. Se encontraron 31 especies en el lago Erhai, mientras que la riqueza en otras masas de agua no superó las 14 especies, mostrando la mayor diversidad de biotopos en este lago. Sólo se encontraron hembras partenogenéticas de la mayoría de las especies, lo que sugiere que la zona de Dali tiene un clima suficientemente suave como para permitir a las especies paleárticas pasar el invierno como poblaciónes activas. Ilyocryptus cuneatus *Štifter, 1988 se ha citado en China por primera vez;* Alona kotovi *Sinev, 2012,* Camptocercus uncinatus *Smirnov, 1971 y* Disparalona ikarus *Sinev & Kotov, 2011, se han citado también por primera vez para la China continental.*

Palabras clave: *cladóceros, zoogeografía, morfología, China, Yunnan.*

INTRODUCTION

The Cladocera of East Asia have been actively investigated during the last decades. Local faunas were recently studied in Far East of Russia (Kotov *et al.*, 2011ab), South Korea (Kotov *et al.*, 2012, 2017; Jeong *et al.*, 2014) and China (Sinev *et al.*, 2015; Chertoprud *et al.*, 2017) and numerous new taxa were described from the region (Kotov *et al.*, 2006; Korovchinsky, 2009; Kotov & Sinev 2011; Jeong *et al.*, 2012, 2013, 2017; Sinev *et al.*, 2016) Checklists were published for Korea (Jeong *et al.*, 2014) and China (Xiang *et al.*, 2015; Ji *et al.*, 2015). But most regions of continental China are not yet well studied, with most faunistic data for the country based on ecological work with doubtful identifications (Xiang *et al.*, 2015; Ji *et al.*, 2015).

The main water body of Dali Bai Autonomous Prefecture (Yunnan Province, China) is Lake Erhai, the second largest lake in Yunnan Province. It is a fault lake situated at 1972 m above sea level. Its area is about 250 square kilometers; length of the lake is about 40 kilometers and width is about 7–8 kilometers; average depth is 11 m. Several large natural lakes - Xihu, Zibi, Jainhu, Chenghai and Shuizhangdi, as well as numerous smaller reservoirs and artificial ponds are located in the vicinity of Lake Erhai at altitudes of 1800-2000 m. Lake Erhai region is rather insular, surrounded by mountainous ranges with no lentic water bodies. Distance from Lake Erhai to Lake Dianchi (Kunming Area), the largest lake in the region, is over 250 km, with no natural lakes in between, but several small reservoirs were constructed there in the course of the 20th century.

The Cladoceran fauna of the area has been poorly studied; most data come from previous hydrobiological studies of Lake Erhai (Lu, 1939). They revealed 12 species of Cladocera there. Pelagic communities of Lake Erhai were investigated on a regular basis (Li *et al.*, 1963; Wu & Wang, 1999; Yang *et al.*, 2014), and Cladocera remains in the lake sediments were also studied recently (Liu *et al.*, 2014; Lu *et al.*, 2016). During the last century, Lake Erhai became subject to eutrophication, exotic fish introduction and degradation of natural macrophyte communities, lead to strong changes in cladoceran species composition (Liu *et al.*, 2014; Lu *et al.*, 2016). No data for other large water bodies in Dali area are available. While records for Yunnan cladocerans in general are numerous (see Xiang *et al.*, 2015; Ji *et al.*, 2015), only few records refer specifically to Dali Area.

The aim of present study was to evaluate spring-winter fauna of Cladocera of Lake Erhai and other water bodies of Dali area (Table 1), with special attention to the littoral fauna.

MATERIALS AND METHODS

Samples were collected by the two first authors in January 2015 and in April 2016 by a standard plankton net (25 cm diameter, 100 μm mesh size) and dip net (100 μm mesh size) and immediately fixed in 3 % formaldehyde. In locations with a complex structure of the littoral zone, samples were taken in different zones of vegetation, i.e. plants with submerged or floating leaves were rinsed by water to a bucket, reed-like plants scraped by dip nets, etc. Specimens were selected from the samples under a binocular stereoscopic microscope Biolam MBI-10, placed on slides in a drop of a glycerol-water mixture and studied under microscopes Olympus CX-41 and CX-51. Dissections were conducted by electrolytically sharpened tungsten needles. Measurements were conducted using an eyepiece-micrometer. Drawings were made by means of camera lucida.

RESULTS

We recovered 34 species of Cladocera, including a single species of Sididae, 11 species of Daphnidae, a single species of Macrothricidae, two species of Ilyocryptidae, a single species of Bosminidae, and 18 species of Chydoridae (see Table 2). *Ilyocryptus cuneatus* Štifter, 1988 is here recorded for China for the first time. Three more species, *Alona kotovi* Sinev, 2012, *Camptocercus uncinatus* Smirnov, 1971 and *Disparalona ikarus* Sinev & Kotov, 2011, known only from Hainan Island (Sinev *et al.*, 2015) are recorded for continental China for the first time. Comments on the taxa are represented below. Among 34 species recorded, 7 are planktonic and 27 are

Table 1. List of sampling sites (W - winter samples, S - spring samples). *Lista de lugares de muestreo (W – en invierno, S – en primavera).*

	Sampling site	Latitude	longitude	Date
W1	Lake Erhai, Xi'er river mouth within Dali city, stone embankment, abundant submerged macrophytes and filamentous algae	N 25º 36' 11.4"	E 100º 13' 43.9"	19-01-2015
W2	Lake Erhai, stone embarkment within Dali city, abundant submerged macrophytes and filamentous algae	N 25º 36' 26.7"	E 100º 14' 27.8"	19-01-2015
W3	Decorative pond within Dali city, with rock bottom without macrophytes	N 25º 36' 33.9"	E 100º 15' 08.8"	19-01-2015
W4	Lake Erhai, low clay shore, submerged terrestrial grasses	N 25º 39' 53.2"	E 100º 17' 01.9"	19-01-2015
W5	Lake Erhai, open rocky littoral, filamentous algae on stones	N 25º 39' 52.9"	E 100º 16' 52.6"	19-01-2015
W6	Lake Erhai, littoral zone with water hyacinth (*Eichhornia crassipes)*	N 25º 41' 27.2"	E 100º 16' 26.6"	19-01-2015
W7	Lake Erhai, open rocky littoral, filamentous algae on stones,	N 25º 44' 00.7"	E 100º 13' 56.3"	19-01-2015
W8	Lake Erhai, rocky littoral with water caltrop (*Trapa* sp.) and filamentous algae on rocks	N 25º 49' 53.2"	E 100º 13' 09.9"	19-01-2015
W9	Lake Erhai, low clay shore, submerged terrestrial grasses	N 25º 51' 11.9"	E 100º 13' 14.9"	19-01-2015
W10	Lake Erhai, rocky littoral with water caltrop (*Trapa* sp.), water hyacinth (*Eichhornia crassipes)*, and filamentous algae on rocks	N 25º 53' 43.1"	E 100º 12' 52.0"	19-01-2015
W11	Lake Erhai, low clay shore with water hyacinth (*Eichhornia crassipes)* and water fern (*Salvinia* sp.)	N 25º 57' 09.9"	E 100º 09' 24.1"	19-01-2015
W12	Paddy field	N 25º 56' 10.5"	E 100º 06' 30.8"	19-01-2015
W13	Temporary pool with submerged terrestrial vegetation and water fern (*Salvinia* sp.) on meadow close to W12			19-01-2015
W14	Ornamental pond with stone embankment, without macrophytes	N 25º 51' 13.0"	E 100º 13' 35.4"	19-01-2015
W15	Irrigation ditch in garlic field	N 26º 00' 41.0"	E 100º 04' 25.8"	20-01-2015
W16	Lake Xihu, littoral zone with water hyacinth (*Eichhornia crassipes*) and abundant submerged macrophytes	N 26º 00' 56.1"	E 100º 03' 07.5"	20-01-2015
W17	Lake Xihu, littoral zone with abundant submerged macrophytes	N 26º 00' 57.5"	E 100º 03' 09.7"	20-01-2015
W18	Pond near Lake Xihu, overgrown with water lily and submerged macrophytes	N 26º 00' 54.5"	E 100º 03' 12.4"	20-01-2015
W19	Pond near Lake Xihu, overgrown with submerged macrophytes, close to W18	-	-	20-01-2015
W20	Paddy field	N 26º 00' 57.7"	E 100º 03' 13.2"	20-01-2015
W21	Lake Zibi, stone embankment, abundant submerged macrophytes	N 26º 08' 04.5"	E 99º 57' 20.3"	20-01-2015
W22	Lake Zibi, low coast, submerged terrestrial grasses	N 26º 08' 04.1"	E 99º 57' 08.1"	20-01-2015
W23	Fish pond close to Lake Zibi, abundant filamentous algae	N 26º 08' 05.3"	E 99º 57' 07.2"	20-01-2015
W24	Yuhua reservoir, low coast with submerged terrestrial grasses	N 26º 25' 35.4"	E 99º 57' 54.0"	20-01-2015
W25	Lake Jainhu, shallow littoral zone with submerged macrophytes	N 26º 29' 06.4"	E 99º 56' 36.9"	20-01-2015
W26	Pond in agricultural area, without macrophytes	N 25º 43' 26.3"	E 100º 10' 54.6"	21-01-2015
W27	Fish pond in agricultural area, without macrophytes	N 25º 43' 42.3"	E 100º 10' 59.6"	21-01-2015
W28	Lake Erhai, submerged terrestrial vegetation and water hyacinth (*Eichhornia crassipes)*	N 25º 43' 51.8"	E 100º 11' 14.4"	21-01-2015
W29	Lake Erhai, rocky littoral with water hyacinth (*Eichhornia crassipes*) and submerged macrophytes	N 25º 44' 00.0"	E 100º 11' 04.6"	21-01-2015
W30	Irrigation channel going from Lake Erhai, about 50 m from the lake, muddy bottom and submerged macrophytes	N 25º 44' 15.3"	E 100º 10' 18.6"	21-01-2015
W31	Reservoir, clay shore with submerged terrestrial grasses	N 25º 27' 16.2"	E 100º 11' 42.8"	21-01-2015
W32	Chenguanchang reservoir, clay shore without macrophytes	N 25º 24' 19.8"	E 100º 11' 18.5"	21-01-2015
W33	Pool in river valley	N 25º 24' 12.2"	E 100º 12' 05.6"	21-01-2015
S1	Pond near Lake Xihu, overgrown with water lily and submerged macrophytes (same loc. as W18)	N 26º 00' 54.5"	E 100º 03' 12.4"	19-04-2016
S2	Lake Xihu, littoral zone with abundant submerged macrophytes	N 26º 00' 53.7"	E 100º 03' 11.4"	19-04-2016
S3	Lake Xihu, littoral zone with water hyacinth (*Eichhornia crassipes*) and abundant submerged macrophytes (same loc. as W16)	N 26º 00' 56.1"	E 100º 03' 07.5"	19-04-2016

Cont.

Table 1. (cont.)

S4	Lake Xihu, littoral zone with abundant submerged macrophytes (same loc. as W17)	N 26º 00' 57.5"	E 100º 03' 09.7"	19-04-2016
S5	Lake Zibi, littoral zone with abundant submerged macrophytes	N 26º 08' 22.5"	E 99º 57' 07.7"	19-04-2016
S6	Lake Zibi, littoral zone with abundant submerged macrophytes	N 26º 08' 23.2"	E 99º 57' 05.2"	19-04-2016
S7	Lake Zibi, littoral zone with abundant submerged macrophytes	N 26º 08' 35.8"	E 99º 58' 58.9"	19-04-2016
S8	Pond near Lake Zibi, abundant submerged macrophytes	N 26º 08' 37.4"	E 99º 56' 58.0"	19-04-2016
S9	Lake Zibi, littoral zone with reed stands	N 26º 08' 50.5"	E 99º 56' 55.6"	19-04-2016
S10	Reservoir, clay shore	N 26º 17' 24.5"	E 99º 58' 39.7"	19-04-2016
S11	Yuhua reservoir, low clay coast with filamentous algae	N 26º 25' 26.2"	E 99º 58' 02.0"	19-04-2016
S12	Lake Jainhu, shallow littoral zone with submerged macrophytes (same loc. as W25)	N 26º 29' 06.4"	E 99º 56' 36.9"	20-04-2016
S13	Lake Jainhu, open shallow littoral close to S12	-	-	20-04-2016
S14	Reservoir, clay bottom with submerged terrestrial vegetation	N 25º 28' 34.9",	E 100º 25' 40.2"	20-04-2016
S15	Fish pond	N 25º 27' 06.7"	E 100º 34' 06.6"	20-04-2016
S16	Fish pond	N 25º 26' 11.7"	E 100º 35' 14.7"	20-04-2016
S17	Southern coast of Shuizhangdi lake, abundant submerged macrophytes and filamentous algae	-	-	20-04-2016
S18	Pond close to Shuizhangdi lake, abundant submerged macrophytes	N 25º 26' 15.4"	E 100º 36' 03.1"	20-04-2016
S19	ditch with concrete embankment close to Shuizhangdi lake, abundant submerged macrophytes	N 25º 26' 17.2"	E 100º 36' 04.7"	20-04-2016
S20	Shuizhangdi lake, abundant submerged macrophytes and filamentous algae	N 25º 26' 20.7"	E 100º 35' 36.7"	20-04-2016
S21	Lotus pond	N 25º 26' 19.8"	E 100º 35' 33.1"	20-04-2016
S22	Reservoir, sample at the dam	N 25º 41' 39.4"	E 100º 38' 49.2"	20-04-2016
S23	Same reservoir as S22, clay bottom without macrophytes	N 25º 41' 13.3"	E 100º 38' 43.2"	20-04-2016
S24	Small reservoir, abundant submerged macrophytes,	N 26º 23' 34.6"	E 100º 38' 38.7"	21-04-2016
S25	Same reservoir as S24, open littoral with clay bottom	N 26º 23' 34.1"	E 100º 38' 25.9"	21-04-2016
S26	Lake Chenghai, open gravel littoral	N 26º 27' 49.6"	E 100º 38' 44.2"	21-04-2016
S27	Lake Chenghai, open gravel littoral	N 26º 33' 34.1"	E 100º 38' 27.4"	21-04-2016
S28	Pool in stream bed	N 26º 05' 23.2"	E 100º 33' 47.0"	21-04-2016
S29	Pond connected by channel to Lake Erhai	N 25º 43' 16.9"	E 100º 11' 32.1"	22-04-2016
S30	Pond in agricultural area, without macrophytes (same loc. as W26)	N 25º 43' 26.3"	E 100º 10' 54.6"	22-04-2016
S31	Fish pond without macrophytes (same loc. as W27).	N 25º 43' 42.3"	E 100º 10' 59.6"	22-04-2016
S32	Lake Erhai, rocky littoral with water hyacinth (*Eichhornia crassipes*) and submerged macrophytes, (same loc. as W29).	N 25º 44' 00.0"	E 100º 11' 04.6"	22-04-2016
S33	Lake Erhai, shallow littoral zone with water caltrop (*Trapa* sp.) and abundant submerged macrophytes	N 25º 56' 22.3"	E 100º 05' 50.5"	22-04-2016
S34	Irrigation channel close to Lake Erhai, abundant submerged macrophytes	N 25º 56' 11.4"	E 100º 06' 32.3"	22-04-2016
S35	Lake Erhai, Xi'er river mouth within Dali city, abundant submerged macrophytes and filamentous algae (same loc. as W1)	N 25º 36' 11.4"	E 100º 13' 43.9"	22-04-2016
S36	Lake Erhai, stone embankment within Dali city, abundant submerged macrophytes and filamentous algae (same loc. as W2)	N 25º 36' 26.7"	E 100º 14' 27.8"	22-04-2016
S37	Decorative pond within Dali city, with rock bottom without macrophytes (same loc. as W3)	N 25º 36' 33.9"	E 100º 15' 08.8"	22-04-2016
S38	Lake Erhai, open rocky littoral, filamentous algae on stones (same loc. as W5)	N 25º 39' 52.9"	E 100º 16' 52.6"	22-04-2016
S39	Lake Erhai, bay separated by stone pier, abundant submerged macrophytes, filamentous algae on stones	N 25º 41' 22.8"	E 100º 16' 24.8"	22-04-2016
S40	Lake Erhai, open rocky littoral, filamentous algae on stones (same loc. as W7)	N 25º 44' 00.7"	E 100º 13' 56.3"	22-04-2016

substrate-associated. We did not find *Bosmina coregoni*, which is present in pelagic zone of Lake Erhai across the year according to Yang *et al.* (2014), probably because we collected only shore samples.

In winter, most frequent littoral species in the area were *Chydorus* cf. *sphaericus* and *Flavalona costata*. Other common species were *Disparalona chappiuisi*, *Camptocercus uncinatus* and *Coronatella rectangula*. In spring, all these species remain common, *Chydorus* cf. *spahaericus* and *Coronatella rectangula* being most frequent, and two more species, *Simocephalus mixtus* and *Pleuroxus quasidenticulatus* became common as well. Among planktonic species, *Bosmina longirostris* was most common during both winter and spring.

Family Sididae

Sida ortiva Korovchinsky, 1979. Littoral species, associated with vegetation; specimens are able to attach to a substrate. Common in the area in both winter and spring, found in vegetated areas of Lake Erhai, lake Xihu and Lake Jianghu, Zibi reservoir and in ponds. East Asian species, distributed from East Siberia to Bangladesh and South Vietnam (Korovchinsky, 2004). A first record for Yunnan province. Earlier records of *Sida crystallina* (O. F. Müller, 1776) from South-East China, including Yunnan (Chiang & Du, 1979) probably all belong to *S. ortiva* (see Korovchinsky, 2004). For description, see Korovchinsky (2004), and Kotov *et al.*, (2012).

Family Daphniidae

Ceriodaphania dubia Richard, 1894. Planktonic species, found only in Lake Erhai in winter (loc. W2, W6, W7). Widely distributed Palearctic species, rare in China, with few records in Taiwan, Wuhan, Jiangxi, Yunnan (Xiang *et al.*, 2015), and in Xinjiang (Chertoprud *et al.*, 2017). Studied specimens (Fig. 1A-C) share diagnostic characters of Palearctic populations. For description of European populations, see Hudec (2010).

Ceriodaphnia quadrangula (O.F. Müller, 1785). Planktonic species, rare in the area, found in Erhai in winter and spring (loc. W11, W12, S29) and in Zibi in spring only (loc. S7). Widely distributed Palearctic species, common in China (Xiang *et al.*, 2015). Recorded for Dali Area by Lu (1939). For description of European populations, see Hudec (2010)

Ceriodaphnia reticulata (Jurine, 1820). Planktonic species. Found only in Lake Chenghai in spring. Widely distributed Palearctic species, rare in China, recorded mostly in mountainous areas (Tibet, Xinjiang, Yunnan, Gansu and Qinghai provinces), and in Nanjing, Jiangsu (Xiang *et al.*, 2015) but, in our opinion, the latter record is doubtful. For description of European populations, see Hudec (2010).

Daphnia (Daphnia) galeata Sars, 1864. Pelagic planktonic species, found in Lake Erhai, Lake Xihu, and Lake Shuizhangdi, in open water samples. Common Palearctic species. According to Xiang *et al.* (2015), common in large lakes and reservoirs of China, including Yunnan, and almost the only pelagic *Daphnia* in Southern China, reaching the island of Hainan in the South. For Yunnan, taxonomic status of *D. galeata* from Lake Dianchi was confirmed by genetical studies (Ma *et al.*, 2015). Record of *D. hyalina* from Erhai (Lu, 1939) probably belongs to *D. galeata* instead. For description, see Benzie (2005).

Daphnia (Daphnia) pulex Leydig, 1860. Planktonic species, inhabiting small water bodies and vegetated coastal areas. Rare in the area, found in winter only in Erhai (loc. W1) and Xihu (loc. W16), both locations are characterized by abundant submerged macrophytes. Palearctic species, so far recorded mostly in North and Central China, records in South-East China rare (see Xiang *et al.*, 2015). For description, see Benzie (2005).

Daphnia (Ctenodaphnia) sinensis Gu, Xu, Li, Dumont, Han, 2013. Planktonic species inhabiting mostly small water bodies. Rare in the area, found in winter in one locality in Lake Erhai (loc. W2). Species is widely distributed in Asia and Africa (see Popova *et al.*, 2016), was recorded from China as *D. similis* and *D. similoides*, both these species are not present in the region (Popova *et al.*, 2016). For description, see Popova *et al.* (2016).

Scapholeberis kingi Sars, 1888. Littoral species associated with water surface. Found in a single locality, a pond in agricultural area Lake

Table 2. Distribution of cladocera species in Dali area in winter 2015 and spring 2016. Abbreviations: W, winter samples; S, spring samples; EastAs, East Asian species; PaleoTr, Paleotropical; PanTr, Pantropical; PaleAr, Palearctic; SC, probable species-complex; WD, widely distributed or cosmopolitan. *Distribución de las especies de cladóceros en la zona de Dali en invierno de 2015 y primavera de 2016. Abreviaturas: W, muestras de invierno; S, muestras de primavera; EastAs, especies del Este asiático; PaleoTr, Paleotropical; PanTr, Pantropical; PaleAr, Paleártica; SC, probable complejo de especies; WD, especie cosmopolita o ampliamente distribuida.*

	Area of distribution	Erhai		Xi Hu		Zibi		Jianhu		Chenghai	Shuizhangdi	Small resrvoirs		Ponds		Samples total	Samples total
Time of sampling		W	S	W	S	W	S	W	S	S	S	W	S	W	S	W	S
Sida ortiva	EastAs	+	+	+		+	+	+						+	+	7	7
Ceriodaphnia dubia	PaleAr	+														3	0
Ceriodaphnia quadrangula	PaleAr	+	+				+									2	2
Ceriodaphnia reticulata	PaleAr									+						0	1
Daphnia galeata	PaleAr	+	+	+					+		+	+	+			7	4
Daphnia pulex	PaleAr	+														2	0
Daphnia sinensis	WD	+														1	0
Scapholeberis kingi	PaleoTr													+	+	1	1
Simocephalus congener	WD	+														2	0
Simocephalus expinosus	WD	+														1	0
Simocephalus mixtus	WD	+	+	+		+	+				+	+		+	+	9	14
Simocephalus serrulatus	WD	+	+	+		+	+				+				+	4	9
Macrothrix spinosa	PaleoTr	+														1	0
Ilyocryptus spinifer	WD	+														3	0
Ilyocryptus cuneatus	PaleAr												+			0	1
Alona affinis	PaleAr		+											+	+	1	2
Alona guttata	WD, SC	+	+				+					+		+	+	4	3
Alona kotovi	EastAs	+														3	0
Anthalona harti	PaleoTr	+														1	0
Camptocercus uncinatus	PaleAr	+	+	+	+	+	+						+			10	10
Coronatella rectangula	PaleAr	+	+	+	+		+	+			+	+	+	+	+	11	23
Flavalona costata	PaleAr	+	+	+	+	+	+	+				+	+	+	+	20	17
Graptoleberis testudinaria	WD, SC	+	+		+	+	+								+	3	8
Leydigia ciliata	PaleoTr		+							+						0	2
Oxyurella tenuicaudis	PaleAr	+														1	0
Alonella excisa	WD, SC	+	+					+								2	1
Chydorus cf. *sphaericus*	WD, SC	+	+	+	+	+	+	+	+	+	+	+		+	+	27	25
Disparalona chappuisi	PaleoTr	+	+	+	+	+	+	+	+					+	+	10	15
Dispralona ikarus	EastAs		+										+			0	2
Pleuroxus aduncus	PaleAr	+	+		+										+	2	5
Pleuroxus laevis	PaleAr	+														5	0
Pleuroxus quasidenticulatus	PaleoTr	+	+	+	+		+			+			+	+	+	6	11
Pseudochydorus bopingi	EastAs	+	+				+			+			+			3	6
Bosmina longirostris	WD, SC	+	+		+	+	+	+	+			+	+		+	11	10
Total number of species		31		14		14		8		5	5	11		13			

Erhai in both winter and spring (loc. W26, S30). Paleotropical species, described from Australia (Dumont & Pensaert, 1983). Common in China (Xiang *et al.*, 2015). For description, see Dumont & Pensaert (1983).

Simocephalus (Echinocaudus) congener (Koch, 1841). Littoral species, associated with vegetation; specimens are able to attach to substrate. Several specimens found in Lake Erhai (loc. W9) in winter. Species inhabit Central and Eastern Europe and Siberia (Orlova-Bienkowskaya, 2001). Recorded for China only in Potatso National Park in Shangri-La (Xiang *et al.*, 2015) and in Manning reservoir on Hainan Island (Sinev *et al.*, 2015). This species is close to *S. expinosus*. According to Orlova-Bienkowskaya (2001), it is a separate species which differs from *S. expinosus* by the morphology of the postabdominal claw, having a pecten of 18–22 spines on the outer side instead of 8–12 in *S. expinosus*. However, in reality, such conclusions must be checked, as the species diagnosed by Orlova-Bienkowskaia (2001) is open to criticism (Huang *et al.*, 2014).

Simocephalus (Echinocaudus) expinosus (De Geer, 1778). Littoral species, associated with vegetation; specimens are able to attach to substrate. Rare in the area, few specimens found in Lake Erhai (loc. W29) in winter. Distributed in West Hemisphere (Orlova-Bienkowskaia, 2001); for list of locations in China see Xiang *et al.* (2015). For description, see Orlova-Bienkowskaia (2001).

Simocephalus (Simocephalus) mixtus (O. F. Müeller, 1776). Littoral species, associated with vegetation; specimens are able to attach to substrate. Most common species in the area, found in vegetated areas of lakes and ponds in both winter and spring. Widely distributed species, recorded in all climatic zones of North Hemisphere (Orlova-Bienkowskaia, 2001), common on Hainan Island (Sinev *et al.*, 2015), but in continental China recorded only once, in Heilongjiang Province (Xiang *et al.*, 2015). Possibly confused with its sibling-species, *S. vetulus* and *S. vetuloides*, and being identification based on the key by Orlova-Bienkowskaia (2001) vulnerable to criticism (Huang *et al.*, 2014).

Simocephalus (Coronocephalus) serrulatus (Koch, 1841). A littoral species, associated with vegetation; specimens capable to attach to the substrate. Common species in the area, found in vegetated areas of lakes and ponds in both winter and spring. Cosmopolitan species, common in the Oriental region (Orlova-Bienkowskaia, 2001), widely distributed but rare in China (Xiang *et al.*, 2015). For a description see Orlova-Bienkowskaia (2001).

Family Ilyocryptidae

Ilyocryptus cuneatus Śtifter, 1988. Benthic, associated with muddy or clayey bottom. Rare in the area, found in a single small reservoir in spring (loc. S23). Palearctic species; in Asia recorded for Asian Russia and Japan (Kotov & Śtifter, 2006). The first record for China, and also southernmost record for the species. Distinctive characters of species includes retained valves from previous molt (Fig. 1D); setae on posterior margin of valves with distinctive spine-like setules one side in its basal portion (Fig. 1E); postabdomen with anus opening at the middle (Fig. 1F); preanal margin of postabdomen with doubled spines and no setules near their bases (Fig. 1G); and postbadominal claw with long ventral setules at the base (Fig. 1F). For detailed description, see Kotov & Śtifter (2006).

Ilyocryptus spinifer Herrick, 1882. Benthic, associated with mud or clay bottom. Rare in the area, found only in winter in Lake Erhai (W7, W11) and in a temporary pool in agricultural area (W13). No evidence of the non-cosmopolitanism of this species has been found (Kotov & Dumont, 2000); common in the Oriental region, including China. For list of records in China, see Xiang *et al.* (2015). For detailed description see Kotov & Dumont (2000) and Kotov *et al.* (2012) for Far Eastern populations.

Family Macrothricidae Norman & Brady, 1867

Macrothrix spinosa King, 1853. Littoral species, associated with vegetation. Rare in the area; several specimens found in Lake Erhai in winter (loc. W2). Species presumed to be Pantropical (Smirnov, 1992), common in the Oriental region. Common in South-East China (Ji *et al.*, 2015).

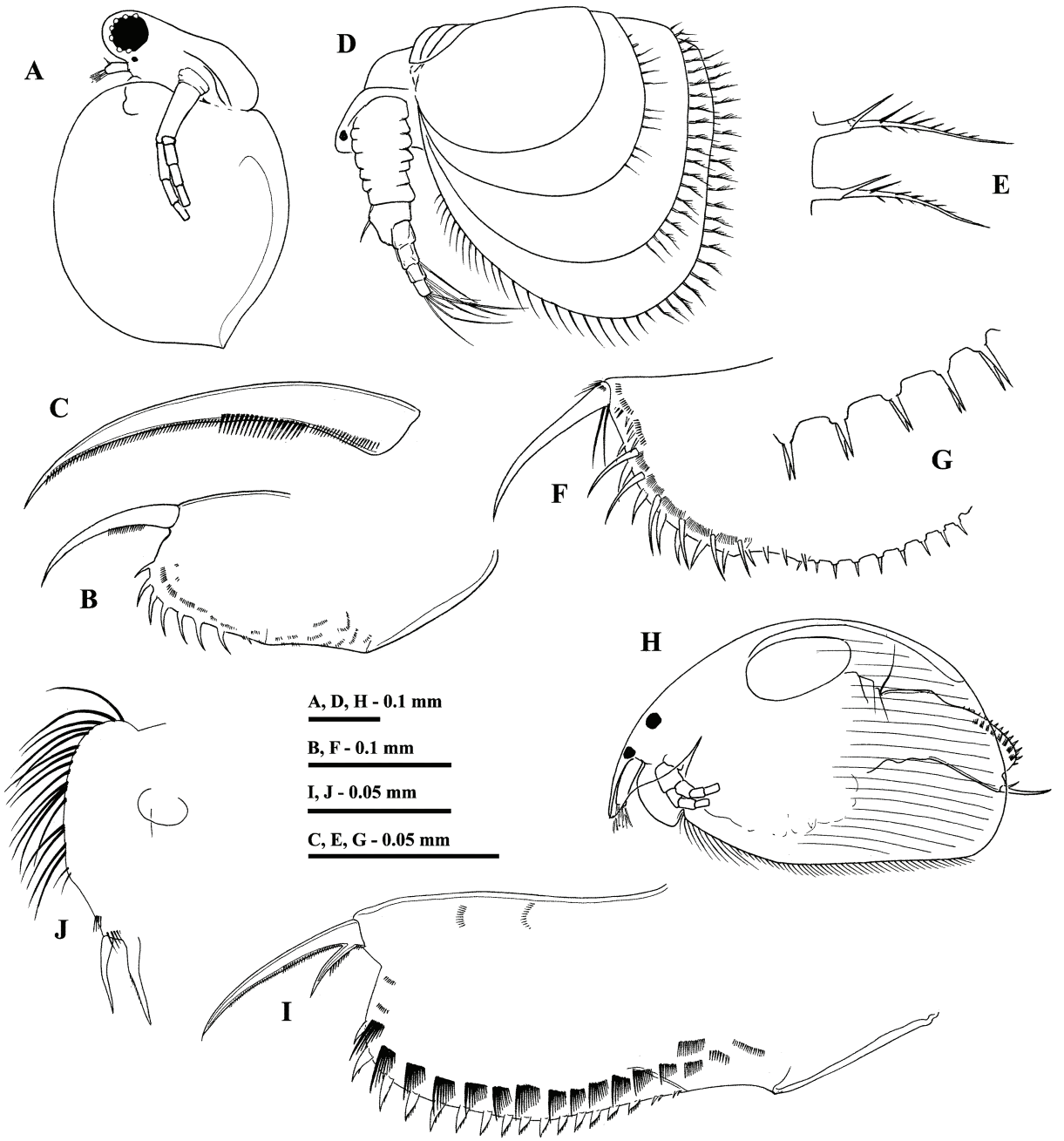

Figure 1. A-C, *Ceriodaphania dubia* Richard, 1894 from Lake Erhai (loc. W2), parthenogenetic female. A, lateral view. B, postabdomen. C, postabdominal claw. D-G, *Ilyoryptus cuneatus* Štifter, 1988 from reservoir in Dali area (loc. S 23), parthenogenetic female. D, lateral view. E, setae of posterior margin of valves. F, postabdomen. G, spines on preanal margin of postabdomen. H-J, *Alona kotovi* Sinev, 2012 from Lake Erhai (loc. W11), parthenogenetic female. H, lateral view. I, anterior margin of thoracic limb I. Ceriodaphania dubia *Richard, 1894 del lago Erhai (loc. W2), hembra partenogenética. A, vista lateral B, postabdomen. C, pinza postabdominal. D-G,* Ilyoryptus cuneatus *Štifter, 1988 del embalse en la zona de Dali (loc. S 23), hembre partenogenética. D, vista lateral. E, seta del margen posterior de las valvas. F, postabdomen. G, espines del margen preanal del postabdomen. H-J,* Alona kotovi *Sinev, 2012 del lago Erhai (loc. W11), hembra partenogenética. H, vista lateral. I, margen anterior del limbo torácico I.*

For description, see Smirnov (1992) and Hollwedel *et al.* (2003); for description of Indochina populations see Idris (1983).

Family Chydoridae, subfamily Aloninae

Alona affinis (Leydig, 1860). Littoral species, inhabiting both vegetated and open littoral zone. Rare in the area, found in decorative pond in Dali city in both spring and winter (loc. W3, S37), and in one location in Lake Erhai in spring (S35). Common widely distributed Palearctic species, also recorded in South Africa (Sinev, 2009). Common in China, recorded for Yunnan (Ji *et al.*, 2015). For description, see Alonso (1996) and Sinev (2009).

Alona guttata Sars, 1862. Littoral species, associated with vegetation. Found in Lake Erhai and in single pond in both winter and spring, in Lake Zibi and smaller reservoirs in spring (loc. W3, W8, W10, W31, S6, S35, S37), never abundant. Species presumed to be cosmopolitan; recent studies of Mexican populations revealed no significant differences from European specimens (Sinev & Silva-Briano, 2012). Common in China (Ji *et al.*, 2015), recorded for Erhai by Lu (1939). For detailed description, see Alonso (1996).

Alona kotovi Sinev, 2012. Rare littoral species, associated with muddy or clay bottom, found in Lake Erhai in winter only (loc. W10, W11, W29). Species described from Vietnam, and recently recorded from Korea (Jeong *et al.*, 2014) and Hainan Island (Sinev *et al.*, 2015). first record of the species for continental China. The only Oriental species of the *quadrangularis*-group (Sinev, 2012, 2016) its area of distribution probably includes India, South-East Asia and South China where it was confused with Palearctic *A. quadrangularis* (O.F. Müller, 1776). Studied specimens (Fig. 1H) share all diagnostic features of *A. kotovi*, including postabdomen with only weakly convex postanal margin (Fig. 1I), and over 12 large setules on anterior margin of thoracic limb I (Fig. 1J) instead of 7-8 in *Alona quadrangularis* s. str. For description, see Sinev (2012).

Anthalona harti harti Van Damme, Sinev & Dumont, 2011. Littoral species, associated with macrophytes. Several specimens in Lake Erhai in winter (loc. W2), among macrophytes. For detailed descriptions see Van Damme *et al.* (2011), for description of Indochina populations see Sinev & Kotov (2012). The first record for Yunnan province. Distributed in tropical Asia, Mediterranean region, and Africa (Van Damme *et al.*, 2011, Sinev & Kotov, 2012). Recorded for China mostly as *Alona verrucosa* Sars, 1901 (Ji *et al.*, 2015).

Camptocercus uncinatus Smirnov, 1971. Littoral species, rather common in Lake Erhai, Lake Xihu and Lake Zibi in both winter and spring; in all lakes among macrophytes and on rocks with filamentous algae. *C. uncinatus* is distributed in southern Europe, Israel, Iraq, Egypt, Ethiopia, Rift Valley of Africa, South-West and East Siberia and Korea (Sinev, 2014). It was recently recorded in Hainan (Sinev *et al.*, 2015). In China, the most frequently reported species of *Camptocercus* is *Camptocercus australis* Sars, 1988 (Ji *et al.*, 2015) but this species is confined to Australia (Sinev, 2015) and all these records most probably belong to *C. uncinatus* as well. Records of subfossil *C. rectirostris* from Erhai (Lu *et al.*, 2016) probably belong to *C. uncinatus*. For description see Sinev (2014), for description of East Asian populations see Kotov *et al.* (2012).

Coronatella rectangula (Sars, 1862) (= *Alona rectangula* Sars, 1862). Littoral species, associated with macrophytes, common in both winter and spring in most water bodies. *C. rectangula* is a common Palaearctic species, distributed from Spain to Far East of Russia, common in China. In East Asia, the species penetrates South up to Peninsular Malaysia and Borneo, but South-East Asian populations slightly differs from Palearctic by narrower postabdomen, probably presenting species-complex (Sinev & Yusoff, 2015; Sinev *et al.*, 2015). Common in China, including Yunnan (Ji *et al.*, 2015), recorded for Lake Erhai (Lu, 1939). For description, see Van Damme & Dumont (2008).

Parthenogenetic females from Dali area (Fig. 2A) have morphology typical for Palearctic populations, with relatively broad postabdomen (Fig. 2B). Inner distal lobe of limb I (Fig. 2C) with rudimentary seta 1 seta 2 curved, claw-like, with two thin spines at the middle and thin posterior portion armed with thin setules, seta 3 thick,

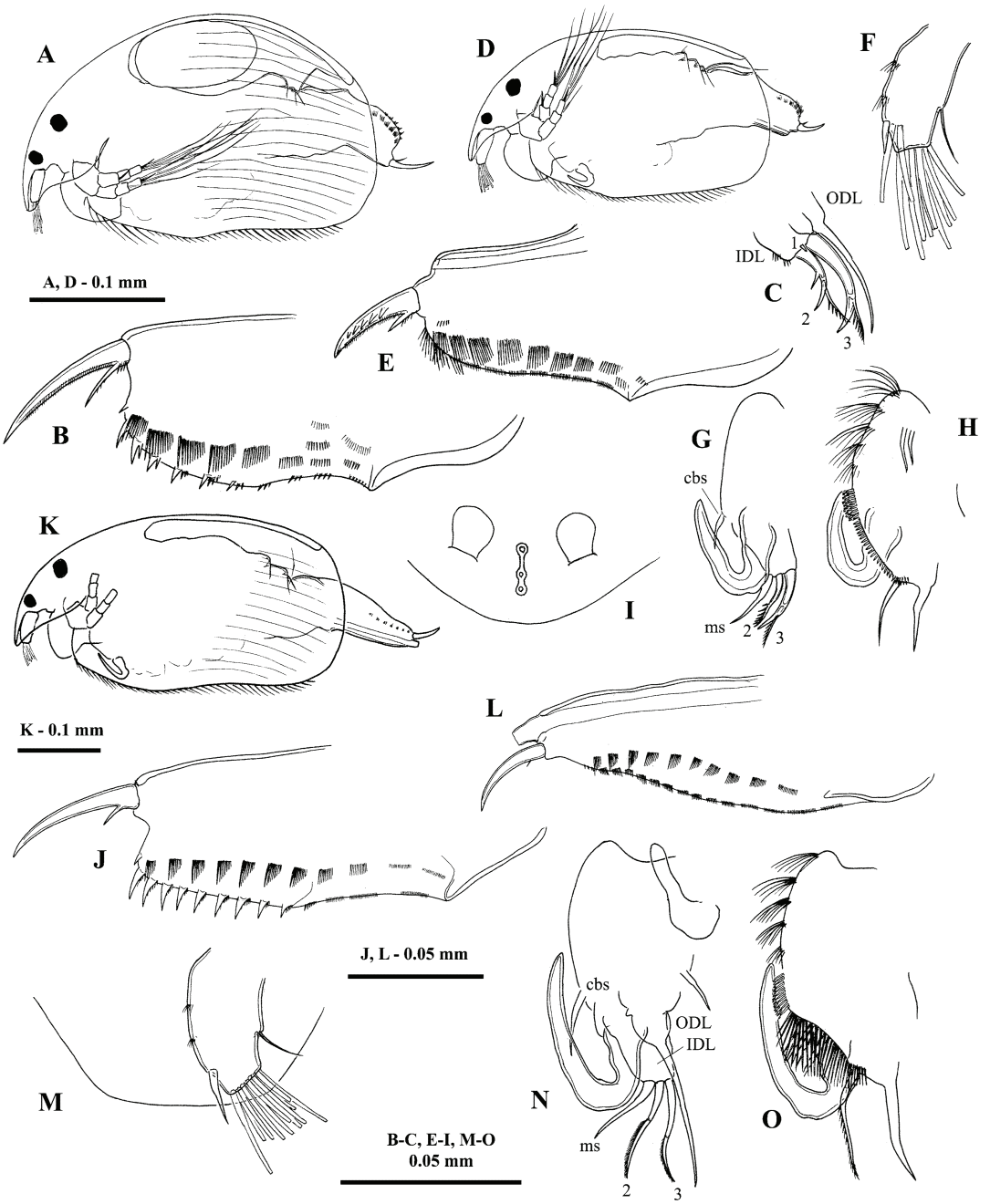

Figure 2. A-H, *Coronatella rectangula* (Sars, 1862) from Lake Erhai (loc. W10). A-C – parthenogenetic female. A, lateral view. B, postabdomen. C, inner distal lobe of thoracic limb I. D-H, adult male. D, lateral view. E, postabdomen. F, antennule. G-H, thoracic limb I (endites not shown). *Flavalona costata* (Sars, 1962) from small reservoir (loc.S14). I-J, parthenogenetic female. I, head pores. J, postabdomen. K-O, adult male. K, lateral view. L, postabdomen. M, antennule and outline of rostrum. N-O, thoracic limb I (endites not shown). Abbreviations: cbs – copulatory brush seta; IDL – inner distal lobe; ms – male seta; ODL – outer distal lobe. Coronatella rectangula *(Sars, 1862) del lago Erhai (loc. W10). A-C – hembra partenogenética. A, vista lateral. B, postabdomen. C, lóbulo distal interior del limbo torácico I. D-H, macho adulto. D, vista lateral. E, postabdomen. F, anténula. G-H, limbo torácico I (no se muestran los endites).* Flavalona costata *(Sars, 1962) de un pequeño embalse (loc.S14). I-J, hembra partenogenética. I, Poros de la cabeza. J, postabdomen. K-O, macho adulto. K, vista lateral. L, postabdomen. M, anténula y silueta del rostrum. N-O, limbo torácico I (no se muestran los endites). Abreviaciones: cbs – seta pincelada copulatoria; IDL – lóbulo interior distal; ms – seta de macho; ODL – lóbulo distal exterior.*

curved, claw-like, with single thick spine at the middle and thin posterior portion armed with setule; seta 2 shorter and two times thinner than seta 3, seta 3 slightly longer than outer distal lobe seta. Morphology of males from East Asian population were never studied in detail, so full description is provided.

Male. Body (Fig. 2D) low oval, height-length ratio about 0.6. Ocellus and eye are of the similar size as in female, eye two times larger than the ocellus.

Postabdomen (Fig. 2E) is short, of moderate width, with subrectangular distal portion. Ventral margin almost straight. Gonopores located at the end of postabdomen. Distal margin almost straight, distal angle broadly rounded. Postanal and anal margin almost straight. Distal part of postabdomen 1.5 times longer than preanal part; anal and postanal portion of similar length. Postanal angle not defined, preanal angle well-defined, prominent. Clusters of short setules in place of marginal denticles, lateral fascicles of setules similar to those of female, but distal setule in each fascicle thinner, of similar thickness as the others. Postabdominal claw short, about 2/3 length of postanal margin, weakly curved, with short thick basal spine about 1/4 length of claw itself. There are 4-5 thick short spines on inner side of claw, these spines are not present in other species of *Coronatella*.

Antennule (Fig. 2F) moderately long, length about 2.5 widths. Male seta short, arising at 3/4 distance from the base and reaching to the end of antennule. Two lateral and ten terminal aesthetascs, longest of them slightly shorter than antennule itself. All aesthetascs projecting beyond anterior margin of the head shield. Thoracic limb I (Fig. 2G-H) with short U-shaped copulatory hook two times shorter than limb itself. Copulatory brush present; copulatory brush seta short. Ventral face of limb below them with about 20 short thick setules. Inner distal lobe without seta 1; setae 2 and 3 much shorter and thinner than in female; seta 2 slender, without any spines at the middle, distal portion armed with thin setules; seta 3 moderately thick, curved, with single spine at the middle and thin posterior portion armed with thin setules, longer than seta 2; male seta curved, shorter than seta 3.

Morphology of males fully agrees with earlier descriptions (Frey 1988a; Alonso, 1996; Van Damme & Dumont 2008) with one exception – lateral aesthetascs on antennulae were never reported for males of *C. rectangula*. Due to small size of the animal it is unclear if they were overlooked in previous studies or are present only in studied population.

Flavalona costata (Sars, 1962) (former *Alona costata* Sars, 1862). Littoral species, associated with macrophytes, common in both winter and spring in most water bodies. Palearctic species, in East Asia penetrating South to the Hainan Island and North-East Thailand (Sinev, 2016). Common in China, including Yunnan (Ji *et al.*, 2015), recorded for Lake Erhai by Lu (1939). Studied females have typical for the species morphology of postabdomen (Fig. 2J) and head pores (Fig 2I), with length of lateral head pores about half distance between anterior and posterior main head pores, and with rounded lateral head pore pockets. Ephippial females were found in Lake Erhai in winter (loc. W10) and in small reservoir and fish pond in spring (loc S.14, S15). Males of *F. costata* are rarely recorded for East Asian populations, so their full description is provided.

Body (Fig. 2K) low oval, dorsal margin only weakly convex. Maximum height at the middle of the body, height/length ratio c. 0.55. Ocellus smaller than eye. Rostrum short, slightly truncated (Fig. 2M).

Postabdomen (Fig. 2L) moderately long, narrowing distally in postanal part. Ventral margin wavy in studied specimens. Basis of claws bordered from distal margin by clear incision. Genital process short, about 1/4-1/3 length of postabdominal claw. Distal margin very short, distal angle obtuse. Dorsal margin convex in anal portion, straight in postanal portion. Preanal and postanal angles not defined. Clusters of short setules in place of marginal denticles, distalmost cluster consisting of 3-5 thick short setules. Lateral fascicles as in female. Postabdominal claw slightly longer than preanal portion of postabdomen, curved. Basal spine short and thin, visible only under oil immersion.

Antennule (Fig. 2M) with 12 terminal aesthetascs, longest about 3/4 length of anten-

nule. Male seta arising at 1/4 length from tip, about 1/3 length of antennule. Thoracic limb I (Fig. 2N-O) with U-shaped copulatory hook, two times shorter than limb itself. IDL with three setae. IDL setae 2 and 3 thin, of similar length. Male seta curved, shorter than seta 2. Copulatory brush seta about 2/3 length of IDL seta 2. Ventral face of the limb under the copulatory brush with row of about 20 long stiff setules.

Morphology of males fully agree with the previous descriptions of European populations of the species (Alonso, 1996; Sinev, 1999; Hudec, 2010; Sinev & Dumont, 2016). For detailed description see Sinev & Dumont (2016).

Graptoleberis testudinaria (Fischer,1851). Littoral species, associated with macrophytes with submerged leaves. Uncommon in the area, found in Erhai, Xi Hu and Zibi, and in some ponds, more frequent in spring. Species recorded worldwide, but probably composes a species-complex, common in China (Ji *et al.*, 2015), recorded for Lake Erhai by Lu (1939). For description of European populations, see Alonso (1996), Hudec (2010).

Leydigia ciliata Gauthier, 1939. Benthic species, associated with muddy or clay bottom. Found in Erhai and Chianghai lakes in spring only. Known in Africa, tropical Asia, common in Oriental region (Kotov, 2009). Common in China (Ji et al., 2015). For detailed description, see Kotov *et al.* (2003).

Oxyurella tenuicaudis (Sars, 1862). Littoral species, associated with vegetation. Rare in the area; few specimens in Lake Erhai in winter (loc. W6). Widely distributed Palearctic species; frequently recorded in China, including Yunnan; southmost records in Guangdong province (Ji *et al.*, 2015), but, according to these authors, some records, especially from South China, can be erroneous. Not found in Hainan Island (Sinev *et al.*, 2015), where it is substituted by tropical species *Oxyurella singelansis*. For description, see Alonso (1996) and Hudec (2010).

Family Chydoridae, subfamily Chydorinae

Alonella excisa (Fisher, 1854). Littoral species, associated with vegetation. Rare in the area, several specimens found in Lake Erhai once in winter (W6) and once in spring (loc. S32), and in Lake Jainhu in winter (loc. W25). Common in China, including Yunnan (Ji *et al.*, 2015), recorded for Lake Erhai by Lu (1939). The species presumed to be cosmopolite (Smirnov, 1996). For description, see Alonso (1996).

Chydorus sphaericus (O.F. Müller, 1776) s. lato. Eurybiotic littoral species, sometimes encountered in pelagic zone. The most common species in the area, found in all types of water bodies in littoral samples. *Chydorus sphaericus* s. lato in Eurasia is a complex of species with identical morphology of parthenogenetic females (Belyaeva & Taylor, 2009; Klimovsky & Kotov, 2015; Kotov *et al.*, 2016). *Chydorus sphaericus* s. lato is common in China, including Yunnan (Ji *et al.*, 2015), recorded for Lake Erhai by Lu (1939). Two ephippial females were found in Lake Erhai in winter (loc. W11). These specimens had ephippia with single egg, typical for most species of *C. sphaericus* group, while two species of the group found in North-East Palearctic, *C. belyaevi* Klimovsky & Kotov, 2015 and *C.* cf. *biovatus* Frey, 1985 have ephippia with two eggs (Klimovsky & Kotov, 2015).

Disparalona (Disparalona) ikarus Kotov & Sinev, 2011. Species associated with open littoral. Rare, in spring in Lake Erhai (loc. S40) and two small reservoirs (loc. S14, S25). Species so far is known from Amur river basin in Russia, South Korea and Hainan Island (Kotov & Sinev, 2011; Kotov *et al.*, 2012; Sinev *et al.*, 2015). It is the first record of the species in continental China. For description, see Kotov & Sinev (2011) and Kotov *et al.* (2012).

Disparalona (Mixopleuroxus) chappuisi Brehm, 1934. Littoral substrate-associated species. Common, encountered in most water bodies in both spring and winter, more abundant among macrophytes. Species known from Africa and tropical Asia, in East Asia penetrating north to Far East of Russia (Neretina et al., 2018). Population of *D. chappuisi* from East and South-East Asia, including these from China (see Ji *et al.*, 2015; Sinev *et al.*, 2015) were recorded as *D. hamata* Birge,1879, but recent revision clarified its status (Neretina *et al.*, 2018). For detailed description see Neretina *et al.* (2018).

Pleuroxus (Pleuroxus) aduncus (Jurine,

1820). Littoral species, associated with vegetation. Uncommon, found in vegetated areas of Lake Erhai in both winter (loc. W12, W28) and spring (loc. S29, S32, S33), in spring also found in Lake Xihu (loc. S3) and fish ponds (loc. W15). The species was considered cosmopolitan (Smirnov, 1996), but its absence in South Hemisphere was proved recently (Smirnov *et al.*, 2006). Common in China, but some records, especially from South part, can be unreliable (Ji *et al.*, 2015); recorded for Erhai by Lu (1939). Dali area is a one of Southmost sure records for the species. For description, see Smirnov (1996) and Frey (1991).

Pleuroxus (Picripleuroxus) laevis Sars, 1862. Rare littoral species, associated with vegetation, found in winter in five locations in Lake Erhai only (loc. W1, W7, W9, W13, W29), absent in spring. Palearctic species (Smirnov, 1996). Common in China, including Yunnan (Ji *et al.*, 2015). The first record for Dali Area. For description see Smirnov (1996) and Frey (1988b).

Pleuroxus (Picripleuroxus) quasidenticulatus (Smirnov, 1996). Littoral substrate-associated species. Most common species of *Pleuroxus* here, found mostly among macrophytes, but also on open littoral; in Erhai, Xi Hu, Zibi and Chianghai lakes and in various ponds, common and abundant in spring, infrequent in winter. recorded frpm Australia, Iran, South-East Asia, China, Korea and Far East of Russia (Smirnov, 1996; Sinev & Korovchinsky, 2013; Sinev & Sanoamuang, 2013; Kotov *et al.*, 2017). For description, see Sinev & Sanaomuang (2013).

Pseudochydorus bopingi Sinev, Garibian & Gu, 2016. Littoral species, feeding on the bodies of dead microcrustaceans. Found in limited numbers (several specimens per sample) in samples with abundant littoral cladocera, in Lake Erhai in both winter and spring, and in Zibi, Chianghai and two smaller reservoirs (loc. S14, S25) in spring. The species was recorded in South Vietnam, Hainan Island, Hunan and Hubei provinces of China (Sinev *et al.*, 2016). The first record for Yunnan. Earlier *Pseudochydorus* records from China were attributed to *P. globosus* (*et al.*, 2015), but all populations from South-East China probably belong to *P. bopingi*. For description, see Sinev *et al.* (2016).

Family Bosminidae

Bosmina (Bosmina) longirostris (O. F. Müller, 1776). Pelagic plankton species. Common in the area, found in most large water bodies in the area and in some ponds, more frequent in spring. Recorded worldwide, according to Chatterjee *et al.* (2013), who refer to unpublished genetic data of Taylor and Kotov, one of the few truly cosmopolitan cladocera. Common in China, including Yunnan (Xiang *et al.*, 2015). For description see Alonso (1996).

DISCUSSION

Among the 34 species found in the area, 31 were present in Lake Erhai and 8 of were found only in Lake Erhai (see Table 1). In our opinion, this reflects a higher diversity of biotopes in the lake, for example, clusters of water caltrop and open rocky littoral exists there, while these are not present in other lakes. Number of species in two intensively sampled lakes, Xihu and Zibi, was low, only 14 species in each. Three other large lakes, Jianhu, Chenghai, Shuizhangdi, were sampled less intensively, and their diversity probably underestimated. Only 13 species were found in the ponds, and only 11 in various reservoirs with severe water fluctuations.

Lake Erhai region winter-spring fauna is conspicuous by the absence of several common groups of Cladocera, including the genera *Diaphanosoma* and *Moina*, both quite common in Central Yunnan, including Kunming area. Kunming area was sampled by the authors at the same time as Dali Area, and at least two species of *Moina* and three species of *Diaphanosoma* were present in the area, being dominating in many samples. The only species of *Diaphanosoma* recorded in Dali Area is *Diaphanosoma brachyurum*, present in Lake Erhai pelagic zone in Jule-November (Yang et al., 2014). *Diaphanosoma dubium* and *Moina micrura* were found in the area to be usual by the second author (Gu, unpublished). Several tropical species, reported for ponds and paddy fields of Dali area (see Xiang *et al.*, 2015); *Ephemeroporus barroisi*, *Leberis diaphanus*, *Dunhevedia crassa* King, 1853, were not found during our study neither. With these

records, the number of taxa in Dali area could be increased until 40 species.

Lake Erhai region fauna during winter-spring is composed by three ecological groups of species. Most cladocera here (25 species), including all plankton taxa, are either Palearctic or widely distributed taxa. For some of them (*Ceriodaphnia dubia*, *Ceriodaphnia reticulata*, *Daphnia galeata*, *Daphnia pulex*, *Pleuroxus aduncus*, *Oxyurellla tenuicaudis*, *Ilyocryptus cuneatus*), Dali Area is on the southmost margin of distribution area. For these taxa, Dali Area is an "area of penetration" sensu Korovchinsky (2004, 2006), since their "areas of primary distribution" are in North Palearctic. Their appearance in Dali Area is probably a reflection of specific local conditions (moderately high altitude).

The second group are East Asian taxa (four species, *Sida ortiva*, *Disparalona ikarus*, *Pseudochydorus bopingi* and *Alona kotovi*) distributed from South-East Asia to Amur basin (Kotov, 2016). The third group are predominantly Paleotropical taxa (five species, *Scapholeberis kingi*, *Macrothrix spinosa*, *Anthalona harti*, *Leydigia ciliata* and *Pleuroxus quasidenticulatus*), they are rare in the area in spring-winter, only the latter species became frequent in spring. All these species have areas of primary distribution in the Oriental region and South China, but penetrate further north in lowland East China (see Korovchinsky, 2013).

In both sampling seasons, only parthenogenetic females were found in a majority of species. Few gamogenetic females and males were found in few common and abundant species: in winter for *Coronatella rectangula*, *Chydorus spahaericus*, *Flavalona costata* and *Daphnia galeata*, and in spring for *Flavalona costata* only. This shows that Dali area climate is mild enough to allow Palearctic species to overwinter as active populations, giving them an advantage over tropical species, which should overwinter at resting egg stage.

Many Cladocera described from Europe historically were presumed to be distributed across the whole Palearctic region. However, recent studies revealed that such taxa are often composed of sibling species, usually with limited ranges. For example, investigation of *Chydorus sphaericus* complex (Belyaeva & Taylor, 2009; Klimovsky & Kotov, 2015; Kotov *et al.*, 2016) revealed that *C. sphaericus* s. str. is not present in the East Palearctic, being substituted there by *C.* cf. *biovatus* Frey, 1988, *C. belyaevae* Klimovsky & Kotov, 2015 and several not yet described species of the clade. Genus *Leptodora*, presumed to be monotypical, is composed of at least two species distributed in West and East Palearctic (Korovchinsky, 2009); similar situation was revealed for genus *Polyphemus* (Xu *et al.*, 2009). *Pleuroxus trigonellus* is substituted by sibling species in East Palearctic (Garibian *et al.*, 2018). On the other hand, *Daphnia curvirostris* is distributed throughout the whole Palearctic region, but in East Asia it coexists with a cluster of local sibling-species (Kotov *et al.*, 2006; Ishida *et al.*, 2006).

Our data on two species of Aloninae, *Flavalona costata* and *Coronatella rectangula*, show that these populations are similar to European ones in both female and, more importantly, male morphology. In the family Chydoridae, differences in male morphology between sibling species are usually more pronounced than those in females (Frey, 1988b; Sinev, 1999, 2018; Neretina *et al.*, 2018). Some sibling species can be morphologically distinguished by male morphology only (Klimovsky & Kotov, 2015; Sinev & Atroschenko, 2011; Sinev, 2013; Garibian *et al.*, 2018). Our data suggests that *F. costata* and *C. rectangula* are monotypic within whole Palearctic region, and patterns of East-West distribution in Palearctic cladocera are rather variable even within one family.

All four species of the Cladocera recorded for continental China for the first time are substrate-associated. Two of these, *Alona kotovi* and *Camptocercus uncinatus* were previously recorded for Yunnan as *A. quadrangularis* and *C. australis* or *C. rectirostris*, respectively (Ji *et al.*, 2015); these taxa are not present in South-East China. Our data confirms persistent problems with identifications of substrate-associated Cladocera in China (Xiang *et al.*, 2015; Ji *et al.*, 2015).

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