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Three new species of *Cymbella* (Bacillariophyta) from high altitude lakes, China

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Abstract – This paper describes three new *Cymbella* species from high altitude lakes of Hengduan Mountains region, southwest China. *Cymbella heihainensis* Li et Gong nov. spec. is similar to *C. modicepunctata* Krammer, *C. asiatica* Metzeltin, Lange-Bertalot et Li, Y., but differs from them in valve size, stigmata, raphe ending and also striae number. *Cymbella shudunensis* Li et Metzeltin nov. spec. is related to *C. terrafuegiana*, but differs in wider valve size, larger central area and coarser puncta. *C. shudunensis* differs from *C. proxima* Reimer in Patrick et Reimer group in reverse lateral raphes at the proximal endings, and distinguished from *C.cistula* (Ehrenberg) O.Kirchner group in the absent central area on dorsal side. *Cymbella xingyunnensis* Li and Gong sp. nov. resembles the group around *C. proxima*, and the most similar taxon is *C. sinensis* Metzeltn et Krammer, which can be distinguished by its lack of stigmata.

Key words: *Cymbella heihainensis, Cymbella shudunensis, Cymbella xingyunnensis,* diatoms, China

Introduction

The global warming and nitrogen deposition in the last century have enriched lakes on the hemispheric scale, and resulted in a loss of biodiversity in natural habitats (ABER et al. 1995). As is well known, high altitude lakes are an important part of natural ecosystems. Southeast Asia is becoming a hot spot because of its unique topographic character and the increasing anthropogenic disturbance (GALLOWAY and COWLING 2002). Diatom community is used as a main indicator of environmental and biodiversity change, both in limnology and palaeolimnology (SMOL and STOERMER 2010).

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There is limited investigation of freshwater diatoms in SE Asia. Among species of the genus Cymbella, 49 were reported from northeastern China (FAN et al. 1993, BAO et al. 1992), 8 from Xingjiang Province, NW China (YOU et al. 2005, 2008), 44 from India (JENA et al. 2006, NAUTIYAL et al. 2004), and 9 from Japan (HIRANO 1972). One new variety of *Cymbella* was described from Qinghai Province, NW China (LI et al. 2003b). In the Himalayan region, 4 new species of *Cymbella* from alpine lakes and springs have been reported from Everest National Park of Nepal (JÜTTNER et al. 2010, 2000). There were also studies on cymbelloid diatoms near Mount Everest in China (LI et al. 2004, 2007b), showing that 44 species belong to Cymbella, of them 16 new records, some of them unique to this region. One new species of *Cymbella* has been found from northwest Tibet (LI et al. 2003a), and one from the Far East (LEE et al. 1993), respectively. Also, a few studies have been carried out on the diatoms from the Hengduan Mountains region, SW China (SKUJA 1937, ZHU and CHEN 1994, LI et al. 2003c, LI et al. 2007a). One *Cymbella* species was found that is unique to this area (LI et al. 2007a), and some taxa belonging to *Cymbella* are found that have different morphological features compared with previously published descriptions (LI et al. 2003c).

In this paper we describe three *Cymbella* species new to science from three high altitude lakes in the Hengduan Mountains Region. One is related to C. *modicepunctata* Krammer and similar species; one is similar to *C. terrafuegiana* Krammer; and we also give a detailed morphological description of a new taxon similar to *C. sinensis* Metzeltn et Krammer.

Study area

The Hengduan Mountains region (23–33°N, 97–103°E) comprises western Sichuan Province, western Yunnan Province and part of eastern Tibet, southwest China. The area is about 0.5 million km^2 (ZHANG 1997). This region is a transitional zone between lowland tropical and subtropical climate zones because of the uplift of Tibetan Plateau (YANG 1983). The elevation ranges from more than 5000 m a.s.l. to less than 2000 m a.s.l. It is predominantly affected by the SW Asian monsoon from India in summer (CHEN 1998). Plentiful monsoon precipitation promotes the development of forest, and its topographic complexity. Besides, the unique geologic history makes this region become one of the world's biodiversity hotspots (FAN et al. 2012, MYERS et al. 2000). Thus there are rich flora and fauna in this area, including many relict diatom species (LI et al. 2007a). The high altitude lakes located are important reservoirs of regional biodiversity.

Methods

Samples were taken from the surface sediments of Heihai Lake (Tab. 1), Shudu Lake and Xingyun Lake with the use of a Kajak gravity corer in the deepest part of the lakes. Heihai Lake is above the tree line, the catchment is characterized by alpine meadows; Shudu Lake is located within the alpine/sub-alpine ecotone with the catchment primarily consisting of *Picea/Abies*, while Xingyun Lake is situated within subtropical evergreen coniferous and broad-leaved mixed forest, dominated by *Pinus yunnanensis*.

Diatom samples were kept under 4 °C in refrigerator before laboratory treatment. They were treated with HCl and H_2O_2 (YANG et al. 2008). Permanent slides were made from cleaned materials and mounted in Naphrax® for observation with light microscopy (Olym-

Tab. 1. Location and environmental characteristics of the three lakes.

	Heihai Lake	Shudu Lake	Xingyun Lake
Latitude (°N)	27°21'	27°54'	24°20'
Longitude (°E)	100°04'	99°57'	102°47'
Altitude (m)	4117	3630	1748
Lake area (km^2)	0.18	1.70	34.71
Maximum depth (m)	42.4	7.8	8.3
pH	7.79	7.77	9.15
SD (m)	4.5	0.8	0.9
TN (mg L^{-1})	0.26	1.52	1.22
TP (mg L^{-1})	0.013	0.036	0.263
Conductivity (ms cm^{-1})	57	31.6	410

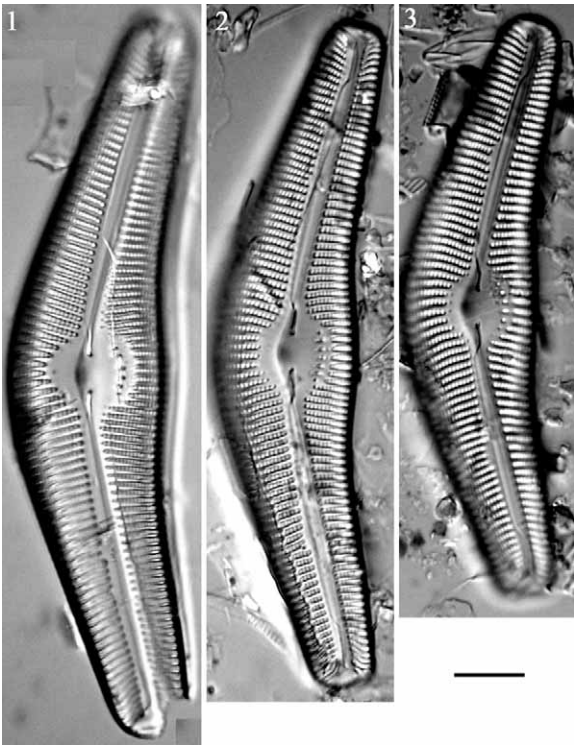
pus, BX-51, DIC). Cleaned materials were also investigated with a Leo 1530 scanning electron microscope (SEM). At least 500 valves were counted in each surface sediment sample. Lake water pH and specific conductance were measured in the field using a YSI 650 multi–parameter display system (650 MDS, YSI Incorporated 1700/1725 Brannum Lane, Yellow Springs, OH 45387 USA) with a 600XL probe. Water samples were taken from about 50 cm under the surface. Total nitrogen (TN) and total phosphorus (TP) were measured by a Shimadzu UV2450 ultraviolet-visible spectrophotometer at Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, using alkaline potassium persulfate digestion-UV spectrophotometric method (NYDAHL 1978) and ammonium molybdate spectrophotometry method (EBINA et al. 1983), respectively.

Results

***Cymbella heihainensis* Li et Gong nov. spec.**

Figs. 1–6. Fig. 1 is of the holotype.

Description: Valves are strongly dorsiventral. Dorsal margins strongly convex, ventral margins slightly to moderately concave and slightly tumid in the middle. Ends are bluntly rounded. Length 82–105 μm, breadth 19–22.5 μm, maximal length/breadth is about 4.7. Raphe is at middle line of valve, strongly lateral, and becoming slightly reverse-lateral near the proximal ends. Axial area is moderately broad. Central area is orbicular to broadly elliptical, about 1/2 breadth of the valve. Striae slightly radiate in the middle portion, and radiate more towards the end, coarsely punctuate. 7–10 stigmata surrounding the ventral side on the central area separated from the shortened ventral striae by a narrow hyaline area, sometimes there are several smaller stigmata between the main stigmata and the middle ventral striae (Fig. 2), on dorsal side, 0–3 stigmata distance from the shortened striae (Figs. 1, 3). Striae 7–8/10 μm in the middle, and becoming 8–10/10 μm towards the distal, with 14–16 areolae in 10 μm. In SEM external valve view: proximal and distal raphe endings deflected on ventral side, raphe slit is located on a rib and thickened part of the centre axial areas, expanded drop-like central pores at proximal raphe ends (Figs. 4, 6); the distal raphe endings are question mark-shaped and dorsally deflected, terminating in a large apical pore



Figs. 1–3. *Cymbella heihainensis*. Light microscopy, valve views showing size diminution series for the species. Figure 1 is the holotype. Scale bar denotes 10 μm.

with a big hyaline area on the ventral side of the raphe slit, and small, round pore foramina are arranged irregularly at the margin pole fields (Fig. 5); 6–7 large main stigma foramina on the ventral side of the central nodule, and a second row of some roundish smaller pores is present between the stigmata and the median ventral striae (Fig. 6); striae composed of slit-like areolae becoming shortened, Y-, X- or irregular round shaped towards centre and margin of the valve (Figs. 5, 6).

Distribution: Heihai Lake, which is slightly alkaline and oligotrophic with low TN and TP concentration (Tab. 1).

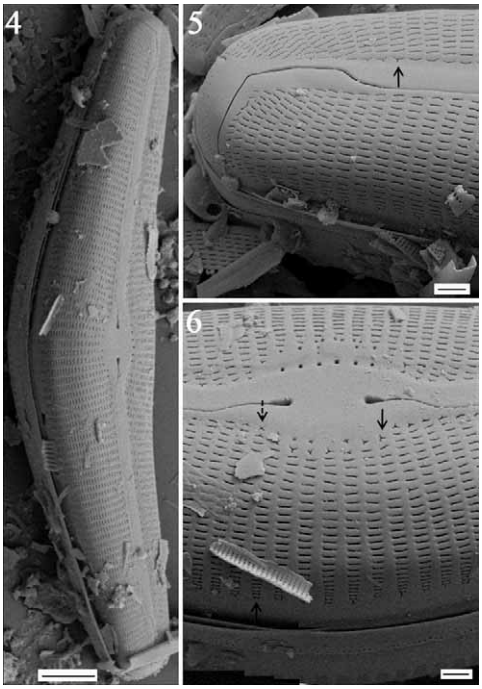
Typus: Praep. Heihai-1, Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences (NIGLAS).

Locus typicus: Heihai Lake (27°21'19.3"N, 100°04'12.1"), 11th September, 2007, surface sediment, leg. Dr. Rong Wang.

***Cymbella shudunensis* Li et Metzeltin nov. spec.**

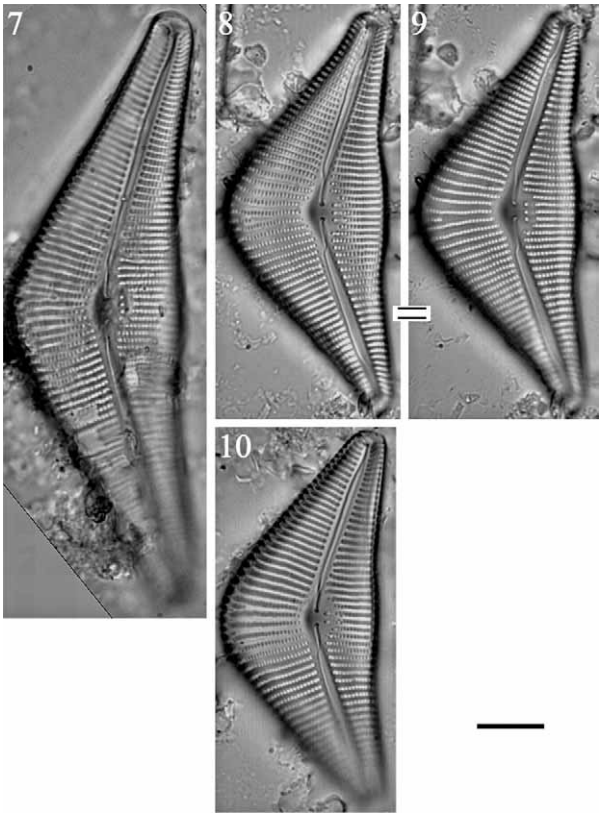
Figs. 7–13. Fig. 7 is of the holotype.

Description: Valves are strongly dorsiventral and triangle. Dorsal margin is strongly arched. Ventral margin is slightly concave with slightly tumid central part. Valve ends broadly rounded, not protracted. Length 55–87 μm and width 24–27 μm, the maximal



Figs. 4–6. *Cymbella heihainensis*. SEM, external valve views. **Fig. 4** – entire valve view showing the proximal and distal raphe endings ventrally deflected, raphe is located on a thickened part of the centre axial areas. Scale bar denotes 10 μm. **Fig. 5** – view of the pole with question mark-shaped raphe ending, pore foramina are arranged irregularly at the margin pole fields. Scale bar denotes 2μm. **Fig. 6** – central portion of the valve showing enlarged proximal raphe ends and six rounded bigger stigma openings with some smaller circular stigma near the shortened striae on ventral side, sometimes small round stigmata which are differ from areolae present on the dorsal side. Striae composed of silt-like areolae and becoming X- or Y-shaped towards centre and margin of the valve, the Y- shaped areolae are illustrate with arrows and one X- shaped areolae is pointed with dashed line arrow. Scale bar denotes 2 μm.

length/width ratio is about 3.3. Axial area is narrow, nearly linear, and the two branches form an obtuse angle. Central area is rounded, and dorsal side is smaller than ventral side. Raphe is strongly ventrally displaced as the axial area, distinctly lateral, becoming filiform near the distal and slightly reverse-lateral near the proximal ends. Central pores small, ventrally bent, terminal fissures dorsally deflected. Striae slightly radiate and become more radiate towards the valve ends. Some short striae arranged on the convex dorsal side in the middle of the valve. 2–4 stigmata appear ventrally from the central nodule, and distant from the middle ventral striae. Striae 7–10/10 μm in the middle and becoming 10–12/10 μm towards the distal, with 17–19 areolae in 10 μm. In SEM external valve view: striae composed of elliptical areolae extending to the mantle, and becoming more rounded towards the valve centre and the valve margin, the striae on the convex dorsal middle part are slightly undulating (Figs. 11, 12); round central pores at proximal raphe ends (Fig. 12); roundish stigma foramina, arranged distant from the foramina of the areolae at central area on ventral side (Figs. 11, 12); scythe-shaped in an angle of 90° at terminal fissures (Fig. 13).



Figs. 7–10. *Cymbella shudunensis*. Light microscopy. **Fig. 7** is the holotype. **Figs. 8, 9** – the same valve at different focus. Scale bar denotes 10 µm.

Distribution: Shudu Lake, China. This lake is characterized by high total nitrogen, low total phosphorus concentration, and also low specific conductance (Tab.1).

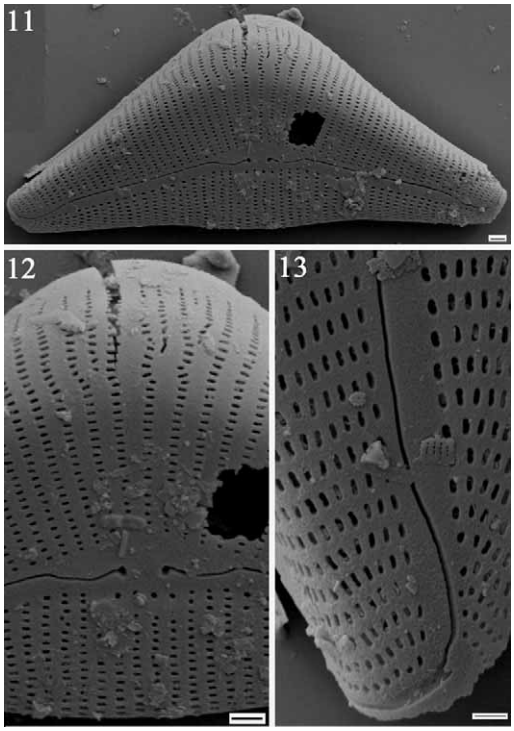
Typus: Praep. Shudu-1, Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences (NIGLAS).

Locus typicus: Shudu Lake (27°54'36.9"N, 99°56'58.4"), 15th September, 2007, surface sediment, leg. Dr. Rong Wang.

***Cymbella xingyunnensis* Li et Gong sp. nov.**

Figs. 14–32. **Fig. 14** is of the holotype.

Description: Valves are strongly dorsiventral, and broadly lanceolate. Dorsal margin is strongly arched. Ventral margin is straight or slightly concave with slightly tumid central part. Valve ends are narrow, rounded, not protracted. Length 25–41 µm, width 11.5–13.5 µm, the maximal length/width ratio is about 3.0. Axial area is narrow, and nearly linear. Central area is small and orbicular, developed more on the ventral side. Raphe is nearly in the midline or slightly ventrally displaced, moderately lateral, becoming filiform near the distal and the proximal ends. Central pores indistinct in LM, and terminal fissures dorsally

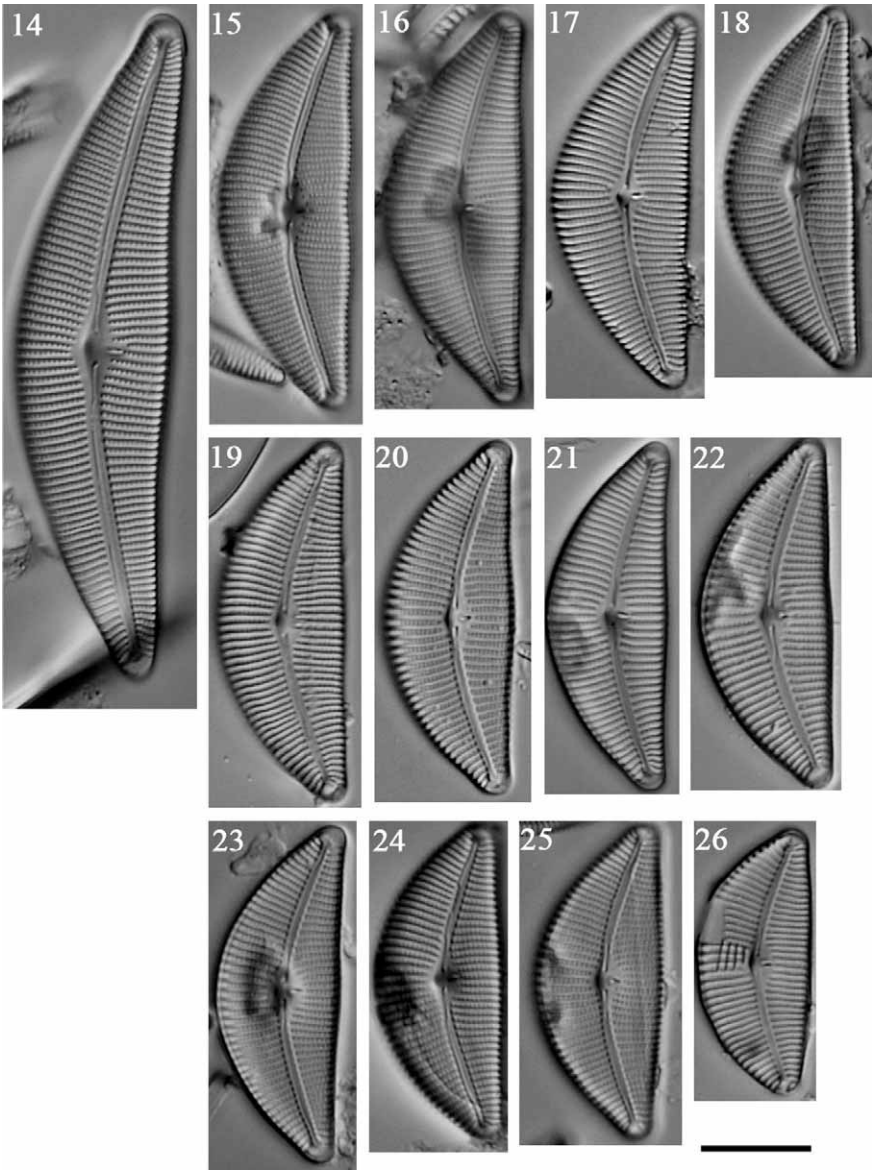


Figs. 11–13. *Cymbella shudunensis*. SEM, external valve views. **Fig. 11** – whole valve view showing striae composed of elliptical areolae extending to the mantle, and becoming more rounded towards the valve centre and the valve margin. Scale bar denotes 2 μm. **Fig. 12** – valve centre with drop-like proximal raphe ends and four roundish stigma opening. v 2 μm. **Fig. 13** – pole field with an angle of almost 90° scythe-shaped terminal raphe end. Scale bar denotes 1 μm.

deflected with big pole area. Striae radiate, distinctly punctuate-lineolate. One big stigma appears on the ventral side of the central nodule. Striae 12–14/10 μm in the middle and becoming 14–16/10 μm towards the distal, with 22–25 areolae in 10 μm. In SEM external valve view: elongated areolae combined the striae and extending onto the mantle, becoming round towards the central area (Figs. 27); terminal fissures dorsally bent off in an angle of nearly 60°, and small roundish foramina arranged in lines around the pole (Fig. 28); one large, long stigma foramina at central area, expanded drop-like central pores at proximal raphe ends (Fig. 29). In SEM internal valve view: striae with internal areolae openings, and no papillae are present on the areolae inside (Fig. 30); the distal raphe endings dorsally curved, knob-like helictoglossae with parallel arranged pole field alveoli (Fig. 31); central area formed a small hock in proximal raphe ends, one large stigma alveoli with irregular structures near the shorten striae on the ventral side (Fig. 32).

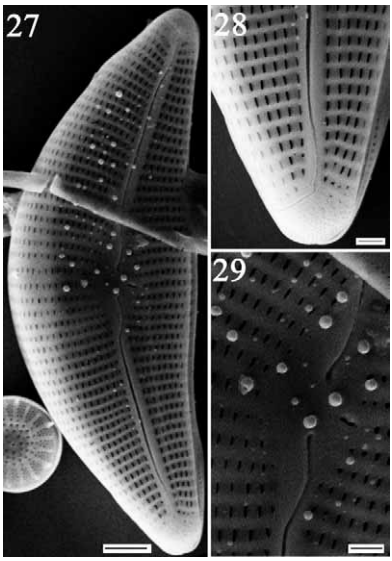
Distribution: Xingyun Lake, China. It is an alkaline, eutrophic lake with relative high specific conductance (Tab. 1). Erhai Lake, China.

Typus: Praep. Xingyun-2, Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences (NIGLAS).

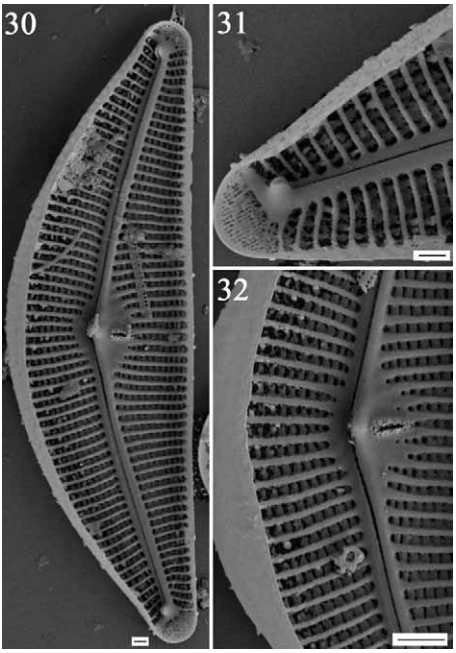


Figs. 14–26. *Cymbella xingyunnensis*. Light microscopy, valve views showing size reduction. Fig. 14 is the holotype. Scale bar denotes 10 μm.

Locus typicus: Lake Xingyun in China, (24°21'35.9"N, 102°46'33.0"), 4th September, 2007, surface sediment, leg. Dr. Rong Wang.



Figs. 27–29. *Cymbella xingyunnensis*. SEM, external valve views. **Fig. 27** – whole valve view showing the striae composed of elongated elliptical areolae extending onto the mantle. Scale bar denotes 3 μm. **Fig. 28** – view of valve end with an angle of nearly 60° dorsally bent terminal raphe ending and small roundish areolae present in lines around the pole. Scale bar denotes 1 μm. **Fig. 29** – central portion of the valve showing drop-like proximal raphe ends and long stigma opening. Scale bar denotes 1 μm.



Figs. 30–32. *Cymbella xingyunnensis*. SEM, internal valve views. **Fig. 30** – internal valve view shows striae are a composite of internal areolae openings without papillae. Scale bar denotes 1μm. **Fig. 31** – valve ends with dorsally curved knob-like helictoglossae and parallel alveoli are arranged on the pore field. Scale bar denotes 1 μm. **Fig. 32** – On the central area of the valve, proximal raphe ends form a small hook, and the margins of the stigma alveoli are surrounded with irregular structures. Scale bar denotes 2 μm.

Discussion

Taxonomy

Cymbella heihainensis appears closely allied to *C. modicepunctata* and *C. asiatica* Metzeltin, Lange-Bertalot et Li, Y. (KRAMMER 2002, METZELTIN et al. 2009) (Tab. 2). The most similar taxon is *C. modicepunctata*: it has larger valve size, bigger central area, and more striae in 10 μm, distinguishing it from *C. heihainensis*. *Cymbella heihainensis* has bigger stigmata near the central area and smaller ones near the middle striae ventrally and sometimes stigmata on dorsal side, but *C. modicepunctata* only has the same size stigmata on the ventral side. The same stigmata feature of *C. heihainensis* is also found in *C. schimanskii* and its variety var. *excelsa* (Meister) Krammer. In SEM view, *C. schimanskii*

Tab. 2. Morphological characters of *Cymbella heihainensis* Li et Gong, *C. modicepunctata* Krammer, *C. asiatica* Metzeltin, Lange-Bertalot et Li, Y., *C. schimanskii* Krammer and *C. arctissima* Metzeltin.

Species/ Feature	New species	Species for comparison			
	C. heihainensis Li et Gong	*C. modice-punctata* Krammer	*C. asiatica* Metzeltin, Lange-Bertalot et Li, Y.	*C. schimanskii* Krammer	*C. arctissima* Metzeltin
Valve length, µm	82–100	102–140	50–105	100–200	98–105
Valve width, µm	19–22.5	21–22	14–18	29–36	17–18
Length/width ratio	4.7	max 6.4	max 5.8	max 5	max 5.8
Striae in 10 µm	7–10	5.5–6	6–7	7–12	7–10
Areolae in 10 µm	14–16	14–16	18–22	10–16	18–21
Areolae	Slit-like, Y-, X- shaped	Lineolate	not known	Slit-like, Y-shaped	Slit-like
Stigmata	ventral side: 7–10 big and some smaller, dorsal side: 0–5	ventral side: 7–10	ventral side: 4–6	ventral side: 6–10 big and some smaller, dorsal side: sometimes some	ventral side: 6–8
Central area	1/2 width	2/3–3/4 width	1/2 width	1/3 width	2/3 width
Central raphe endings	expanded drop-like, slightly ventrally deflected	distinct, very slightly reverse-lateral	distinct, abruptly reverse-lateral	small, slightly reverse-lateral	small, dorsally deflected
Reference	This study	KRAMMER (2002)	METZELTIN et al. (2009)	KRAMMER (2002)	KRAMMER (2002)

has Y-shaped areolae openings in the middle of the valve and elsewhere they are slit-like, which is similar to the case of *C. heihainensis*, and the raphe is also located on a rib and thickened part (Pl. 79, Figs. 1–3 in KRAMMER 2002). However, they differ from *C. heihainensis* in the bigger valve size and smaller central area, also in the central pores (roundish shaped vs expanded drop- as in *C. heihainensis*). *C. sturii* Grunow has stigmata on both side, but the ventral stigmata are the same size. *C. heihainensis* can be distinguished from *C. asiatica* in valve size, shape of ends and stigmata numbers. *Cymbella asiatica* varies between 50 and 105 µm in length and 14–18 µm in width, with broadly rounded ends, 4–6 stigmata on the ventral side and no stigmata on the dorsal side. C. *heihainensis* is also similar to *C. arctissima* Metzeltin, which can be separated by dorsally deflected proximal raphe endings, thinner (17–18 µm vs. 19–22.5 µm) valve size and finer punctuate (18–21/ 10 µm vs. 14–16/10 µm).

Based on the morphological characters, *C. shudunensis* belongs to the group around *C. cymbiformis* Agardh (e.g. indistinct central area on dorsal side, less than 20 puncta in 10 μm, and 1–6 stigma). *Cymbella shudunensis* differs from *C. proxima* Reimer in Patrick et Reimer group in reverse lateral raphes at the proximal endings, and can be distinguished from *C.cistula* (Ehrenberg) O. Kirchner group in the absent central area on dorsal side. The outline shape of this species is rare, as it is in all the similar species (Tab. 3). The taxon most similar to *C. shudunensis* is *C. terrafuegiana* which belongs to *C. cymbiformis* group with strongly dorsiventral broadly semirhomboid. The outline of *C. shudunensis* is more convex than *C. terrafuegiana* on a wider valve size, larger central area and coarser puncta (Tab. 3). The similar taxa *C. proxima* (Pl. 112, Figs. 1–6b in KRAMMER 2002), *C. baicalensis* Skvortzow et Meyer and *C. perfossilis* Krammer all have a less convex dorsal outline and central axial area. Except the above differences, *C. proxima* differs from *C. shudunensis* in bigger central area, larger length/width ratio, different raphe type, the lineolae-like areolae in contrast to the elliptical shaped areolae, and also the arched terminal fissures against the

Tab. 3. Morphological characters of *Cymbella shudunensis* Li et Metzeltin, *C. terrafuegiana*, *C. proxima* Reimer in Patrick et Reimer, *C. baicalensis* Skvortzow et Meyer and *C. perfossilis* Krammer.

Species/ Feature	New species	Species for comparison			
	C. shudunensis Li et Metzeltin	*C. terrafuegiana* Krammer	*C.proxima* Reimer in Patrick et Reimer	*C. baicalensis* Skvortzow et Meyer	*C. perfossilis* Krammer
Valve length, μm	55–87	64–74	38–120	112–195	48–121
Valve width, μm	24–27	18–22	18–24	51–60	20–26
Length/width ratio	3.3	Max 3.6	Max 5	3.3	3.7
Striae in 10 μm	7–12	8–11	7–11	Middle 6–7	7–12
Areolae in 10 μm	17–19	19–21	12–18	About 8	13–18
Areolae	Slit-like, Y-, X- shaped	Not know	Slit-like	Not know	Not known
Stigmata	Ventral side: 2–4	Ventral side: 2–4	Ventral side: 2–5	Ventral side: 2–4	Ventral side: 2–5
Central area	Small and indistinct dorsal	Absent or small round	Orbicular, 1/3 width	Orbicular, 1/3–1/4 width	Irregularly round, 1/3 width
Central raphe endings	Round, ventrally bent	Small	Bulbous, somewhat dorsally bent	Large	Distinct, ventrally bent
Reference	This study	KRAMMER (2002)	KRAMMER (2002)	KRAMMER (2002)	KRAMMER (2002)

scythe-shaped; *C. baicalensis* is different in the larger size and the much coarser puncta. *Cymbella perfossilis* can be distinguished by the outline and larger dorsal central area.

Cymbella xingyunnensis resembles to the group around *C. proxima*, but with smaller size than the species included in this group now. All the similar species compared with this new taxa (Tab. 4). *Cymbella xingyunnensis* is quite similar with *C. sinensis*, belonging to *C. proxima* group. But *Cymbella sinensis* has larger valve size, coarser puncta, without the observed stigmata. In SEM, *C. sinensis* has C- shaped areolae, the foramina areolae in the pole are arranged in both side of the terminal fissures in external view, in internal view the foramina surround the helictoglossa contrary to the parallel arrangement in *Cymbella xingyunnensis*. *Cymbella parva* W. Smith has similar SEM view (Pl. 12, Figs. 8–10, KRAMMER 2002), but this taxa can be separated from the LM view, with smaller width, less dense striae and finer puncta. *Cymbella xingyunnensis* is also similar to *C. compacta* Østrup and *C. turgidula* Grunow. The former can be distinguished by the lack of apical pore field

Tab. 4. Morphological characters of *Cymbella xingyunensis* Li and Gong, *C. sinensis* Metzeltn et Krammer, *C. parva* (W. Smith) Kirchner in Cohn, *C. compacta* Østrup and *C. turgidula* Grunow

	New species	Species for comparison			
Species/ Feature	*C. xingyunensis* Li and Gong	*C. sinensis* Metzeltn et Krammer	*C. parva* (W. Smith) Kirchner in Cohn	*C. compacta* Østrup	*C. turgidula* Grunow
Valve length, µm	25–41	48–58	15–47	28–76	30–50
Valve width, µm	11.3–13.5	17–18	7–10	11–15	11–14
Length/width ratio	3	Max 2.8	Max 4.5	Max 5.1	Max 3.3
Striae in 10 µm	13–16	12–13	9–13	10–14	8–14
Areolae in 10 µm	22–25	15–16	28–30	18–24	22–25
Areolae	Elongated, become round towards the centre	C-shaped, become round towards the centre	Elongated, become round towards the centre	silt-like	Not know
Stigmata	Ventral side: one big	No	Ventral side: one big	Ventral side: 4–8	Ventral side: 1–3
Central area	Small and orbicular	Small, orbicular, 1/4–1/5 width	Absent or small	absent	Small, rounded, more on doarsal
Central raphe endings	Indistinct	Indistinct	Distinct, rounded	Small, slightly ventral bent	Slightly rounded
Reference	This study	KRAMMER (2002)	KRAMMER (2002)	KRAMMER (2002)	KRAMMER (2002)

and 4–8 stigmata on the ventral side. The latter has subrostrate to rostrate valve ends, commonly two stigmata, sometimes one to three stigmata on ventral side. *Cymbella xingyunnensis* can be distinguished from *C. subcistula* Krammer in valve size, length/breadth, striae numbers in 10 μm, stigmata numbers, and central area. *Cymbella subcistula* varies between 33 and 85 μm in length and 13.4–18 μm in width, with maximal length/breadth ratio 4.8, 7–12 striae in 10 μm and 2–5 small stigmata on ventral side.

Ecology

So far, *Cymbella heihainensis* has only been found in the surface sediment of Heihai Lake. Heihai Lake is an alpine lake, which is slightly alkaline and base-poor (Tab.1). The associated taxa from the surface sediment on which *Cymbella heihainensis* was found include *Cyclotella distinguenda* var. *unipunctata* (Hustedt) Håkansson et J. R. Carter (42%), *Cyclotella ocellata* Pantocsek (13%), *Achnanthes minutissima* Kützing (10%) and small *Fragilaria* spp. (15%). The small *Cyclotella* species indicate an oligotrophic and open water environment in the pelagic zone (Wunsam et al. 1995, Corella et al. 2011). *Achnanthes minutissima* also shows high abundance in low nutrient and base poor condition (Ponader and Potapova 2007). Liu et al. (2012) reported from Great Xing'An Mountains in NE China morphologically similar species, i. e. *Cymbella* cf. *arctissima* Metzeltin which should be re-examined to establish its identity and relationship to *C. heihainensis*.

Cymbella shudunensis has only been found in Shudu Lake, which is a high altitude, shallow, oligo-mesotrophic lake with relative high TN but low TP concentration (Tab. 1). In Shudu Lake, the diatom community from surface sediment is diverse, and mainly dominated by *Cyclotella stelligera* (Cleve et Grunow) Van Heurck (17%), *Fragilaria pinnata* Ehrenberg (15%), *Achnanthes minutissima* (9%), *Tabellaria flocculosa* (Roth) Kützing (5%) and *Gomphonema minutum* (C. Agardh) C. Agardh (4%). The high diversity of diatom species may reflect the shallow lake conditions with rich available habitats. *Cyclotella stelligera* and *Tabellaria flocculosa* are known as oligo-mesotrophic taxa (Little et al. 2000, Lilham 1971). *Cymbella shudunensis* may prefer mesotrophic water condition.

The new species *Cymbella xingyunnensis* has been found in Xingyun Lake, base-rich, and meso-eutrophic (with relative high TN and TP concentration). The associate diatom assemblage of surface sediment in Xingyun Lake showed the dominance of *Cyclostephanos dubius* (Fricke) Round (49%), *Fragilaria crotonensis* Kitton (28.5%) and *Aulacoseira granulata* (Ehrenberg) Simonsen (10%). This new taxon was also found in Erhai Lake, another meso-eutrophic lake in Yunnan Province (with 0.592 mg L^{-1} TN and 0.045 mg L^{-1} TP), while Erhai Lake was characterized by *Fragillaria crotonensis* (43%), *Aulacoseira ambigua* (Grunow) Simonsen (28%), *Cyclostephanos dubius* (11%) and *Cyclotella ocellata* (10%). *Cyclostephanos dubius* and *Fragillaria crotonensis* are indicators of eutrophic (Bradshaw and Anderson 2003, Lotter 1998). *Cymbella xingyunnensis* may be tolerant to nutrient-rich water. The most resemble taxa of *Cymbella xingyunnensis* is *C. sinensis*, which was considered unique to the Yunnan Plateau (Li et al. 2007b).

Further investigation in this area, especially in the habitats which the species prefer, will be necessary to establish a more comprehensive view of their biogeography, and contribute to the environmental-change research in this region. The internal view of *C. heihainensis* and *C. shudunensis* should be supplemented in future study.

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