

Ctenopoda (Crustacea: Cladocera) of Jeju Island (South Korea), with comments on taxonomic composition of the order of the whole country

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ABSTRACT. A review of the taxonomic composition of Cladocera (Crustacea) of the order Ctenopoda of the large Jeju Island (the southernmost territory of South Korea) has been provided. A reassessment of the species composition of representatives of this order has been carried out, revealing the occurrence of six species — *Diaphanosoma* cf. *brachyurum*, *D. amurensis*, *D. sarsi*, *D. dubium*, *Sida* cf. *americana*, and *Pseudosida szalayi*. Three former species are so far only known from the island. *Sida* cf. *americana* and *D.* cf. *brachyurum* require further systematic revision. A critical review of the knowledge of all known representatives of Ctenopoda in South Korea is provided with an assessment of the validity of each taxon of species and subspecies rank. The Ctenopoda fauna of Jeju Island is significantly impoverished as compared to the mainland, with 6 species compared to 10(12?), which is typical of insular fauna in general. The fauna of the order on the island is mixed, with roughly equal proportions of boreal northern and tropical southern species, corresponding to its location in a wide transition zone between boreal and tropical Cladoceran complexes. How to cite this article: Korovchinsky N.M. 2025. Ctenopoda (Crustacea: Cladocera) of Jeju Island (South Korea), with comments on taxonomic composition of the order of the whole country // Invert. Zool. Vol.22. No.3. P.439–446. doi: 10.15298/invertzool.22.3.05

KEY WORDS: Jeju Island, South Korea, Cladocera, Ctenopoda, species composition, systematic and faunistic revision.

Ctenopoda (Crustacea: Cladocera) острова Чеджу (Южная Корея) с комментариями по таксономическому составу отряда всей страны

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РЕЗЮМЕ. Представлен обзор таксономического состава ветвистоусых ракообразных (Crustacea: Cladocera) отряда Ctenopoda, обитающих на крупном острове Чеджу, являющемся наиболее южной территорией Южной Кореи. Была проведена переоценка видового состава представителей этого отряда, которая выявила обитание здесь шести видов — *Diaphanosoma* cf. *brachyurum*, *D. amurensis*, *D. sarsi*, *D. dubium*, *Sida* cf. *americana* и *Pseudosida szalayi*. Из них три первых вида пока известны только на острове. *Sida* cf. *americana* и *D.* cf. *brachyurum* нуждаются в дальнейшей систематической ревизии. Дан обзор всех известных представителей отряда Ctenopoda Южной Кореи с оценкой валидности каждого таксона видового и подвидового ранга. Фауна ктенопод острова Чеджу значительно обеднена по сравнению с материковой частью

страны (6 видов против 10(12?)), что, в целом, характерно для островной фауны. Фауну отряда на острове можно характеризовать как смешанную, с примерно равными долями присутствия северных бореальных и южных тропических видов, что соответствует его расположению в широкой переходной зоне между бореальным и тропическим фаунистическими комплексами Cladocera.

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КЛЮЧЕВЫЕ СЛОВА: Остров Чеджу, Южная Корея, Cladocera, Ctenopoda, видовой состав, систематическая и фаунистическая ревизия.

Introduction

Cladocera of the order Ctenopoda Sars, 1865 are widely distributed all over the world. In spite of their comparatively low species richness (to date, 71 taxa of species and subspecies rank are known worldwide (Korovchinsky, 2018)), ctenopods demonstrate a high morphological diversity and various life strategies with adaptation to different habitats and predator avoidance. The peculiar adaptations of their representatives place them in a unique position within Cladocera and Branchiopoda in general (Korovchinsky, 1990, 2004, 2018).

The Ctenopoda fauna of South Korea has been studied for a rather long time — since the 1940s (Yoon, Kim, 1987), but only relatively recently the species identification become more reliable (see Yoon, Kim, 2000; Kotov *et al.*, 2012; Jeong *et al.*, 2014). Overall, 16 species and subspecies taxa from this order have been recorded in the country (*Diaphanosoma amurens* Korovchinsky et Sheveleva, 2009, *D. brachyurum* (Liévin, 1848), *D. chankensis* Uëno, 1939, *D. dubium* Manuilova, 1964, *D. leuchtenbergianum* Fischer, 1850, *D. macrophthalma* Korovchinsky et Mirabdullaev, 1995, *D. mongolianum* Uëno, 1938, *D. orghidani* Negrea, 1982, *D. orghidani transamurensis* Korovchinsky, 1986, *D. transamurensis* (?), *D. sarsi* Richard, 1894, *Latonopsis australis* Sars, 1888, *Pseudosida szalayi* Daday, 1898, *Sida crystallina* (O.F. Müller, 1776), *S. ortiva* Korovchinsky, 1979, *Holopedium gibberum* Zaddach, 1855) (Kim, 1988; Yoon, 2010; Kotov *et al.*, 2012, 2022; Jeong *et al.*, 2014, 2015; Garibian *et al.*, 2021). However, some of these records are dubious, and some of the aforementioned taxa are not accepted as valid now.

Jeju Island (Jeju-do), the southernmost territory of South Korea, has been surveyed initially

mostly occasionally (Yoon, Kim, 1987, 2000). Only single publication (Kotov *et al.*, 2022) is entirely devoted to the cladoceran fauna of the island's inner water body. As a result, 41 species of Cladocera have been recorded, including six ctenopod species (*Diaphanosoma* cf. *brachyurum*, *D.* cf. *amurensis*, *D. dubium*, *D. sarsi*, *Pseudosida szalayi* and *Sida ortiva*).

The material on ctenopods from the aforementioned island was available to the author, having been studied only preliminarily. The following survey showed the need for further reinvestigation of it. In turn, this led to the necessity of discussing of taxa living on the mainland South Korea and, ultimately, trying to compile an annotated overview of the entire fauna of South Korean Ctenopoda. Despite a fair number of publications dedicated to ctenopods in the Far East of Asia, in particular South Korea, the status of some taxa is not clear enough, requiring clarification. Therefore, the aim of this paper is to review the representatives of these taxa in more detail and clarify their taxonomic position.

Material and methods

Jeju Island, its geographical position, nature, as well as sampling methods and sampling sites, were described by Kotov *et al.* (2022).

For taxon identification, specimens were selected from samples under a stereoscopic microscope and studied under an Olympus BX41 optical microscope in a drop of water covered with a coverslip and small model clay “legs”. All drawings were made using a *camera lucida*. In total, 16 samples were studied. Ctenopoda specimens presented in them were briefly described and commented upon below. Some additional specimens from mainland South Korea were also used for comparison.

Results — commented species list

Sida cf. *americana* Korovchinsky, 1979

Fig. 1A–C.

MATERIAL: samples 5501 (Banmot pond 1 (largest)) and 5502 (Banmot pond 3 (smallest)), several female specimens.

BRIEF DIAGNOSIS. Head with comparatively long (19–21% of body length) and straight rostrum having end directed backwards (Fig. 1A). Postabdomen proximally broad with a prominent dorsal part. The row of anal teeth slightly curved, the teeth gradually decrease in size proximally (Fig. 1B). The proximal basal spine of the postabdominal claws is relatively long and thin, situated close to the neighboring one (Fig. 1C).

REMARKS. Previously, *Sida* specimens from Jeju Island were erroneously identified as *S. ortiva* (Kotov *et al.*, 2022), an East-Asian species known in mainland South Korea together with *S. crystallina* (Kotov *et al.*, 2012), but *S. cf. americana* is a new species to South Korea and the Eurasian aquatic fauna in general. Its presence can be explained by a human-induced introduction during the Korean War, as it is supposed for the American chydorid species *Alona ossiani herricki* Sinev, 2013 (Kotov *et al.*, 2017). A brief survey of samples from mainland South Korean revealed that *S. cf. americana* also occurs there.

Thus, it turns out that three *Sida* species are co-occurring in South Korea, but this needs to be checked carefully, since the species of the genus remain poorly described morphologically, and the present study reveals the variability of diagnostic traits that make it difficult to identify representatives of the genus. Illustrated descriptions of South Korean species (Kotov *et al.*, 2012) do not provide a complete confidence in their definition, which raises the question of the need for a detailed review of the entire genus throughout its range.

Diaphanosoma brachyurum (Liévin, 1848)

s. lato

Fig. 1D–H.

MATERIAL: samples 4149 (a shallow pool near the road, many females) and 5498 (Doekcheon pond, 1 female, 2 juveniles).

BRIEF DIAGNOSIS. The head roundish-rectangular, its dorsal margin sloping slightly to the front and smoothly joining to the frontal margin. Eye rather large. A lanceolate spine on the basipodital distal outer end (Fig. 1F). First segment of upper two-segmented antennal branch with a minute inconspicuous denticle (Fig. 1E). Postero-ventral valve margin with 7–9 large sharp denticles and 3–9 (mostly 4–8) small ones and one setula between each two of them (Fig. 1G). One

large, sharp, inner thorn near the posterior valve margin (Fig. 1H).

REMARKS. This species was previously mentioned as living in South Korea (Kim, 1988; Yoon, Kim, 1987), although no one author provided evidence of the accuracy of its identification. However, the species later disappeared from species lists (see Yoon, 2010; Kotov *et al.*, 2012; Jeong *et al.*, 2015; Garibian *et al.*, 2021). It has been suggested that the occurrence of *D. brachyurum* in the country is uncertain (Jeong *et al.*, 2014).

The current finding of the species in two locations confirms its presence in South Korea for the first time, as all previous records here and in East Asia in general lacked adequate descriptions. At the same time, there were no males available for more accurate identification. Additionally, it is worth noting that the studied individuals from the island were characterized by an unusually high number of small, intermediate denticles on the posterior-ventral margin of the valve, which is atypical for other representatives of this species and may indicate its taxonomic distinction from the latter. For these reason, despite the close morphological similarity between Korean individuals of *D. cf. brachyurum* and typical European individuals, they and other East Asian members of the taxon need further comparative studies.

Diaphanosoma amurensis Korovchinsky
et Sheveleva, 2009

Fig. 2A–D.

MATERIAL: Samples 5493 (pond 2 without lotus, 2 females, 1 male, 1 juvenile) and sample 5501 (Banmot pond 1 (largest), several females).

BRIEF DIAGNOSIS. Head comparatively large with large eye. Swimming antennae long, surpassing the posterior valve margin (Fig. 2A). Postero-ventral valve margin with 6–8 rather large denticles and 1–2 small denticles and one setula between each two of them (Fig. 2B). Male has straight copulatory appendages with a widened distal part (Fig. 2D).

REMARKS. This species had not been recorded in South Korea until recently (see Jeong *et al.*, 2014). Later, it was supposed to be recorded on Jeju Island (Kotov *et al.*, 2022). Now, considering the diagnostic features of the male, the identification of this species is quite certain. It is interesting to note that this species was not found on the mainland of South Korea. Perhaps, their individuals were confused with members of other species of the genus. Jeju Island is the southernmost known location of the species in East Asia.

Diaphanosoma sarsi Richard, 1894

Fig. 2E–G.

MATERIAL: Samples 4100 (small pond with extensive vegetation, about 40 females and juveniles),

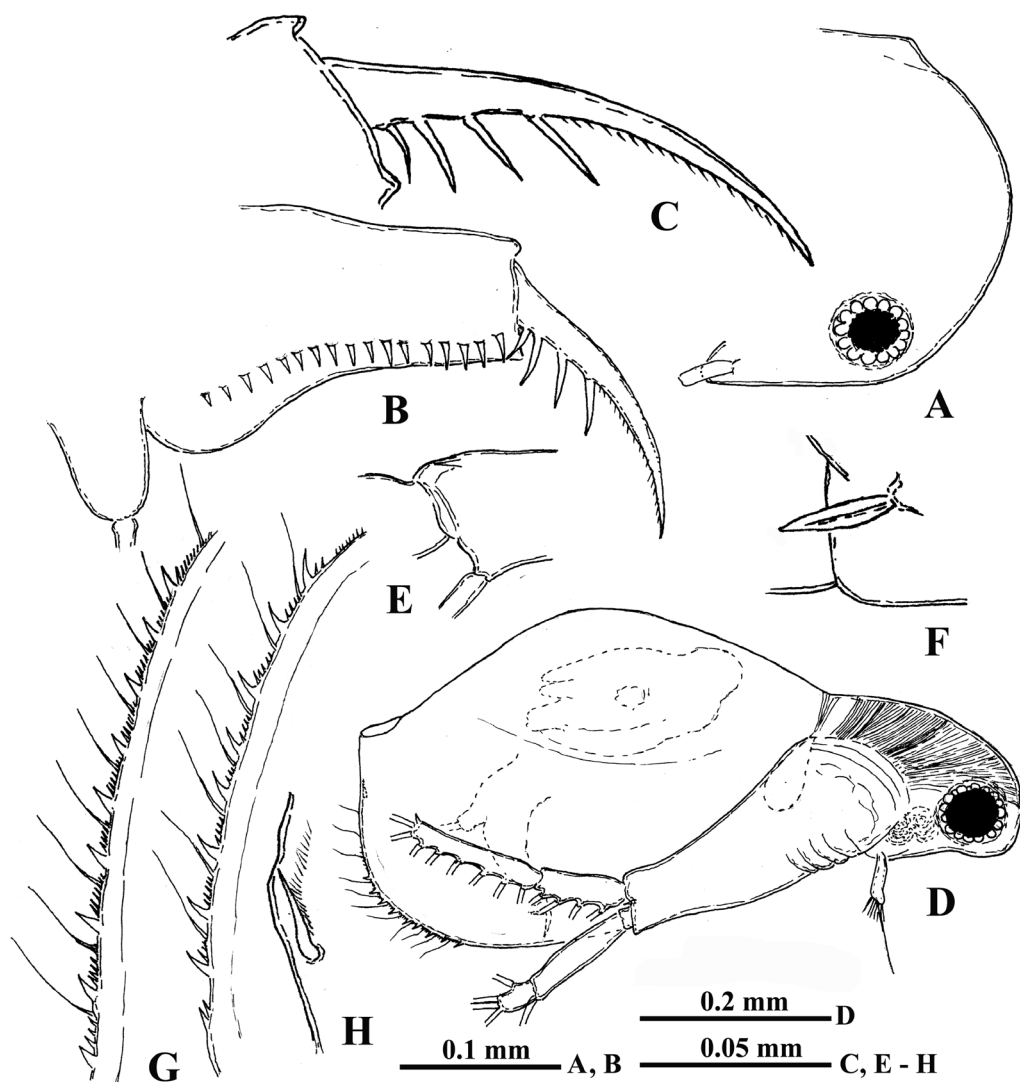


Fig. 1. *Sida* cf. *americana* Korovchinsky, 1979 (A–C) and *Diaphanosoma* cf. *brachyurum* (Lièvin, 1848) (D–H). A — head, lateral view; B — postabdomen, lateral view; C — postabdominal claw; D — general lateral view; E — apical end of proximal segment of upper antennal branch; F — lanceolate spine on outer end of antennal basipodite; G — armament of postero-ventral valve margin; H — inner spine near posterior valve margin.

Рис. 1. *Sida* cf. *americana* Korovchinsky, 1979 (A–C) и *Diaphanosoma* cf. *brachyurum* (Lièvin, 1848) (D–H). A — голова, вид сбоку; B — постабдомен, вид сбоку; C — коготок постабдомена; D — общий вид сбоку; E — апикальный конец проксимального членика верхней ветви антенны; F — ланцетовидный шип на внешней стороне конца базиподита антенны; G — вооружение задне-вентрального края створки раковинки; H — внутренний шип возле заднего края створки раковинки.

4102 (very small pond (10 m in diameter) near previous one, 1 female and 1 juvenile), and 5470 (Yongsuji Reservoir, 2 females).

BRIEF DIAGNOSIS. Head rounded-rectangular with a sloping dorsal side. Eye large. Swimming

antennae relatively short and weak (Fig. 2E). Shell rather high, ventral part of the valve inflexed, forming a wide free flap with a rather narrow cut at its junction with the posteroventral margin, so that the rounded distal part projects backwards. Posteroventral valve

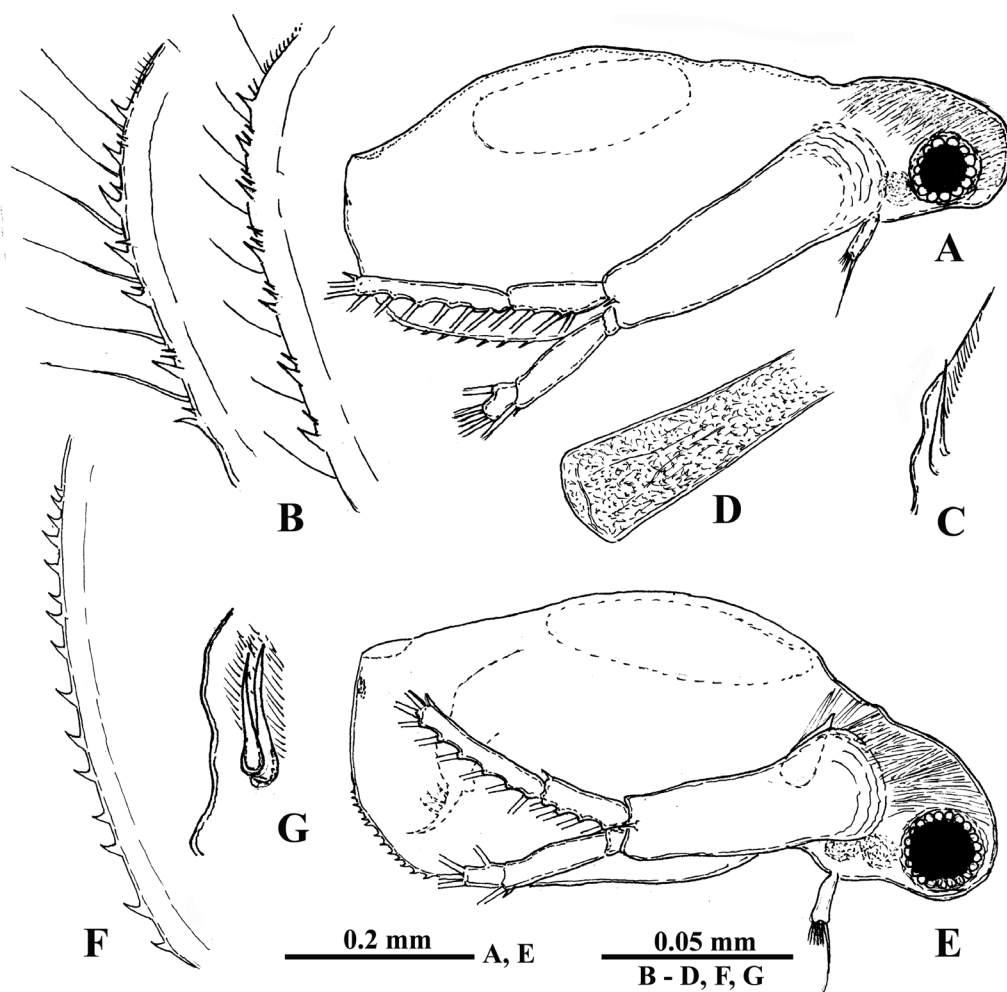


Fig. 2. *Diaphanosoma amurensis* Korovchinsky et Sheveleva, 2009 (A–D) and *D. sarsi* Richard, 1894 (E–G). A, E — general lateral view; B, F — armament of postero-ventral valve margin; C, G — inner spine(s) near posterior valve margin; D — male's copulatory appendage.

Рис. 2. *Diaphanosoma amurensis* Korovchinsky et Sheveleva, 2009 (A–D) и *D. sarsi* Richard, 1894 (E–G). A, E — общий вид сбоку; B, F — вооружение задне-вентрального края створки раковинки; C, G — внутренние шипы возле заднего края створки раковинки; D — копулятивный придаток самца.

margins with a row of 15–20 small denticles diminishing dorsally (Fig. 2F). Two thin inner thorns near the posterior margin of each valve (Fig. 2G).

REMARKS. This species was recorded in South Korea many years ago (Kim, 1988; Yoon, Kim, 2000), but its identification was questioned. Probably for this reason, it was not included in the species list in a later revision of Korean Cladocera (Yoon, 2010). Later, its presence in the country was also considered doubtful (Jeong *et al.*, 2014), but this species was later found in samples from Jeju Island (Kotov *et*

al., 2022, Krolenko *et al.*, 2023, present publ.). Jeju Island is the northernmost known location of the species in East Asia.

Diaphanosoma dubium Manuilova, 1964

MATERIAL: Samples 5442 (Gwangnyeong Reservoir, several females), 5469, 5470, 5472 (Yongsuji Reservoir, numerous females), 5471 (small pond near Yongsuji Reservoir, several females), 5473 (very large pond on the cabbage field, several females).

BRIEF DIAGNOSIS. Head very large, its massive dorsum greatly protruding. Swimming antennae powerful, the apical end of upper antennal branch usually reach the posterior valve margin or exceeds it. Apical end of distal segment of the branch usually with curved spine. Posterior and posteroventral valve margins low, usually oblique or straighter; the latter connects smoothly with the former bearing 20–35 small denticles and thin setulae between them. No internal dorsal spine near the posterior margin of the valve.

REMARKS. In South Korea, this species was originally identified as either *D. brachyurum* or *D. leuchtenbergianum*, and later revised by Yoon and Kim (2000). This species has been found in a large number of localities, sometimes in a large abundance. The taxon is widely distributed throughout East Asia and often dominates aquatic communities (Korovchinsky, 2000, 2018).

Pseudosida szalay Daday, 1898

MATERIAL: Samples 5460 (pond, several females), 5461 (pond near the road, single juvenile), 5502 (Banmot pond 3 (smallest), few females).

BRIEF DIAGNOSIS. Body oval-elongated, with comparatively small head often tilted downwards. Rostrum large, directed more or less ventrally. Large eye located near the anterior or anteroventral margin of the head. Ocellus large, situated near the base of the antennules. Antennules long, with aesthetascs on a small lateral prominence at their basal part, and a long sensory seta, setulated distally. The distal segment of the lower antennal branch small and always bears three setae, one of which is almost as large as the one of the second segment. Two large setae on the lower branch occupy the most ventral position; their proximal segments naked, while the distal segments are armed with ventrally situated setules and terminally they have well developed hooks. Anterior valve margin naked, lacking setae. From seven to nine posteriormost setae on the posteroventral margin decrease in size dorsally, directed backwards and slightly outwards. Posterior valve margin with an inner row of numerous submarginal spinules and clusters of spinules. Postabdomen comparatively short and high, row of 10–12 clusters of anal teeth along each lateral side, mostly with 3–4, rarely 2, 5 or 6 teeth in each cluster. Dorsally, between the base of the claws, postabdomen bears a terminal outgrowth of different shape. Postabdominal claws with three basal spines, two of which are long while the proximalmost very small.

REMARKS. In South Korea, *Pseudosida* cf. *szalay* was first recorded by Kotov *et al.* (2012) and then by Jeong *et al.* (2015), both in a single locality on its continental part. At the same time, on Jeju Island, this species was found in three localities (Kotov *et*

al., 2022, present publ.), which could be related to the southernmost location of the island. The species is rather widespread in the tropics and subtropics of the Eastern Hemisphere, penetrating north to the southern boreal latitudes. Its northernmost location is on the Lower Amur River in the Russian Far East (Korovchinsky, 2010, 2018).

Discussion

Summarizing the above data, we can conclude that four among the six recorded Sididae species on Jeju Island (*Sida* cf. *americana*, *D.* cf. *brachyurum*, *D. amurensis*, and *D. sarsi*) appear to be new records for South Korea, as their occurrence has been confirmed by more detailed morphological analysis. In particular, the list of *Diaphanosoma* species in the country has been significantly expanded. At the same time, all these *Diaphanosoma* species so far have been found only on Jeju Island and are unknown on the mainland of the country. This fact could be partly explained by insufficient accuracy in identifying the material in the past. However, *Sida* cf. *americana* inhabits both the island and the mainland of the country, as do *D. dubium* and *P. szalay*, as mentioned above. In addition to the species mentioned above, two more *Diaphanosoma* species were previously found on the mainland South Korea — *D. macrophthalma* and *D. orghidani transamurensis* (Korovchinsky, 2004, 2018) — which, in contrast, have not been recorded on the island.

As for the other taxa recorded in South Korea earlier, the species *D. leuchtenbergianum* is a synonym of *D. dubium* (Yoon, Kim, 2000). Also, *D. mongolianum*, was also recorded in South Korea by Yoon (2010), but it seems that *D. dubium* has been described again under this name. This species was considered valid for South Korea by Jeong *et al.* (2014), but later its name disappeared from the local species lists. The same is true for *D. chankensis*, which was also recorded in South Korea by Yoon (2010). This author refers to Korinek (1987), whose understanding of the species was incorrect (Korovchinsky, 1998, 2018). In fact, *D. macrophthalma* was probably described under this name. Later, both the invalid taxon ("*D. transamurensis*") and species whose occurrence is extremely unlikely in South Korea (*D. orghidani*) began to appear on the local cladoceran species lists (see Jeong *et al.*, 2015; Garibian *et al.*, 2021; Krolenko *et al.*, 2023). It

is unlikely that using such taxa would be useful in developing faunal and zoogeographic schemes to which the cited works refer.

Thus, excluding the questionable taxa discussed above, five species and one subspecies of the genus *Diaphanosoma* can be considered valid for South Korea: *D. cf. brachyurum*, *D. amurensis*, *D. dubium*, *D. macrophthalma*, *D. orghidani transamurensis* and *D. sarsi*. The former of them requires a revision. In addition to the taxa mentioned above, two more are known in South Korea — *Latonopsis australis*, and *Holopedium gibberum*. The first was recorded by Kim (1988) and Yoon (2010) as a rare species found only in one and two localities, respectively. During later surveys, *L. australis* s.l. was not found in the country despite extensive collection efforts (see Kotov *et al.*, 2012, 2022; Jeong *et al.*, 2015; Garibian *et al.*, 2021). *H. gibberum* was also listed only in early works of Yoon and Kim (1987) and Kim (1988). Later, for some unknown reason, the species was not mentioned in Yoon's (2010) review. The reality of the finding of the species is supported by the fact that representatives of this group can be difficult to confuse with any other. Molecular-genetic analysis of populations of the species from Europe and East Asia (Japan) revealed their conspecificity (Yamamoto *et al.*, 2019).

Summarizing the aforementioned data, we can see that the fauna of Jeju Island is significantly impoverished compared to the mainland (6 species compared to 10 or 12 if three species of *Sida* are considered to be present in South Korea) as it is typical of the entire local fauna of Cladocera (Kotov *et al.*, 2022). Genera such as *Latonopsis* and *Holopedium* are absent here. In turn, three *Diaphanosoma* species, *D. cf. brachyurum*, *D. amurensis* and *D. sarsi*, are known only on the island, which, I repeat, may be reflect of an insufficient level of study of country mainland. As for the geographic (latitudinal) preferences of the Ctenopoda taxa on Jeju Island, there are two boreal species (*D. cf. brachyurum* and *D. amurensis*), two tropical (*D. sarsi* and *Pseudosida szalay*) and a single East Asian species (*D. dubium* which mainly inhabits the south temperate and subtropical zones in the south, probably having recently spread westwards (Korovchinsky, 2000, 2018)), and a single alien species *Sida cf. americana*, also of northern origin. Both boreal and tropical species

occur here at the southernmost and northernmost points of their ranges (see above), respectively. There is no evidence of a significant dominance of tropical taxa over boreal taxa, as noted for the whole cladoceran fauna of the island (see Kotov *et al.*, 2022), rather, the predominance of boreal species is noticeable. All these facts indicate the mixed nature of the local ctenopod fauna, consistent with the location of Jeju Island within a broad transition zone between boreal and tropical cladoceran faunal complexes (Garibian *et al.*, 2021).

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