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Taxonomy and distribution of four Cladoceran families (Branchiopoda: Cladocera: Moinidae, Bosminidae, Chydoridae and Sididae) in Philippine inland waters

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Abstract. Cladocerans are one of the most abundant groups of zooplankton that serves as food for fishes and as an indicator of aquatic ecosystem health. This paper updates the diversity and distribution of cladocerans in freshwater ecosystems in the Philippines. Samples from the University of Santo Tomas – Zooplankton Reference Collection (UST-ZRC) (collected from 2006 to 2012) together with more recent collections (January to October 2013) were examined and analysed. Results indicate the presence of 16 species from families Moinidae, Bosminidae, Sididae and Chydoridae compared to the 56 species that were reported in previous studies. Moinids and Bosminids were mostly encountered in the islands of Luzon and Mindanao but rarely found in the Visayas islands while family Sididae and Chydoridae were more distributed throughout the archipelago. Family Sididae and Chydoridae are considered as the most diverse and well-distributed of the four families inhabiting Luzon, Mindanao and some of the major islands in Visayas. Though seven species of chydorids have been identified in this study, researchers observed very limited number of individual chydorids in sampling locations where they have been collected. Recent alterations to freshwater ecosystems may have also contributed to the disappearance of some species through changes in water quality and the introduction of non-native species. Though no novel species have been identified from these four families so far, our study provides a better understanding of distribution patterns among these taxa.

Key words. Zooplankton, species richness, biodiversity, freshwaters

INTRODUCTION

The Philippines (13.00 N, 122.00 E), located in Southeast Asia between the West Philippine and Philippine Seas, is an archipelago of 7,107 islands covering a total area of 300,000 square kilometres with three main island groups, namely: Luzon, Visayas and Mindanao (Ong et al., 2002). The Philippines is considered as a megadiverse country (Myers, 2000) with numerous endemic species . The archipelago has immense natural resources that are a source of food, shelter and livelihood that can cater its growing population. There are about 211 lakes, 18 major river systems and 22 marshes, swamps and reservoirs which provide energy, irrigation as well as provide sources of fish either from open water fisheries or aquaculture (DENR, 2010). The rise of irresponsible aquaculture practices in many Philippine lakes and other inland waters has led to the decline of water quality and has become a threat to the country's freshwater biodiversity. To avoid the possible misuse of the Philippines' natural resources including inland waters, several major freshwater bodies such as Taal, Paoay, Lanao, and Naujan have been declared as protected areas by the national government to improve water quality monitoring and control the amount of human activity in the lakes. However, much is yet to be known about freshwater zooplankton (members of Class Copepoda, Superorder Cladocera and Phylum Rotifera) in many of these areas due to the lack of specialists and priority by research funding institutions. Recent studies were focused on identifying the composition and ecology of zooplankton in several freshwater bodies in the Philippines, such as Lake Taal (Papa et al., 2012) and Lake Paoay (Aquino et al., 2008). Determining the distribution of freshwater zooplankton in the Philippines has not been undergone since the work of Petersen & Carlos (1984) and Mamaril (2001). The previous studies of Brehm, (1938), Woltereck et al. (1941), Tsi-Chung & Clemente (1954), Mamaril & Fernando (1978); Mamaril (2001), Petersen & Carlos (1984); Korovchinsky (2000), Aquino et al. (2008), Papa & Mamaril (2011), Papa & Zafaralla (2011) and Papa et al. (2012) have identified almost 56 cladocerans in Philippine waters. There is a need to re-analyse previous estimates of zooplankton species richness and taxonomy given the recent advances in cladoceran taxonomy and the development of more accurate microscopic techniques. This, together with the more intensive use of freshwaters for aquaculture and the decline of water quality necessitate a re-analysis of previous estimates.

About 298 cladoceran species are currently known from South East Asia, including 67 valid species, 68 that have already been relegated as synonyms and 163 that represent

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complexes of species (Korovchinsky, 2013). Recent advances in microscopy and molecular phylogenetics may double the number of species found worldwide. Identification of specimens using other morphological characters then considered irrelevant are now being studied through these advances (Elmoor-Loureino, 2006). An estimation of the number of taxa within families, genera and local faunas of Cladocera reveals that only 129 species (17% of all known species) may be considered as sufficiently well described (valid species) (Korovchinsky, 1996) With 28 genera present in Philippine waters, endemicity is highly probable. Even with this diversity, very few studies have been done in their taxonomy and distribution in the country.

This overall lack of interest has become a handicap to both their taxonomy and its use in sustainable aquaculture. Reports on invasive zooplankton species which may eventually become a threat to native species have already been reported (Papa et al., 2012). Studies on the systematics, distribution, and ecology of freshwater zooplankton can add information needed to maintain a sustainable biodiversity for freshwater habitats, as well as improve knowledge on their importance to fisheries.The research aimed to address these problems by surveying the inland waters across the Philippine archipelago for the diversity and distribution of zooplankton, specifically focused on four cladoceran families widely distributed in the country and update on their taxonomy and geographical distribution.

MATERIAL AND METHODS

Sampling. Zooplankton were collected from January to October 2013 in six islands across the Philippines. Together with previously collected samples (2006–2012) deposited in the University of Santo Tomas - Zooplankton Reference Collection (UST-ZRC), a total of 86 freshwater ecosystems including 53 lakes, 17 rivers, 5 reservoirs and 11 other water bodies such as swamps, ponds and temporary pools were analysed for cladocera (Fig. 1). All samples and pertinent details regarding the various collecting sites are available with the corresponding author. Plankton sampling was done by towing 50, 80 and 100 µm mesh-size plankton nets from several transects perpendicular to the lake shore. Littoral and limnetic samples were stored separately unless there was no clear demarcation between littoral and limnetic areas of the lake (Papa & Hołyńska, 2013).

Materials examined. Samples from the UST-ZRC (Ref. Nos. 0001–0105) and more recent collections (UST-ZRC Ref. Nos. 0106–0309) were sorted, dissected and identified using Olympus CX21 Compound Microscope and Swift Stereomicroscope at the University of Santo Tomas (Manila, Philippines). Additional analyses were also performed in Jinan University (Guangzhou, China) using Zeiss Stereomicroscope Discovery Version 2.0, Nikon Eclipse 80I, Zeiss Fluorescent Microscope 8X10, Olympus CX41 Compound Microscope and Hitachi TM300 Tabletop Microscope. Dissection was done in a drop of glycerine in a glass slide and fixed permanently using nail varnish prior to examination under light microscopes. For SEM viewing, specimens fixed in 70% EtOH was transferred to 1ml of HMDS (Hexa-methyl-disalizane) + 99% EtOH solution and kept for 15 minutes. After which, one more change of 100% HMDS was done for 15 minutes and allowed to dry. Dried specimens were picked up using fine dissecting needles and mounted on the stub made of glass slide by using carbon tape. Gold coating was carried out by the EMS 7620 Mini sputter coater attached to the scanning electron microscope . SEM images were taken using the Hitachi TM300 Tabletop Microscope.

Identification was aided by descriptions, taxonomic keys and illustrations by Burckhardt (1924, 1941), Goulden (1968), Fryer (1968), Kořínek et al., (1997, 1999, 2002), Mamaril & Fernando (1978), Korovchinsky (1991, 1992, 1995, 1996, 1998, 2000), Dumont & Negrea (2002), Fernando (1980,

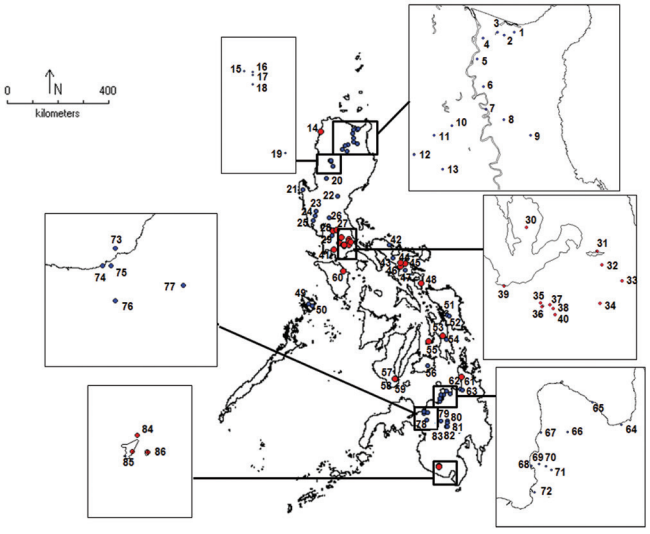

Fig. 1. Map of the Philippines indicating inland waters included in this study. Refer to Table 1 for other pertinent details on the sampling sites.

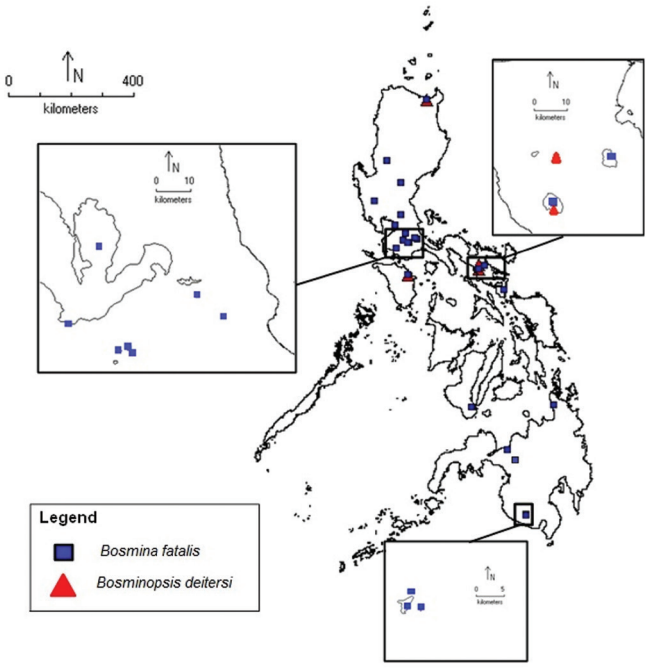

Fig. 2. Distribution of family Bosminidae based on recently collected samples (2013) and stored samples in the UST ZRC.

2002), Smirnov (1996), Kotov et al., (2009), Petersen (2009) and Papa et al. (2012).

Slides were deposited in the University of Santo Tomas – Zooplankton Reference Collection (UST-ZRC) with accession numbers 0072–0096A. The distribution of identified species were noted and compared with those from previous studies. Updated distribution maps were made using DIVA-GIS Software Version 7.4.

RESULTS

Key to the species of the four Cladoceran families

1. Head with a protective head shield. Swimming antennae with less than ten natatory setae.....2 (Order Anomopoda)
– Head without a protective head shield. Swimming antennae with more than ten natatory setae ..... 12 (Order Ctenopoda:Family Sididae)
2. Antennules fused with rostrum ..... 3 (Family Bosminidae)
– Antennules not fused with rostrum 4
3 Distal part of the antennules diverging. Postabdomen cone-like with rounded tip ..... *Bosminopsis deitersi*
– Distal part of the antennules parallel. Postabdomen rectangular in shape with oblique anal opening .....*Bosmina fatalis*
4. Body laterally compressed. Rostrum present..... .....5 (Family Chydoridae)
– Body not laterally compressed. Rostrum absent..... ..... 11 (Family Moinidae)
5. Body more globular. Postabdomen short .... 6 (Subfamily Chydorinae)
– Body more oval. Postabdomen long ...8 (Subfamily Aloninae)
6. Rostrum blunt. Labrum with serrated teeth .... *Ephemeroporus barroisi*
– Rostrum pointed. Labrum without serrated teeth 7
7. Anal denticles gradually diminishing in size, valves without polygons..... *Pleuroxus* (*Picripleuroxus*) cf. *quasidenticulatus*
– Anal denticles almost equal in sizes, valves with polygons..... ..... *Chydorus* cf. *sphaericus*
8. Ventral margin with long feathered setae. Postabdomen with long terminal claw.....9
– Ventral margin with long naked setae. Postabdomen with short terminal claw 10
9. Antennae with two spines. Postabdomen terminal claws with 3 accessory spines .....*Oxyurella singalensis*
– Antennae with three spines. Postabdomen terminal claws with 2 accessory spines .....*Camptocercus* cf. *uncinatus*
10. Two main head pores. Lateral head pores lobed .... *Anthalona* sp.
– Three main head pores. Lateral head pores circular..... .....*Alona pulchella*
11. Ocellus absent. Head rounded with supraocular depression ....*Moina micrura*
– Ocellus present. Head triangular without supraocular depression .....*Moinodaphnia macleayi*
12. Head clearly delimited from the body. Antennule with a shorter sensory seta than its basipodite, eye situated more ventrally... ..... 13 (Genus *Diaphanosoma*)
– Head not clearly delimited from the body. Antennule with a longer sensory setae than its basipodite, eye situated more dorsally .....*Latonopsis australis*
13. Head cone shaped. Swimming antennae with hooked spines in the apical ends of the first and second segment of the antennal branches 14
– Head rectangular in shape. Swimming antennae with straight spines in the apical ends of the first and second segment of the antennal branches 15
14. Head one half of the body size. Postabdomen without a strong convex curve..... D*iaphanosoma dubium*
– Head one third of the body size. Postabdomen with a strong convex curve.....*Diaphanosoma tropicum*
15. Head large with a raised dorsal side. Carapace with narrow free flap. Swimming antennae strong and long ..... *Diaphanosoma excisum*
– Head small with a sloping dorsal side. Carapace with broad free flap. Swimming antennae weak and short ..... *Diaphanosoma sarsi*

Class Branchiopoda
Superorder Cladocera
Order Anomopoda
Family Bosminidae

Genus *Bosmina* Baird, 1846

The body is more or less globular ranging from 0.4–0.8 mm in length. The head and the carapace have no demarcation. Head shield has three types of pores (one dorsal, one frontal and two paired lateral ones). The female rostrum has an elongated conical extension where the antennules are inserted. Antennules are elongated, recurved, immobile, pluri-articulated and with sensory setae on the anterior border. Ocellus is absent. The carapace has posterior border that is more or less rectilinear ventrally ending in a mucro. It has six pairs of trunk limbs but the last pair reduced to a small, naked lobe. First limb of the male has a very distinct copulatory hook. Second limb contains marginal setae of endopodite. The exopod of the third limb has seven setae. The fourth and fifth limb has eight and five setae respectively. The postabdomen is rectangular in shape with anal opening in apical position.

Bosmina fatalis Burckhardt, 1924

Specimen examined. 12 samples from Lake Taal, Lake Buhi, Laguna de Bay, Lake Lumot-Mahipon and Pantabangan Dam were examined and stored in UST-ZRC with reference numbers 0083–0089, 0094A–0095A and 00134–00136.

Description. Body length ranges in 0.4–0.6 mm. *Bosmina fatalis* has a long rostrum fused with antennules of variable length and shape (Fig. 3B). *B. fatalis* in the study has an oval shaped front head pore situated at the midpoint between the two frontal setae that conforms to the description of (Fig. 4D) that conforms to the description of Kořínek et al. (1997). A small and round median head pore (MHP) is also located on the dorsal surface of the head which is connected to the cord-like structure that is suggested to be a supraeosophageal ganglion (Kořínek et al., 1997). Long mucro situated at the distal end of the carapace. Setules are observed in the postabdomen with a slightly convex ventral margin and an anal opening at the lateral aspect. The postabdominal claw consists of a row of 6–8 teeth with minute spines continuing ventrally (Fig. 3C).

Distribution. Cagayan: Lake Bangalau, Benguet: Ambuklao dam; Nueva Ecija: Pantabangan dam; Tarlac: Lake Tambo; National Capital Region (NCR): Pasig River, Marikina River; Laguna: Lake Palakpakin, Lake Kalibato, Lake Yambo, Lake Tadlak, Lake Caliraya, Lake Lumot-Mahipon; Batangas: Lake Taal; Camarines Sur: Lake Buhi, Lake Bato; Sorsogon: Lake Bulusan; Oriental Mindoro: Lake Naujan; Negros Oriental: Lake Danao, Lake Kabalin-an; Lanao del Norte: Agus IV Dam; Agusan Del Norte: Lake Mainit; South Cotabato: Lake Lahit, Lake Siloton, Lake Sebu; Lanao del Sur: Lake Lanao (Fig. 2).

Remarks. *B. fatalis* collected in the Philippines were compared to the same species sampled in Taihu Lake, China (type locality). The species is reported in East Asian lakes and reservoirs. *B. fatalis* can also be found from the temperate zone in the north to the subtropical and tropical areas (Japan, Philippines, China and Indonesia) (Fernando, 2002).

Superorder Cladocera
Order Anomopoda
Family Bosminidae

Genus *Bosminopsis* Richard, 1895

The head of *Bosminopsis* is relatively smaller than *Bosmina.* The rostrum is fused with antennules that diverge at the distal end. A cervical sinus separates the head from the carapace. Postabdomen is cone-like narrowing to the obtusely rounded tip. Short but robust postabdominal claws are distinguishable on the tip of the postabdomen.

***Bosminopsis deitersi* Richard, 1895**

Specimen examined. Three samples from Lake Bangalau in Cagayan and Lake Naujan, Mindoro were stored in UST-ZRC with reference numbers 0090–0092.

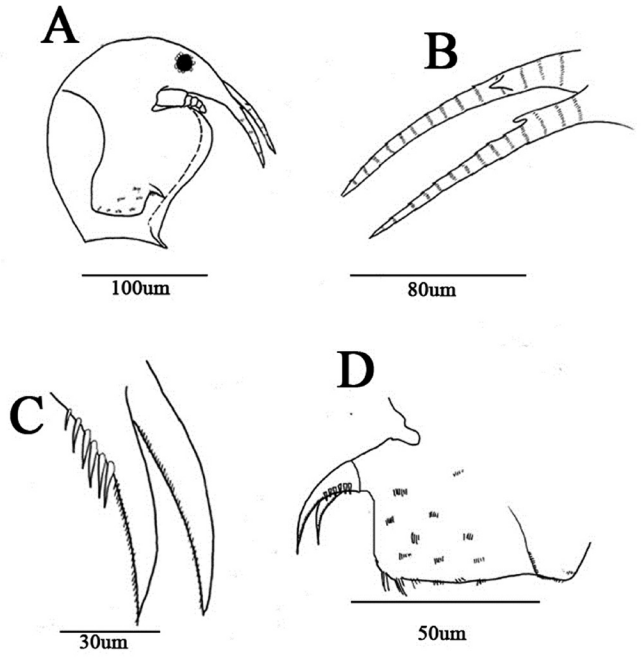

Fig. 3. *Bosmina fatalis* parthenogenic female. A, habitus; B, antennule; C, terminal claws; D, postabdomen.

Description. Body length ranges in 0.1–0.4mm. Distributed through the tropics and some localities in the temperate, this species are characterised by relatively small with a supraocular depressions or slight keels (Fig. 5A). The antennule and the rostrum are merged (Fig. 5B). The distal part of the antennules are diverging which makes *Bosminopsis deitersi* unique from other species under Bosminidae (Fig. 5B). A cone-like postabdomen contains a rounded tip (Fig. 5C) that is mostly seen protruded outside of the carapace. A short sharp postabdominal claw is not similar to most *Bosmina*. It contains small teeth with small spines continuing dorsally.

Distribution. Cagayan: Lake Bangalau; Camarines Sur: Lake Bato, Lake Baao; Oriental Mindoro: Lake Naujan (Fig. 2)

Remarks. The species is reported in both tropics and subtropics in the world with several localities in the north temperate zone. *Bosminopsis deitersi* collected in the Philippines was compared with the species in Taihu Lake, China and revealed the same morphological characters in exception of the setae at the tip of the antennule which are not present in the samples coming from the Philippines (Fernando, 2002).

Class Branchiopoda
Superorder Cladocera
Order Anomopoda
Family Chydoridae
Subfamily Chydorinae

Genus *Chydorus* Leach, 1816

Body globular with ventral margin with setae inserted on its inner surface. Head shield with acute rostrum with two major head pores. Have large labral plates. Antennules do not have a peg. Swimming antennae usually with 8 setae. Species of the genus are the commonest anomopods. Morphological variability has made this genus a possible genus group.

***Chydorus* cf. *sphaericus* (Mueller, 1785)**

Specimen examined. Six parthenogenic female.One mounted specimens (UST-ZRC 0120-Lake Malbato, Palawan). Four were not mounted due to rarity of specimens collected. One specimen was damaged beyond repair.

Description. Chydoridae is the largest family in Anomopoda and the largest family under Superorder Cladocera. It has two recognised sub families: Chydorinae and Aloninae (Dumont & Negrea, 2002). *Chydorus sphaericus* is one of the most common species of chydorids found worldwide. It is characterised by a subglobular body with valves having polygons. It has a well pointed rostrum and a very short antennule. Its labral plate is cuneiform and has an elongated tip. It has a short post abdomen with 8–10 anal teeth. It occurs in both the littoral and the limnetic zones. It has limited distribution in the Philippines found mostly in freshwater bodies with good macrophyte cover in the littoral zones. (Fig. 8)

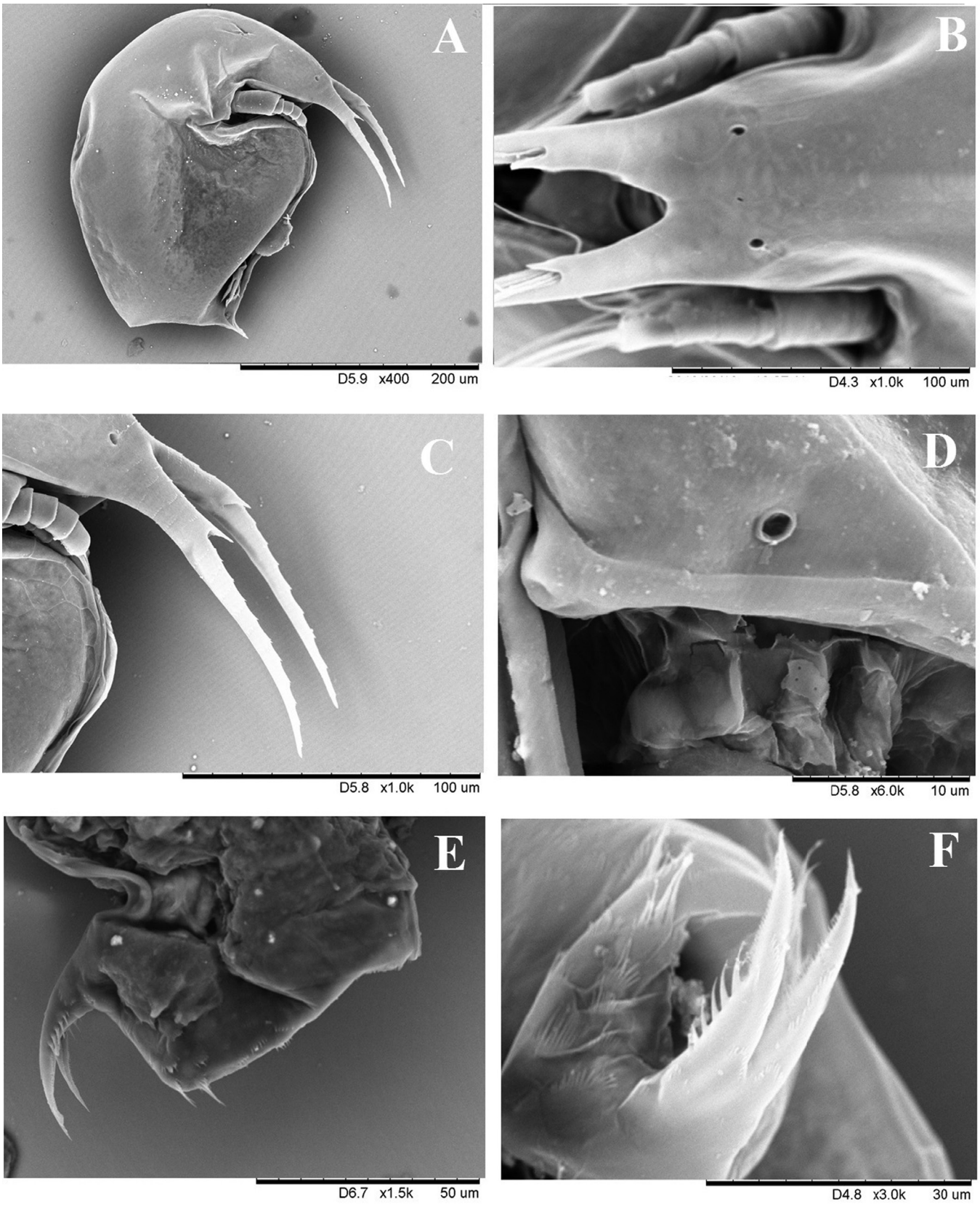

Fig. 4. Scanning electron micrographs of *Bosmina fatalis*. A, habitus; B, frontal head pore (FHP); C, antennule showing the dimensions of the rostrum; D, lateral head pore (LHP); E, postabdomen showing claw; F, inverted postabdominal claw showing pecten and setules.

Distribution. Palawan: Lake Malbato; Misamis Oriental: Lake Danao; Bukidnon: Lake Pinamaloy (Fig. 7).

Remarks. It has a possible worldwide distribution but are less morphologically variable in the tropics. Recognised as a species complex and possibly be separated into several genera and species. It occurs in both littoral and limnetic zones. It is dominant in highly eutrophic waters with dense macrophyte cover.

Genus *Ephemeroporus* Frey, 1982

Body globular to sub globular. Head shield without head pores. Ventral margins with setae that are sub marginal. Rostrum short and blunt. Labral plate with 1–4 serrated teeth. Post abdomen is elongated with a strong sharp pre-anal angle; post anal denticles marginal with 2–4 denticles longer than the rest; terminal claw evenly curved with two basal spines.

Ephemeroporus barroisi (Richard, 1894)

Specimen examined. Six parthenogenic female (UST-ZRC 0126,0131-Lake Danao, Camotes Is., Cebu; 0127–0129- Lake Mainit, Agusan Del Norte;0128- Lake Paoay, Ilocos Norte).

Description. Relocated from the genus *Chydorus*, this species is easily identified by its serrated labrum with four teeth (Frey, 1982). Its body is globular to subglobular like other chydorids. It has short blunt rostrum in comparison with *C. sphaericus*. Its ocellus is large but slightly smaller than the eye. The post abdomen is ciliated along its entire length. It is found only in the tropics. It is relatively well distributed in the Philippines with specimens found from Luzon to Mindanao (Figs. 9, 10).

Distribution. Ilocos Norte: Lake Paoay; Cagayan: A dam in Binag, Lake Nalbuan, Lake Calig, Camarines Sur: Lake Baao; Cebu: Lake Danao; Negros Oriental: Lake Kabalin-

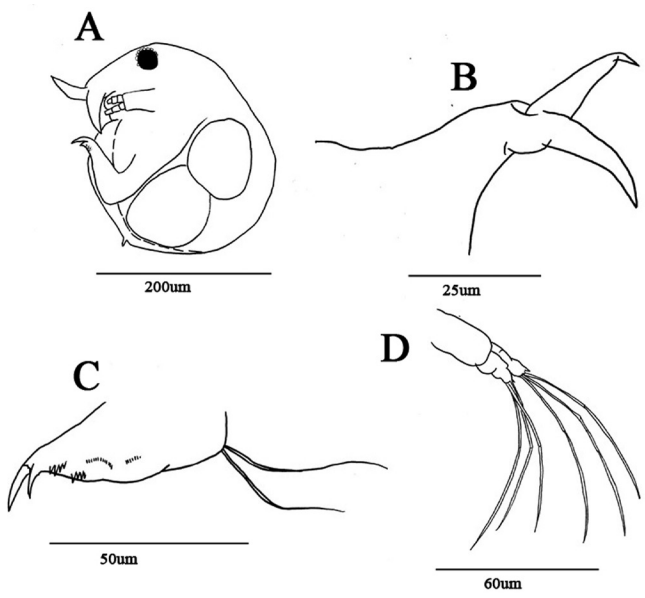

Fig. 5. *Bosminopsis deitersi*. A, habitus; B, antennule; C, postabdominal claw showing the post-anal extension; D, antennae.

an: Agusan Del Norte: Lake Mainit; South Cotabato: Lake Lahit, Lake Siloton (Fig. 7)

Remarks. Possibly well distributed in the tropics and sub tropics with specimens reported in Syria, Iran, India, Sri Lanka, Australia, Nicaragua and North America. It is considered as a species complex that can be separated into several species. Fairly common in littoral zones and sometimes present in low numbers in the limnetic and lotic habitats.

Genus *Pleuroxus* Baird 1843

Body circular to oval. Ventral valves with setae attached to its edges. Posterior dorsal angle of valve lower than the height of the carapace. Antennules with peg. Swimming antennae with spines. Post abdomen of average length; Terminal claw with two basal spines. Several sub genera taken from this genus are still in question and are usually used more often as a sub genus rather than a genus.

Pleuroxus (*Picripleuroxus*) cf. *quasidenticulatus* (Smirnov, 1996)

Specimen examined. Two parthenogenic female. One mounted (UST-ZRC 0138-Lake Nalbuan, Cagayan). One damaged beyond repair.

Description. The status of *Picripleuroxus* as a genus has long been strongly argued. The latter has been re-established as a subgenera in recent literatures. Carapace is oval with no distinct characters in the posterior part of the dorsal margin but rather high on its lateral part. Rostrum curved and pointed. Ocellus situated near the tip of the rostrum. Antennae with one spine on the apical ends of the antennal segment. Post abdomen a little bit long and narrowing to the terminal claw. Anal teeth size is decreasing across the length of the post abdomen but variable across population. Terminal claw with two accessory spines near its base. It has only been observed in two lakes in Cagayan province contrary to previous sightings (Fig. 11).

Distribution. Cagayan: Lake Nalbuan, Lake Cansiritan (Fig. 7).

Remarks. Found also in Australia, Iraq, Argentina, Thailand, Vietnam China and Far East Russia. Commonly found in littoral zones of ponds and reservoirs and streams.

Subfamily Aloninae
Genus *Alona* Baird 1843

Body oval to elliptical curved to moderately convex; ventral valve margins with rows of setae in similar sizes. Head shield with two main head pores connected and circular lateral pores. Ocellus smaller than the eye. Well-developed blunt rostrum. Two antennular aesthetes projecting from the rostrum. Labral plate variable Swimming antennae with well- developed spines. Post abdomen narrow to broad with several variably sized anal denticles with setules. Genus

considered as a complex group and are still being separated into several genera.

Alona pulchella King, 1853

Specimen examined. Ten parthenogenic female. Six mounted specimens (UST ZRC 0121, 0122-Lake Danao, Camotes Is., Cebu;0123–0125-Lake Calig, Cagayan 0137-Lake Nalbuan, Cagayan). Four damaged beyond repair.

Description. The genus *Alona* is the largest anomopod genus. It represents almost half of the species of Chydoridae. The genus itself has been broken down to several genera in recent years. The species represent many synonyms and is recently being separated into several species. In 2002, *A. cambouei* was separated from this group. It has an oval body with around 40–45 setae on the ventral margin. Its head shield is elongated and has short and blunt rostrum. It has a narrow post abdomen of moderate length. Found in several freshwater bodies in all major regions of the Philippines from rivers to lakes and reservoirs (Fig. 12)

Distribution. Cagayan: Lake Calig, Lake Nalbuan; Benguet: Ambuklao Dam; Bontoc and Kalinga: Chico River; Laguna: Lake Tadlak; Camarines Sur: Lake Baao; Cebu: Lake Danao; Agusan Del Norte: Lake Mainit, Agusan River; Lanao Del Norte: Agus IV Dam (Fig. 7)

Remarks. Considered as a species group with tropical to sub-tropical distribution in Asia, Africa and Australia. Fairly common in littoral zones of lakes, rivers and streams.

Anthalona sp. Van Damme, 2011

Specimen examined. 10 parthenogenic female. Three mounted (two whole mounts (UST ZRC 0140, 0141, one dissected UST ZRC 0142). Five subjected to SEM. Two were damaged beyond repair.

Description. Recently established in 2011 by Van Damme, the genus can easily be recognised by their flower-like (lobed) lateral head pores. Body is oval with a prominent rostrum. Has a characteristic connected main head pores and lobed lateral head pores. Eye larger than its ocellus. Labral plate axe-shaped. Post abdomen wide and short and with an S-shaped appearance. Terminal claw long with one small accessory basal spine (Fig. 13, 14). Specimen found in Lake Lanao is morphologically similar to *A. alonopsiformis* described by

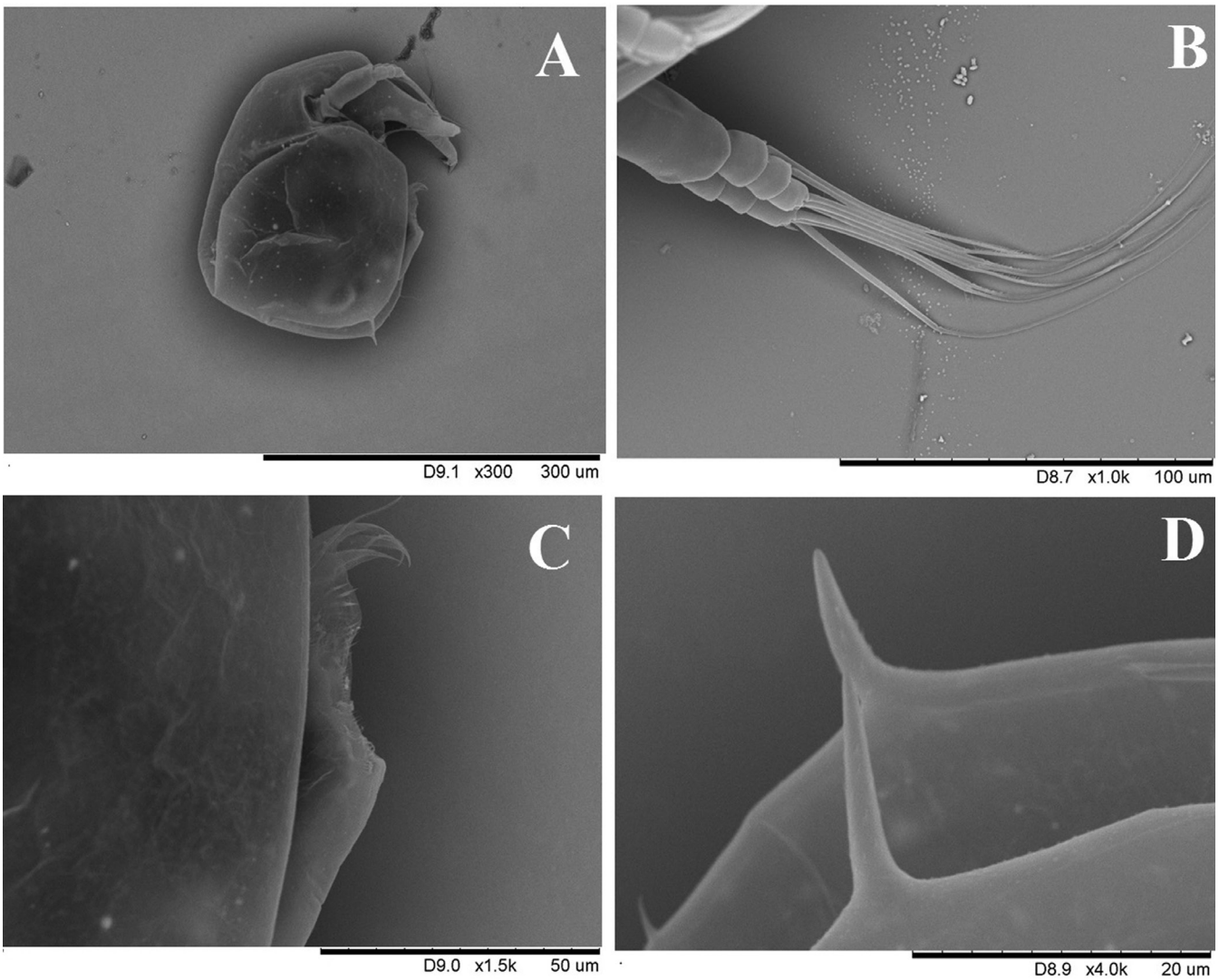

Fig. 6. Scanning electron micrograph of *Bosminopsis deitersi*. A, habitus; B, second antennae; C, postabdominal claw; D, mucro.

Brehm in 1933 by its terminal claw but extensive analsysis is still needed to elucidate its identity.

Distribution. Cagayan: Lake Calig; Mt. Province: Chico River; Lanao del Sur: Lake Lanao (Fig. 7)

Remarks. The genus is mainly distributed in the southern hemisphere with records in Central America, South America, tropical Africa, Indonesia and Australia. They do not tolerate colder waters, with the northern limit of the genus found in the Mediterranean. It prefers shallow sandy or rocky littoral, detritus ridden and heavily vegetated pools and swamps.

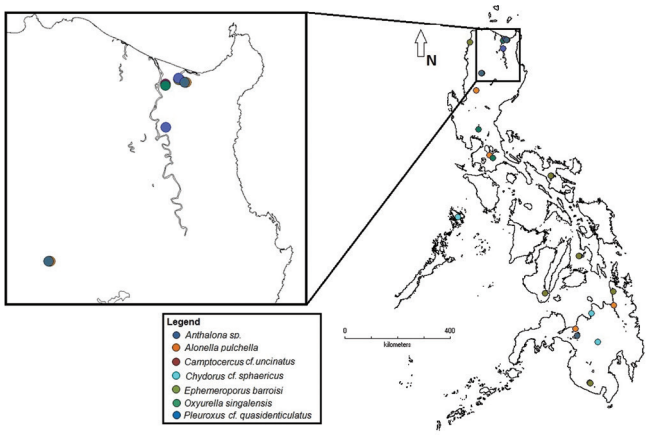

Fig. 7. Distribution of family Chydoridae based on recently collected samples (2013) and stored samples in the UST ZRC.

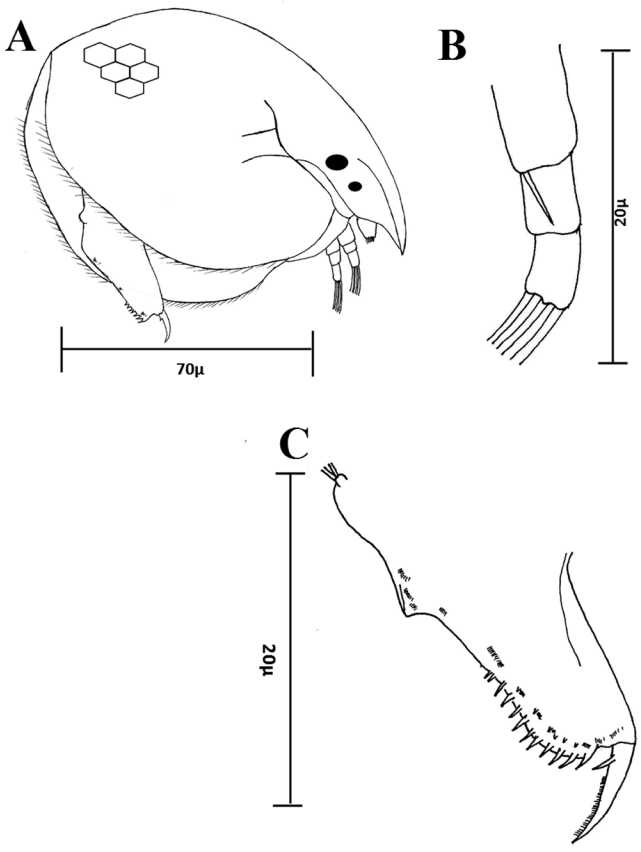

Fig. 8. *Chydorus* cf. *sphaericus* parthenogenic female. Lake Malbato, Coron, Palawan. A, habitus; B, antennae; C, post abdomen.

Genus *Camptocercus* Baird, 1843

Body ovoid with long feathered setae in its ventral margin of its carapace. Head shield with three major head pores.

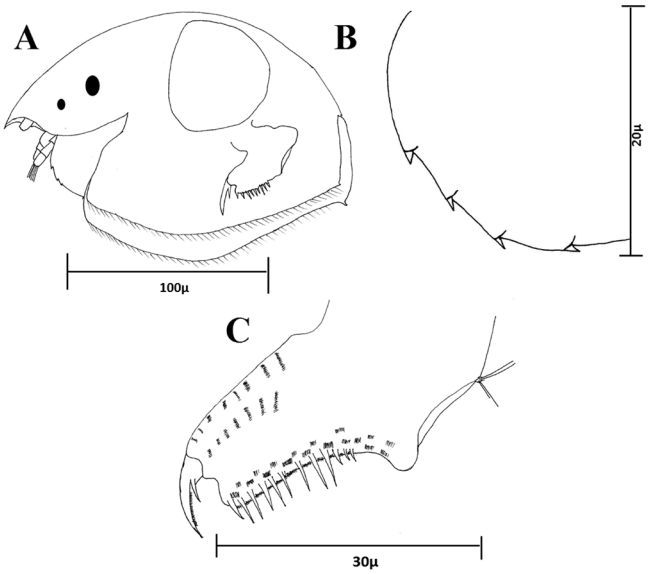

Fig. 9. *Ephemeroporus barroisi* parthenogenic female. A, habitus; B, labrum; C, post abdomen.

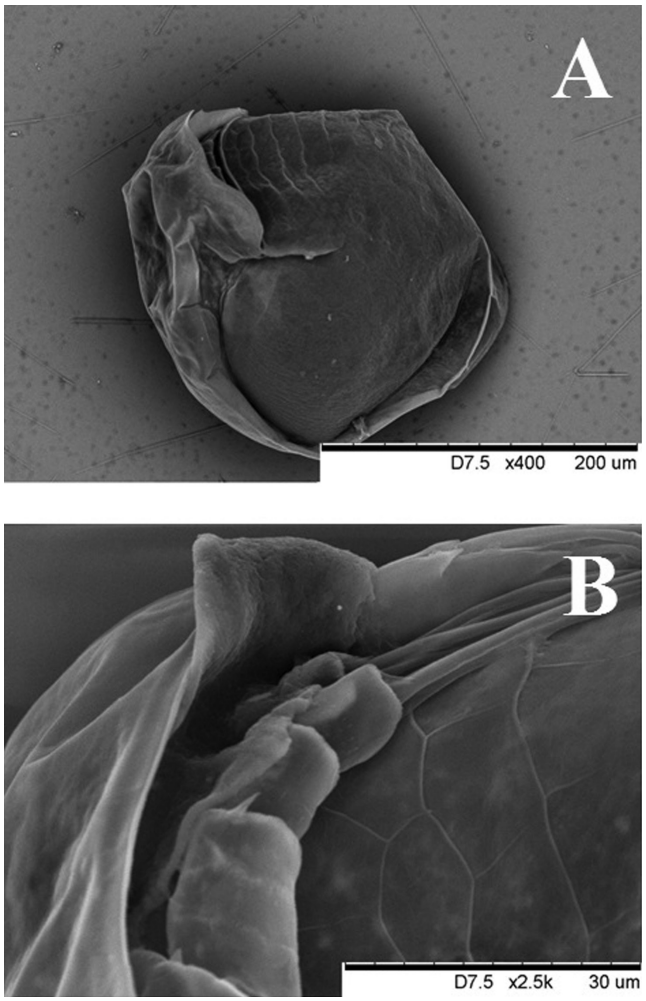

Fig. 10. Scanning electron micrographs of *Ephemeroporus barriosi*. A, habitus; B, antennae.

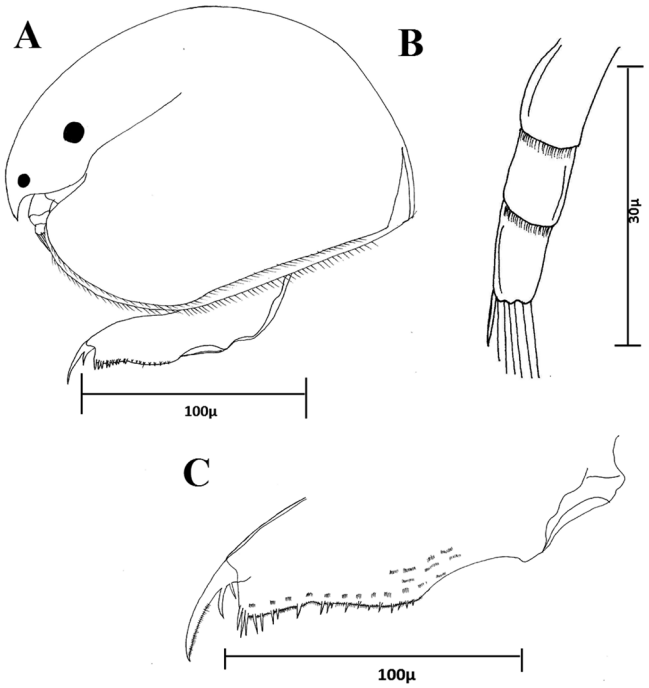

Fig. 11. *Pleuroxus* cf. *quasidenticulatus* parthenogenic female. A, habitus; B, antennae; C, post abdomen.

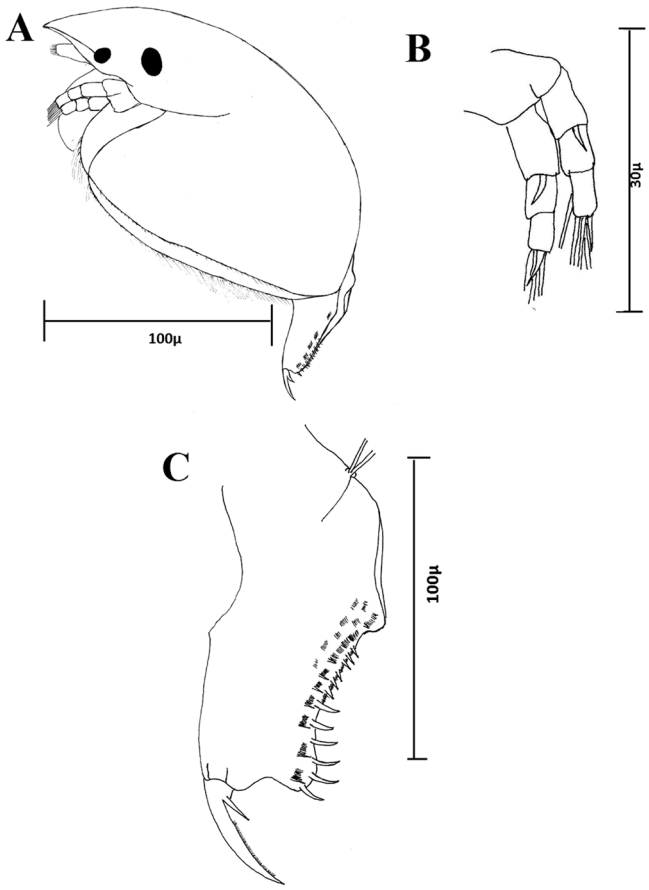

Fig. 12. *Alona pulchella* parthenogenic female. A, habitus; B, antennae; C, post abdomen.

Rostrum slightly pointed. Labral plate with widely rounded apex and cuneiform in shape. Antennule usually reaching the tip of the rostrum. Long but weak swimming antennae. Post abdomen is long and narrow with 1–2 accessory spines on its terminal claw; anal denticles pass over each other

***Camptocercus* cf. *uncinatus* Smirnov, 1971**

Specimen examined. One parthenogenic female (UST-ZRC 0139-Dam in Binag, Cagayan).

Description. First described by Smirnov in 1971, it has a worldwide distribution and is almost exclusively littoral as most chydorids are. It has an oval body with several feathered setae in its ventral margin. It has a very small ocellus situated near its rostrum. It has long antennules almost reaching the apex of the rostrum. Its labrum has an irregular convex anterior margin and a few spines and setules on its ventral margin. It has a very narrow distinct post abdomen with 14–16 anal denticles. A single specimen was observed in a local reservoir in Cagayan province (Fig. 15).

Distribution. Cagayan: A dam in the town of Binag (Fig. 7).

Remarks. A widely distributed species, found in Romania, southwest Siberia, Israel, Iraq, Ethiopia, Egypt, Mexico, and Guatemala. Common in littoral zones of lakes and small streams with thick macrophyte vegetation.

Genus *Oxyurella* Dybowski & Grochowski, 1894

Body ovoid with ventral margins having long feathered setae. Head shield with two separate major head pores with minor head pores in between and lateral to them. Rostrum

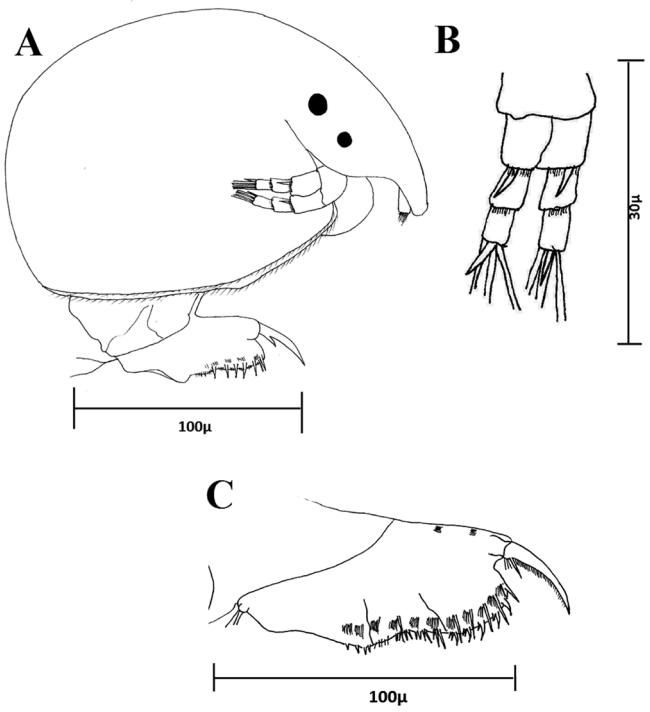

Fig. 13. *Anthalona* sp. parthenogenic female, Lake Lanao, Lanao del Sur. A, habitus; B, antennae; C, postabdomen

not elongated. Labral plate cuneiform and blunt. Antennule with 8–9 sensory aesthetes inserted in the rostrum. Swimming antennae with three spines. Post abdomen broad with large anal denticles; terminal claw with 2–3 basal spines.

Oxyurella singalensis (Daday, 1898)

Specimen examined. Two parthenogenic female (UST ZRC-0132-Lake Sampaloc, Laguna; 0133-Lake Calig, Laguna)

Description. It is common in stationary water bodies and not widely observed in lotic ecosystems. Its body is oval-oblong in shape. The carapace of the species does not have a keel. Its antennule reaches the tip of its rostrum. It has short swimming antennae with two strong well developed spines. The ventral margin of its carapace has long feathered setae. Relatively narrow, the post abdomen of *O. singalensis* has a long basal spine with 3 accessory spines on its base. It was found exclusively in Luzon in both littoral and limnetic samples (Figs. 16, 17)

Distribution. Cagayan: A dam in the town of Binag, Lake Nalbuan; Pampanga: Candaba swamp; Laguna: Lake Sampaloc, Lake Kalibato (Fig. 7)

Remarks. Common in tropical and subtropical Asia, Africa and Australia. Found in sandy and muddy sediments of littoral zones of lakes and reservoirs.

Class Branchiopoda
Superorder Cladocera
Order Anomopoda
Family Moinidae

Genus *Moina* Baird, 1850

The moinids have a large fused compound eye but lack the ocellus in the genus *Moina*, although it is present in one species of *Moina* (*reticulata*). The head is frequently indented above the eye (called the supra-ocular depression) by the attachment of a muscle bundle to the inner surface of the flexible exoskeleton. The second antenna consists of a large basiopod, an endopod with three segments and an exopod of four segments. A third sensory seta is present on the distal end of the basiopod between two rami. The endopod bears one or more long swimming setae on its distal end. The four-segmented exopod contains long swimming setae. The exopod also bears inner row of short teeth that is suspected to clean dentritus from the surface of the shell. Moinids have five thoracic limbs and each limb has been specifically modified towards greater efficiency in its particular function. The first pair of limbs no longer functions for filtering. It has reduced in size and fewer setae that found on the sidids. The two distal setae in the second limbs are modified for grasping food particles from the posterior limbs. The third and the fourth limbs have large filter comb. The fifth limb serves in closing off the posterior end of the filter chamber forward

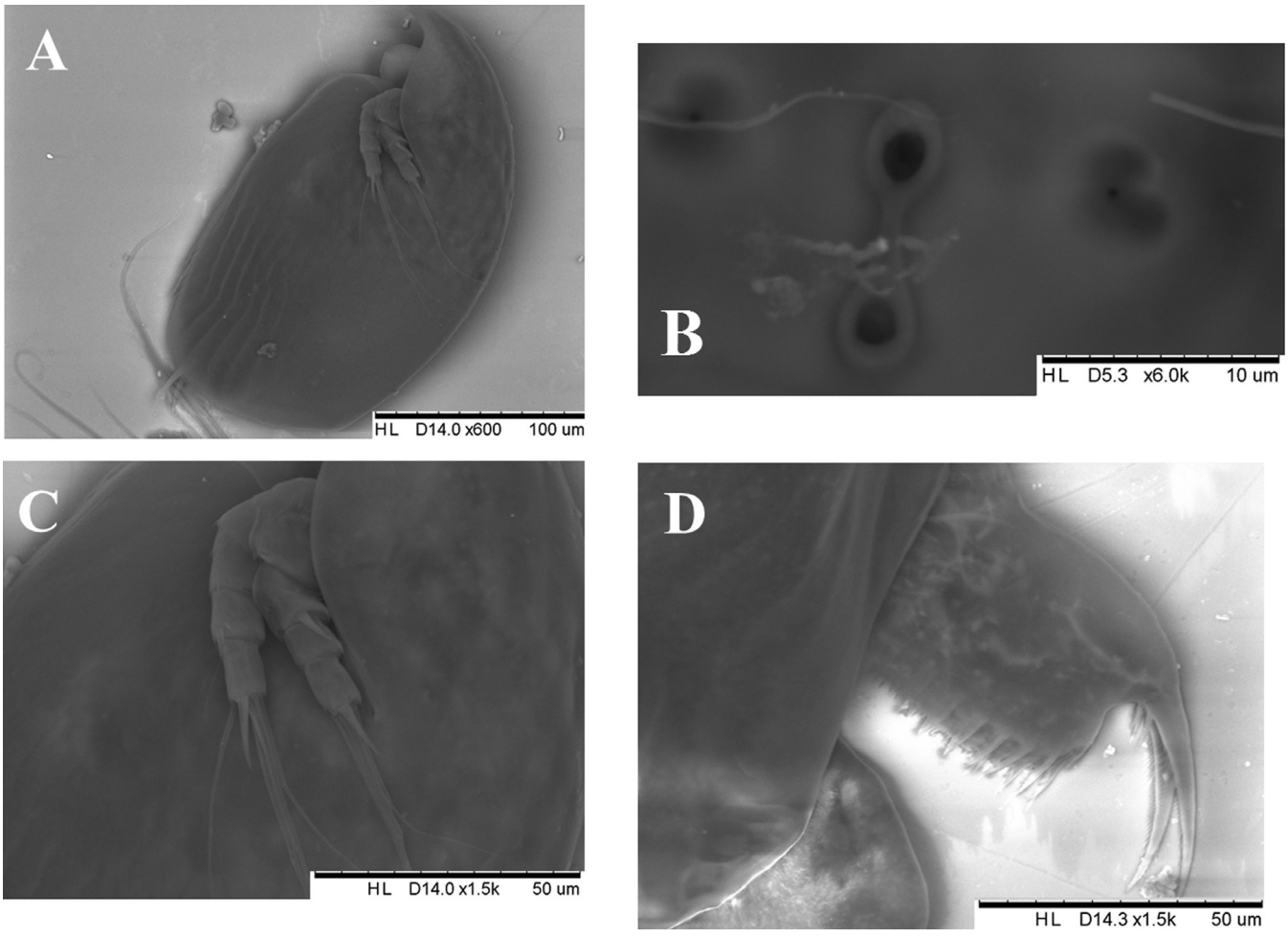

Fig. 14. Scanning electron micrographs of *Anthalona* sp. A, habitus; B, main and lateral head pores; C, antennae; D, post abdomen.

though the filter comb of the fourth leg. Postabdomen has a large post-anal extension which is conical and ends with the distal claws. There is a row of lateral feathered teeth and a single distal bident tooth on the postabdomen. The claw is usually pectinate and has basal spines at the ventral base of the claw that is also called as "Basaldorn"

Moina micrura Kurz, 1875

Specimen examined. 11 adult parthenogenic female specimens from Lake Taal, Lake Sampaloc, and Candaba Swamp were examined and stored in University of Santo Tomas Zooplankton Reference Collection (UST-ZRC) with reference numbers 0072–0081, and 0093.

Description. Moinidae is composed of only two genera: *Moina* and *Moinodaphnia*. *Moina* are found from temporary freshwater pools to brackish and saline lakes. *Moina micrura* are one of the smallest species in Family Moinidae. Mean length in all specimen examined is 1.1 mm. The head is evidently characterised by a well-developed supraocular depression and a large eye (Fig. 19A). The antennules of *M. micrura* are situated in a knob-liked position just behind the eye with two sensory setae in each located one-third to one-half the distance from the head. The sensory papillae are long and distinguishable. A distinct groove located behind the second antennae separates the head and the body. The exopod is composed of four-segmented ramus which contains heavy setation that extends from second to the fourth segment . Two short sensory setae are evident in the second antennae as shown in Fig. 19E. The P1 has reduced its filtering functions but have fewer setae compared to other sidids (Fig. 19D). Carapace is round and surrounded by 37–40 setae in the shell margin.The postabdomen is short and slender. The distal conical portion composes one-fourth of the total length. A sharp postabdominal claw contains three to eleven feathered teeth (Fig. 19C). The number of teeth varies on the body size of the specimen. Its dorsal margin is characterised by having several numbers of setae extend up to the sharp part of the claw. There is also a long bident tooth present located at the base of the feathered teeth. The long and sharply curved postabdominal claw contains four to seven sharp teeth that are also called "basaldorn" that extends towards the distal end (Goulden, 1968).

Distribution. Ilocos Norte: Lake Paoay; Cagayan: Lake Nagatutuan; Benguet: Ambuklao Dam; Pangasinan: Fish Pond in Burgos; Tarlac: Lake Tambo; Nueva Ecija: Pantabangan Dam; Zambales: Lake Mapanuepe; Pampanga: Candaba swamp; National Capital Region (NCR): Pasig River, Marikina River; Laguna: Lake Bunot, Lake Palakpakin, Lake Sampaloc, Lake Pandin, Lake Kalibato, Lake Tadlak, Lake Caliraya, Lake Lumot-Mahipon, Laguna De Bay; Batangas: Taal Lake; Camarines Sur: Lake Buhi; Oriental Mindoro: Lake Naujan; Misamis Oriental: Lake Gumaod; South Cotabato: Lake Siloton, Lake Lahit, Lake Sebu (Fig. 18)

Remarks. *M. micrura* can be distinguished from other Moinids based from its small size and by the complete absence of hairs on both the head and shell. The species is reported in the Palearctic region and also from the tropics

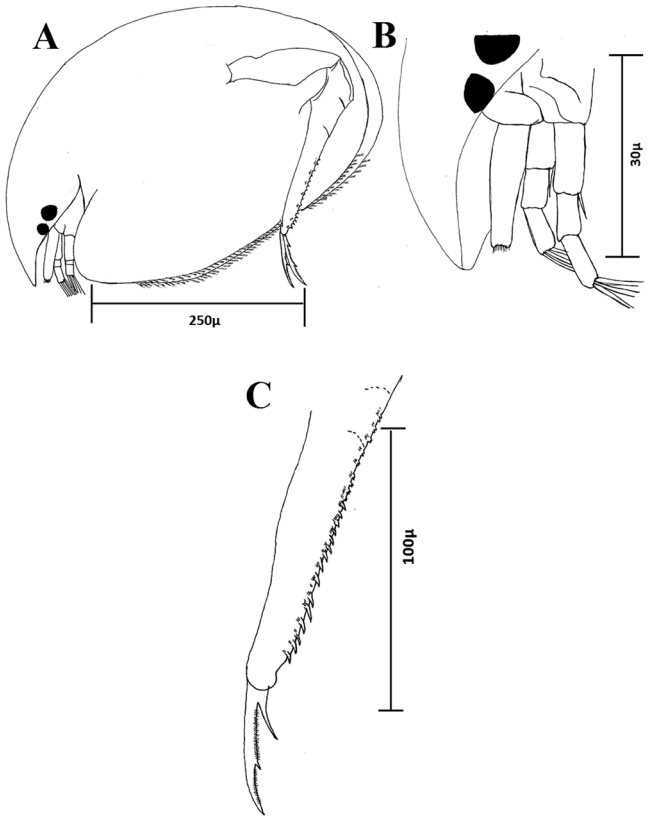

Fig. 15. *Camptocercus* cf. *uncinatus* parthenogenic female. A, habitus; B, antennae and antennule; C, post abdomen

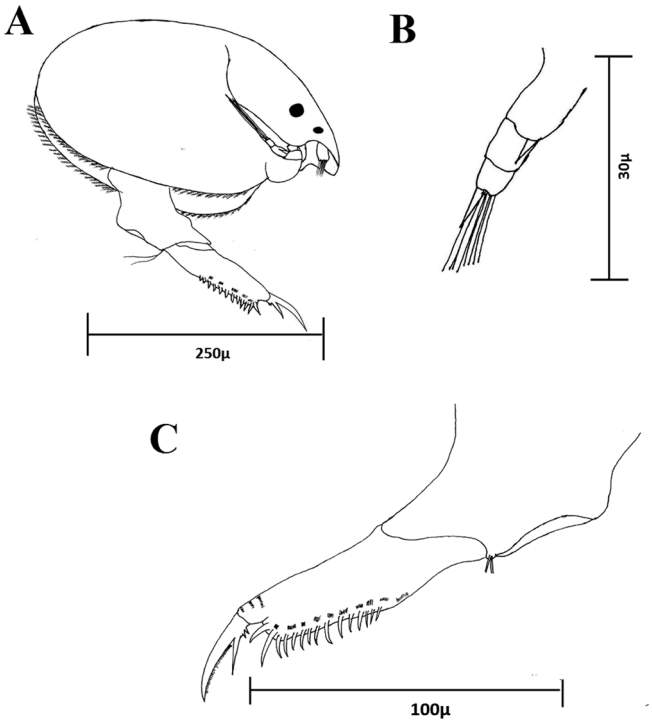

Fig. 16. *Oxyurella singalensis* parthenogenic female. A, Habitus; B, Antennae; C, Post abdomen.

and subtropics of America, Australia (2002) as well as in Africa and Europe (Goulden, 1968). Goulden (1968) also confirmed its presence in the Far East and Southeast Asia specifically in India, Indonesia and Taiwan. The species is mostly found in temporary water bodies but is also common in large plankton of large freshwater lakes (Fernando, 2002; Goulden, 1968).

Genus *Moinodaphnia* Herrick, 1887

Moinodaphnia can easily be distinguished from *Moina* by the presence of an ocellus. The antennules are long and movable. The females are laterally flattened, and the dorsal margin of the shell has a sharp keel. The second antennae are very characteristic because the distal segment of the exopod has four rather short setae rather than three long setae. Postabdomen is long. Only one sexual egg is normally deposited in the ephippium.

Moinodaphnia macleayi King, 1853

Specimen examined. Two specimens were examined and stored in UST-ZRC with reference number 0082 and 0133 collected from Lake Calig and a temporary pool in Asibanglan, Pinukpuk, Kalinga.

Description. The body length ranges in 0.9–1.3 mm. The head is sub-triangular in shape. The large eye fills the tip of the head with an ocellus present below the eye and is located above the origin point of the antennules (Fig. 21D). Supraocular depression is not present in *Moinodaphnia macleayi.* The antennules are long and thin, lack the vertical row of long hairs, and are ornamented only with horizontal rows of short setae. The distal end of the antennule has nine sensory papillae. One segment of the second antennae, the basiopod has two sensory setae which originate from the distal end of the rami (Fig. 12B). One of the four swimming seta has been reduced in size for genus *Moina* but remains its longer size in *Moinodapnia.* The valves of the carapace joined together in the mid-line of the body axis and have a row of small setae. The postabdomen is similar to the genus *Moina* containing 10–11 feathered teeth and one long bident tooth on the lateral side with pattern of fine setae in the dorsal margin. (Fig. 21C).The claw lacks a pecten but with a row of fine short hairs.

Distribution. Cagayan: Lake Calig; Kalinga: Temporary pool in Asibanglan, Pinukpuk (Fig. 18).

Remarks. *Moinodaphnia* has a different distribution and habitat from that of *Moina.* It prefers to be in small temporary

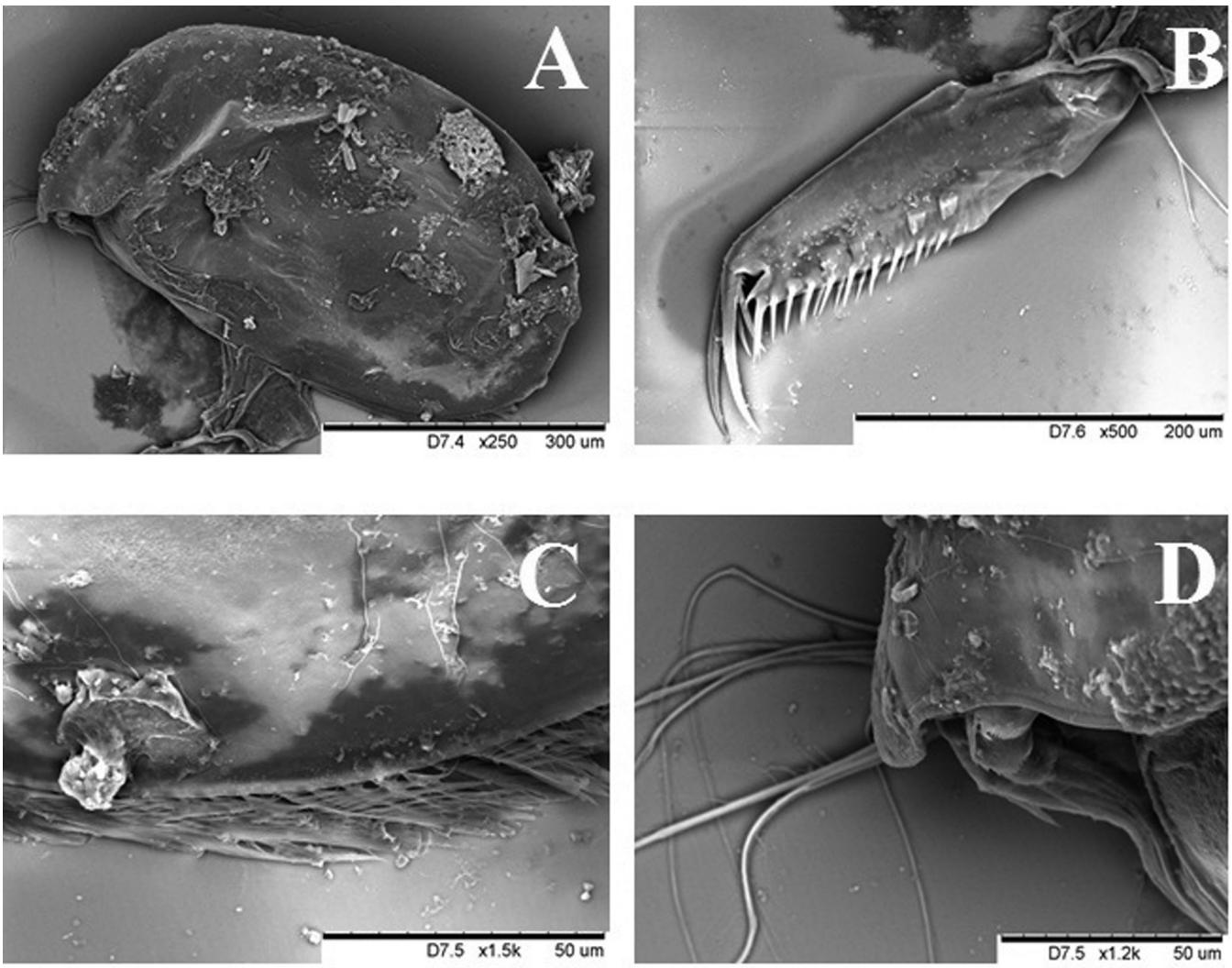

Fig. 17. Scanning electron micrographs of *Oxyurella singalensis*. A, habitus; B, post abdomen; C, Dorsal margin; D, rostrum and antennule.

ponds, small lakes, swamps and pools. The species lives near the mud or in the weeds where it filters the water surrounding the weeds. It is distributed throughout the humid tropics specifically in Africa, Australia, South America, Caribbean Islands, Philippines and India (Fernando, 2002).

Class Branchiopoda
Superorder Cladocera
Order Ctenopoda
Family Sididae

Genus *Diaphanosoma* Fischer, 1850

Head of different forms and sizes, usually conical or rectangular with noticeable dorsal impression in between the head and the valves. Antennules small in size. Swimming antennae are long and strong. Valves forms wide flap inflexions. Post abdomen without anal teeth, with terminal claws with three basal spines.

***Diaphanosoma dubium* Manuilova, 1964**

Specimen examined. Eight parthenogenic female (six Philippine specimens and two Chinese specimens). Three mounted Philippine specimens and one Chinese specimen (UST-ZRC 0114-Lake Sampaloc, Laguna; 0115, 0116 - Lake Tambo, Tarlac; Guangzhou City, Guangdong-0117). Four specimens were damaged beyond repair.

Description. This *Diaphanosoma* species is characterised by a very large cone-shaped head, almost ½ of its body size. Spine on the apical end of the antennal branch can either be curved or straight. Number of denticles in its carapace is increasing with body size with thin setules in between them. It commonly coexists with *D. tropicum* in tropical and sub-tropical Asia (Korovchinsky, 2000). In the Philippines it also co-occurs with *D. sarsi* and *D. excisum* in several freshwater bodies in Luzon (Fig. 24).

Distribution. Tarlac: Lake Tambo; Laguna: Lake Bunot, Lake Yambo, Lake Mohicap, Lake Palakpakin, Lake Pandin, Lake Sampaloc, Lake Caliraya, Laguna De Bay; Camarines Sur: Lake Baao, Bicol River; Agusan Del Norte: Agusan River (Fig. 23)

Remarks. Species can also be found in Russia, China, Mongolia, Bangladesh, Thailand, Sri Lanka, Vietnam and Malaysia. Comparative specimens collected from China (Ming Lake, Jinan University, Guangzhou City) have strongly curved apical antennal spine in comparison with Philippine specimens with straight spines. The species is common in lakes, reservoirs and fish ponds. It is primarily limnetic and can co-exist with other sidids and limnetic cladocerans. Species have bigger head in comparison with its two closely related species *D. tropicum* and *D. modigliani*. It has a variable spine on its antennal branches ranging from straight to strongly curved.

***Diaphanosoma excisum* Sars, 1885**

Specimen examined. Seven parthenogenic female (UST ZRC 0105, 0107-Lake Palakpakin, Laguna; 0106-Lake Buhi, Camarines Norte; 0108-Fish Pond, Laoagan Inn Resort, Kalinga; 0109-Lake Taal, Batangas, 0110, 0111-Lake Cassily, Cagayan).

Description. The species is common throughout the inland waters of the country. Almost always co-existing with *D. sarsi*, it can easily be differentiated from the latter with its strongly-developed dorsal part on its head. This gives

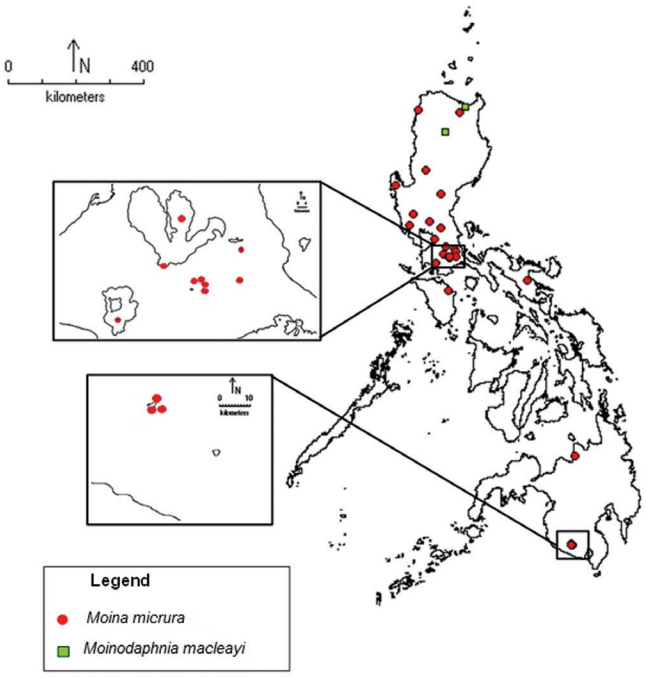

Fig. 18. Distribution of family Moinidae based on recently collected samples (2013) and stored samples in the UST ZRC.

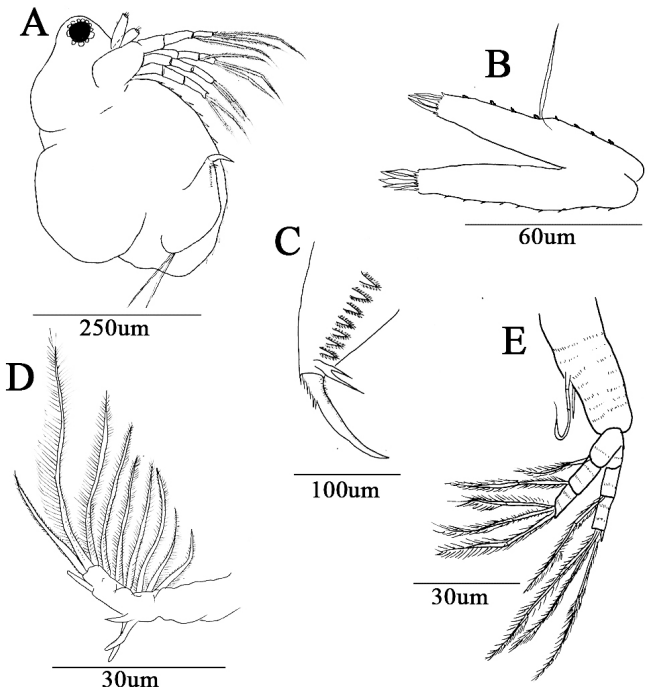

Fig. 19. *Moina micrura* parthenogenic female. A, habitus; B, antennule with exopodite; C, postabdomen; D, P1; E, antennae.

its head a well large rectangular appearance. Eye ranges from moderate to large. Its carapace oblong-oval in shape, with ventral parts forming a narrow free flap with feathered margins. Its ventral margins have large sharp denticles. It is fairly common in the tropics and subtropics, It can survive different environments from highly turbid to slightly saline waters (Chatterji et al., 1995) (Figs. 25, 26).

Distribution. Ilocos Norte: Lake Paoay; Cagayan: Lake Nalbuan, Lake Calig, Lake Nagatutuan, Lake Cansiritan, Lake Cassily; Benguet: Ambuklao dam; Kalinga: Fish pond in Laoagan Resort Inn in Tabuk; Pangasinan: Fish pond in Burgos; Tarlac: Lake Tambo; Nueva Ecija: Pantabangan Dam; Zambales: Lake Mapanuepe; National Capital Region (NCR): Pasig River; Marikina River; Laguna: Lake Bunot, Lake Yambo, Lake Mohicap, Lake Palakpakin, Lake Pandin, Lake Sampaloc, Lake Tadlak, Lake Kalibato, Lake Lumot-Mahipon, Laguna De Bay; Batangas: Lake Taal; Camarines Sur: Lake Bato, Lake Baao, Lake Buhi; Oriental Mindoro: Lake Naujan; Leyte: Lake Bito; Bohol: Malinao Dam; Agusan del Norte: Lake Mainit; Lanao del Norte: Agus IV Dam, Tubud-Mayahay River; Bukidnon: Lake Pulangi, Lake Pinamaloy; South Cotabato: Lake Siloton (Fig. 23)

Remarks. *D. excisum* is also distributed in tropical and subtropical Australia, India, Eastern China, Nepal and possibly Northern Africa. One of the more adaptable sidids, it can survive in acidic, turbid and even slightly brackish waters. It is common to water bodies with aquaculture and co-existing with other limnetic cladocerans. It can be easily differentiated from *D. sarsi* with the strong dorsal portion of its head and more massive antennae.

Diaphanosoma sarsi Richard, 1894

Specimen examined. Ten parthenogenic female, eight mounted specimens (UST-ZRC 0097, 0099-Lake Paoay, Ilocos Norte; 0098 - Lake Danao, Camotes Island, Cebu; 0100-Lake Buhi, Camarines Sur; 0101-Lake Tambo, Tarlac; 0102-Lake Nalbuan, Cagayan; 0103, 0104-Lake Sampaloc, Laguna), two were damaged beyond repair.

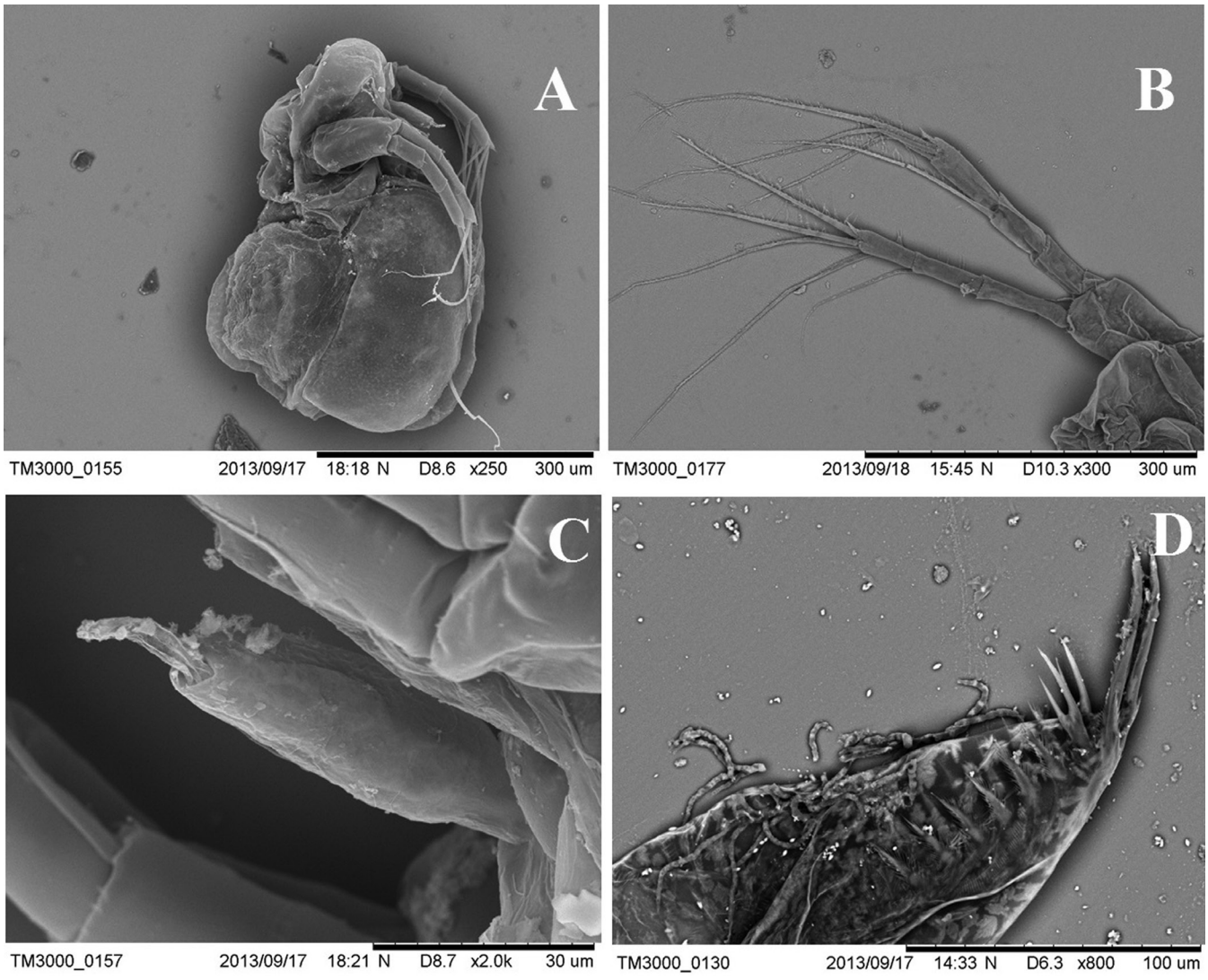

Fig. 20. Scanning electron micrographs of *Moina micrura* parthenogenic female SEM micrograph. A, habitus; B, antennae; C, antennule with exopod; D, postabdominal claw.

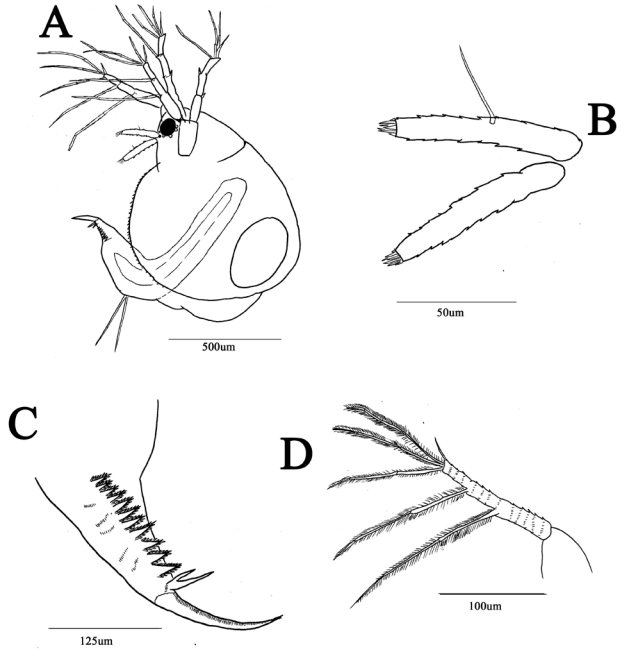

Fig. 21. *Moinodaphnia macleayi* parthenogenic female. A, habitus; B, antennule with exopod; C, postabdomen; D, antennae.

Description. *Diaphanosoma sarsi* is the most well-distributed cladoceran found throughout the Philippines. It is found in almost all types of water bodies from swamps to a few river systems. This species is distinguished by a small roundish rectangular head with sloping dorsal side. Its eye occupies almost the whole area of the head. The carapace of *D. sarsi* is situated high on its body with its ventral parts forming a broad free flap. Its ventral margins have around 13–40 small denticles. It is fairly common throughout inland water bodies especially in lakes and reservoirs in the tropics except Africa (Fernando, 2002). In the Philippines it co-exists with three other species of *Diaphanosoma* (Figs. 27, 28).

Distribution. Ilocos Norte: Lake Paoay; Cagayan: Lake Nalbuan, Lake Nagatutuan Lake, Lake Bangalau; Benguet: Ambuklao dam; Kalinga: Fish pond in Laoagan Resort Inn; Pampanga: Candaba swamp; Tarlac: Lake Tambo; Zambales: Lake Mapanuepe; National Capital Region (NCR): Pasig River, Marikina River; Laguna: Lake Bunot, Lake Yambo, Lake Mohicap, Lake Pandin , Lake Sampaloc, Lake Tadlak, Lake Kalibato, Lake Lumot-Mahipon, Lake Caliraya, Laguna De Bay; Batangas: Lake Taal; Camarines Sur: Lake Baao, Lake Buhi; Sorsogon: Lake Bulusan; Oriental Mindoro:

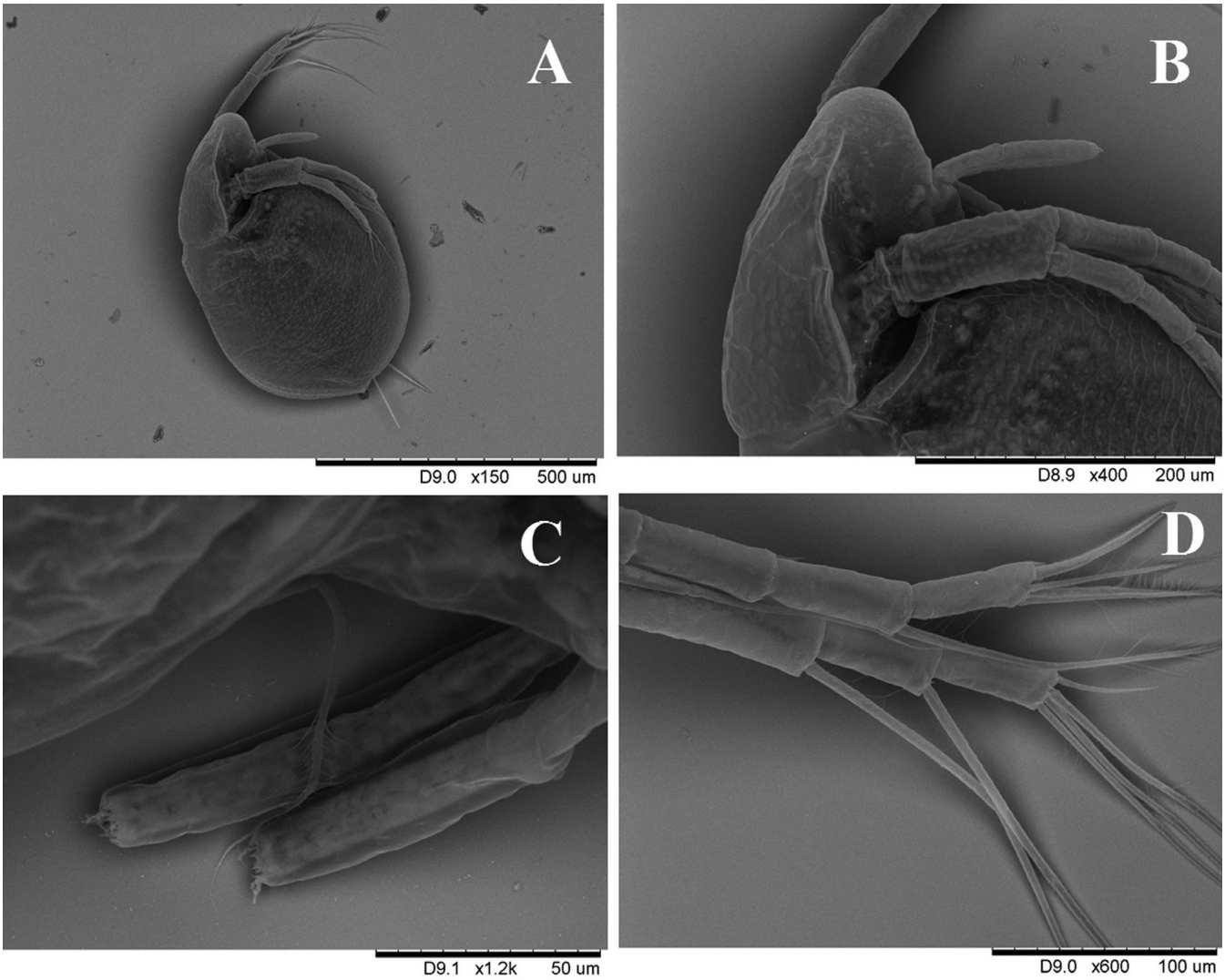

Fig. 22. Scanning electron micrographs of *Moinodaphnia macleayi* parthenogenic female; A. habitus; B, head showing the antennule; C, antennule; D, antennae showing bas, end, and exopod.

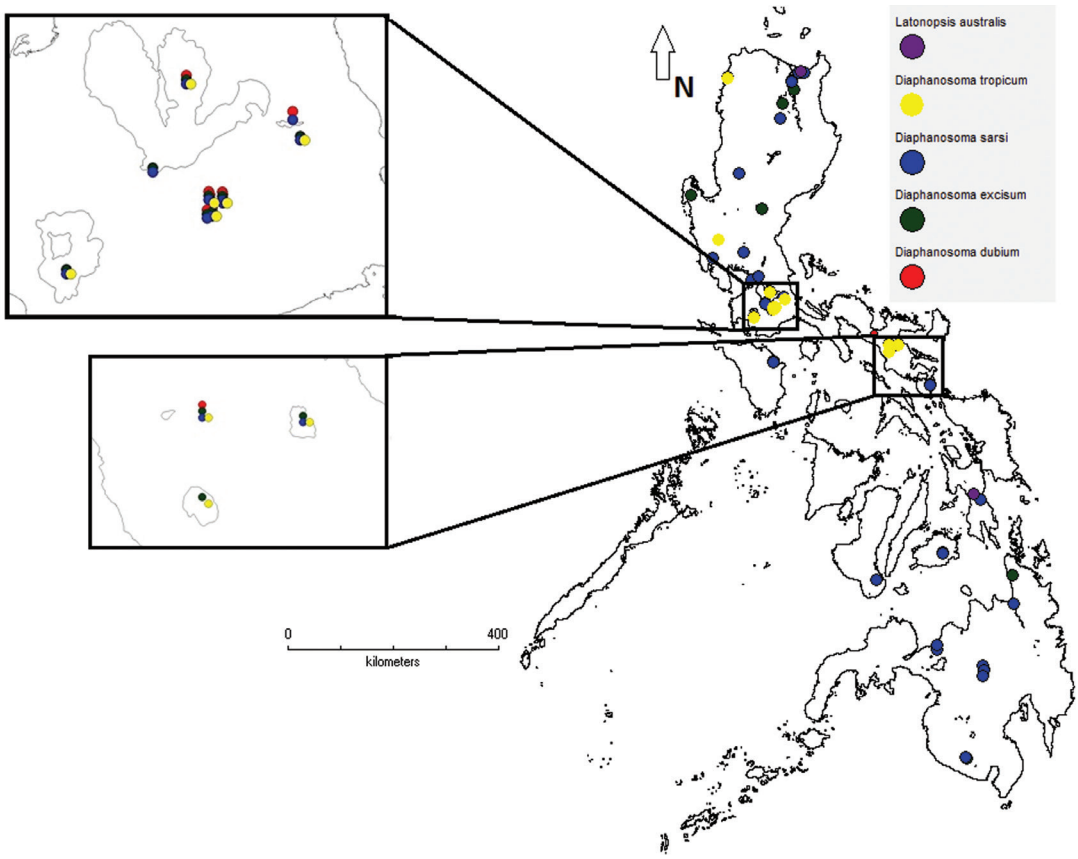

Fig. 23. Distribution of family Sididae based on recently collected samples (2013) and stored samples in the UST ZRC.

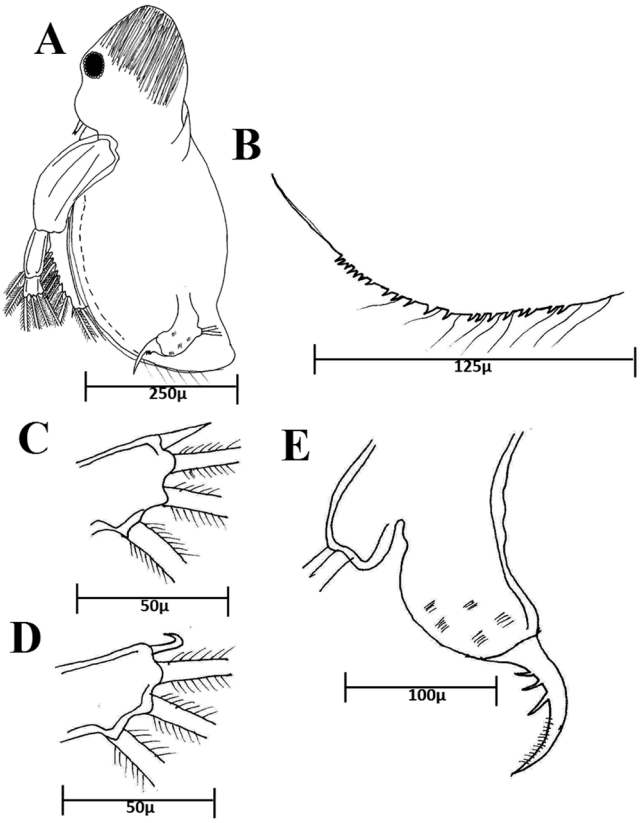

Fig. 24. *Diaphamosoma dubium* parthenogenic female. A, habitus; B, postero-ventral valve margin; C, distal part of second segment of upper 2-segmented antennal branch (Phil.); D, distal part of second segment of upper 2-segmented antennal branch (China); E, postabdomen.

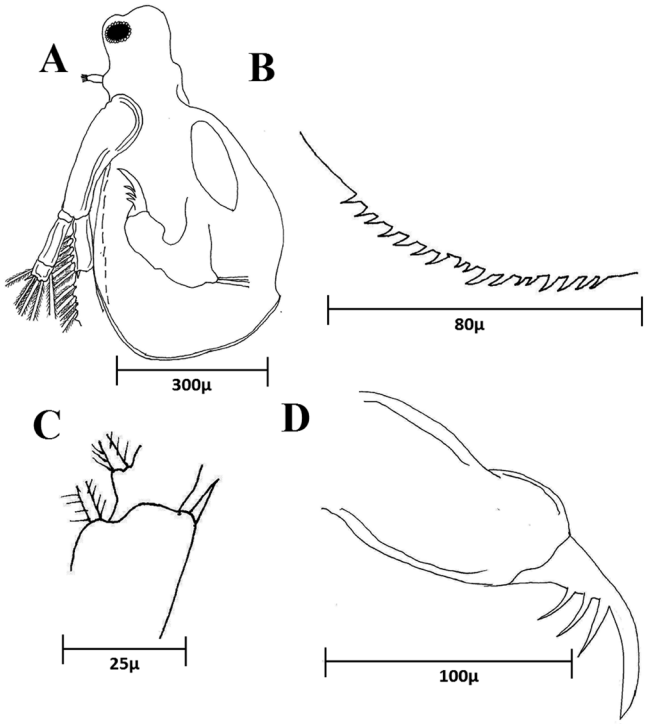

Fig. 25. *Diaphamosoma excisum*, parthenogenic female. A, habitus; B, postero-ventral valve margin; C, distal part of first segment of upper 2-segmented antennal branch; D, post abdomen.

Lake Naujan; Negros Oriental: Lake Balinsasayao; Leyte: Lake Danao, Lake Bito; Bohol: Malinao Dam; Agusan del Norte: Agusan River; Lanao del Norte: Agus IV Dam, Tubud-Mayahay River; Bukidnon: Lake Apo, Lake Pulangi, Lake Pinamaloy; South Cotabato: Lake Lahit (Fig. 23)

Remarks. Species is found in tropical and sub-tropical Asia. Populations have been found in Nepal, Eastern China, Australia, New Guinea, New Caledonia, New Hebrides, Guam and few sites in tropical Africa. It can be found in a wide range of water bodies from large ancient lakes to rice fields. Common sidid found in lotic ecosystems. Prefers shallow waters with heavy vegetation but can also be observed in the limnetic zones of lakes. They are more sensitive to physico-chemical parameters in comparison with other *Diaphanosoma* species. *D. sarsi* has a noticeable sloping dorsal portion of its head that can easily differentiate it from other closely related species.

Diaphanosoma tropicum Korovchinsky, 1998

Specimen examined. Five parthenogenic female, two mounted (UST ZRC 0112-0113-Lake Pandin, Laguna), One specimen with decapitated head with two damaged beyond repair.

Description. Separated from *D. modigliani* by (Korovchinsky, 1998) after re-assessing its occurrence outside Lake Toba in Indonesia, it is characterized by a cone shaped head almost 1/3 of its body size. Its first record in the Philippines is in Lake Taal (Papa & Zafaralla, 2011). It exists in several lakes in Luzon Island and co-existing with the more common *D. sarsi* and *D. excisum*. Ends of the distal segment of its swimming antennae have a noticeable curved spine often having hook like appearance. The postero-ventral margin of its carapace have noticeable differing denticles as they progress dorsally and long thin setules between them. Its post abdomen prominently dorsal and have a strong convex curve. Outside of the country it is found in Malaysia, Thailand, India, Sri Lanka and China (Fernando, 2002) (Fig. 29).

Distribution. Ilocos Norte: Lake Paoay; Tarlac: Lake Tambo; Laguna: Lake Bunot, Lake Palakpakin, Lake Pandin, Lake Lumot-Mahipon, Laguna De Bay; Batangas: Lake Taal; Camarines Sur: Lake Bato, Lake Baao, Lake Buhi (Fig. 23).

Remarks. Recent re-evaluation of localities of *D. modigliani* outside Lake Toba by Korovchinsky in 1998 where the species is commonly associated with have shown that the species is also present in India, Sri Lanka, China, Thailand and Malaysia. Found in lakes and reservoirs co-existing

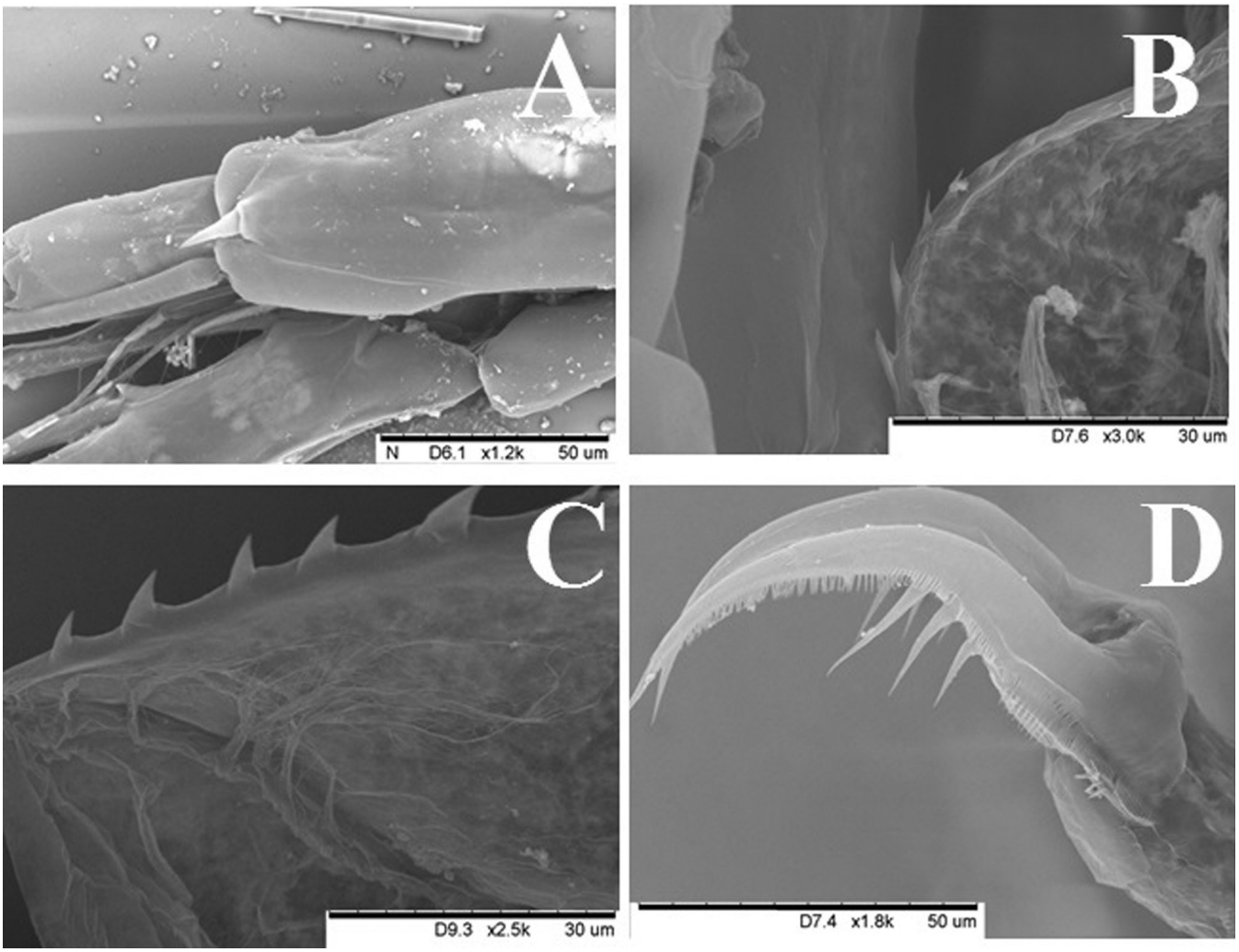

Fig. 26. Scanning electron micrographs of *Diaphanosoma excisum*. A, distal part of first segment of upper 2-segmented antennal branch; B, postero-ventral valve margin; C, ventral valve inflexion; D, terminal claws of post abdomen.

with other limnetic cladocerans with aquaculture. It is an adaptive species that can survive slightly brackish water and a wide range of varying physico-chemical parameters. It is differentiated from *D. modigliani* and *D. dubium* from its strongly curved antennal spine and prominently curved post abdomen.

Genus *Latonopsis* Sars, 1888

Massive head without noticeable separation from the body. Eye situated closer to the dorsal side of the body. Antennules relatively short. Two of the ventral most setae on the antennal branch larger than others with hook ends. Post abdomen with a number of anal denticles with terminal claws having two basal spines. Genus is widely distributed in the tropics and subtropics. Few species are able to survive in the temperate regions.

Latonopsis australis Sars, 1888

Specimen examined. Six parthenogenic female.One mounted specimens (UST-ZRC 0120-Lake Malbato, Palawan). Four were not mounted due to rarity of specimens collected. One specimen was damaged beyond repair.

Description. Contrary to previous records, the species is rare and very few individuals were observed in the collected samples. It is easily identified by its body structure where its head is not clearly delimited from the body. Its eye positioned near the dorsal side of the head. Sensory seta of the antennule of *L. australis* is longer than its basipodite. Its post abdomen is relatively small with few anal spines and has terminal claws with two basal spines. It is also a poorly described species composed of several sub species. They are found mainly in the littoral zone of lakes and reservoirs, in ponds, swamps, and other temporary water bodies (Fig. 30).

Distribution. Cagayan: Lake Calig; Oriental Mindoro: Lake Naujan; Leyte: Lake Danao (Fig. 23)

Remarks. *L. australis* are also found in tropical and sub-tropical Australia, Asia, Africa and America. Temperate localities have also been reported in Italy, Yugoslavia Bulgaria and Northern America. They are found in littoral zones of lakes, reservoirs, and other water bodies with good vegetation. They also thrive in the limnetic zones of pools but prefer bottom sediments for its habitat. It is a poorly described species with a possibility of being a species group.

DISCUSSION

Changes in taxonomy and more intensive sampling effort revealed improvements to previously existing knowledge on the species distribution and richness for cladocera in the Philippines. This verifies the observations of Korovchinsky (2013) where out of 298 species known from Southeast

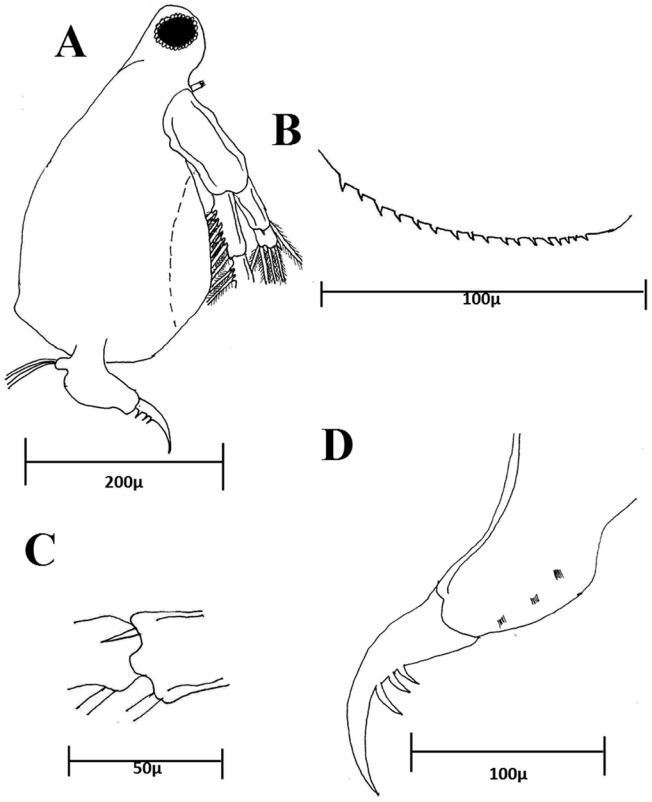

Fig. 27. *Diaphamosoma sarsi*, parthenogenetic female; A, habitus; B, postero-ventral valve margin; C, distal part of first segment of upper 2-segmented antennal branch; D, post abdomen.

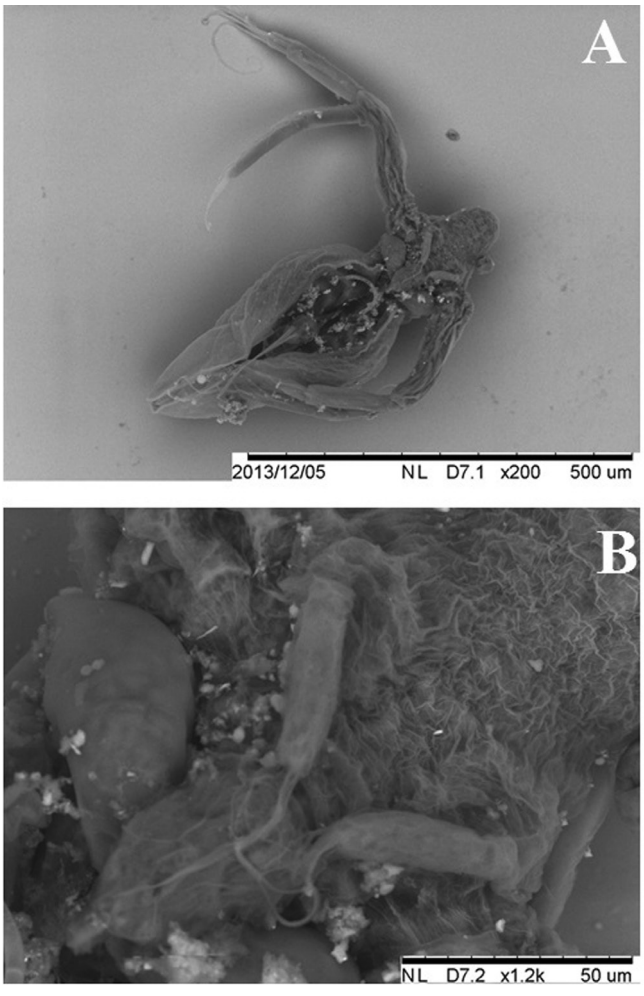

Fig. 28. Scanning electron micrographs of *Diaphanosoma sarsi*. A, habitus; B, antennule.

Asia, only 67 were valid species, 68 have been relegated as synonyms while majority (163 species) represent complexes of species. As such, this just goes to show how more intensive studies on Philippine species revealed further changes in known distribution patterns. Several species described from family Moinidae such as *M. makrophthalma*, *M.dubia, M. dubia parva*, *M. weismanni* and *Moina* sp. (Brehm, 1938; Woltereck et al., 1941; Tsi-Chung & Clemente, 1954; Ueno, 1966) were re-identified as synonyms of *M. micrura* by Goulden (1968). Meanwhile, *M. brachiata* (Mamaril & Fernando, 1978; Mamaril 2001) was not encountered in the any of the inland waters sampled. Both species should not be confused with one another on an account that *M. micrura* has a smaller body size of 0.05–1.2 mm, a different head shape, and the absence of a large claw pecten. The absence of *M. brachiata* in the Philippines was supported by Goulden (1968) and Fernando (2002) mentioning its wide distribution in the north temperate regions specifically in most countries in Europe and some localities in Northern Africa. Tsi-Chung & Clemente (1954), Peterson & Carlos (1984), Mamaril (2001) and Aquino et al. (2008) noted the presence of *M. macrocopa* in several lakes and ponds in Luzon but the lack of descriptions and illustrations of significant taxonomic characters may cause possible confusion in the identity of other Moinids present in the Philippines. *M. micrura* was widely distributed in 17 lakes, two rivers, one reservoir and one swamp in the islands of Luzon and four freshwater lakes in Mindanao. Most moinids encountered were from natural lakes, rivers, temporary swamps and pools in the country. New records for *Moinodaphnia macleayi* were noted in a small lake and a temporary pool in the northern Philippines (Fig. 2) but not in Lake Taal as previously reported by Mamaril (2001). This result verified that *Moinodaphnia macleayi* has a completely different habitat compared to other moinids where it preferred small swamps, pools and lakes (Goulden, 1968). The distribution of the moinids in this paper confirms all previous records that no single species from family Moinidae is present in the Visayas group of islands (Fig. 2). The absence of Moinidae in this area verifies the findings in past studies regarding the lack of *Moina* in the islands.

Comparison between the results of the present survey and previous ones revealed that for Family Bosminidae, *Bosmina longirostris* was not present in more recently collected samples in spite of the fact that it was commonly recorded in the previous studies. Morphological variations in some populations of *B. fatalis* could have led to misidentification of *B. longirostris* because most morphological characteristics of the two species are similar like the shapes of their rostrum, frontal head, and shell spines . Such variations may have led to some confusion which resulted to past misidentifications of *B. longirostris.* To avoid this, Kořínek et al. (1997) proposed the use of the lateral head pore (LHP) pattern as diagnostic characters for species under the genus *Bosmina*. All species of *Bosmina* found in 25 inland waters were subjected to SEM to further analyse the LHP pattern which resulted in the identification of *B. fatalis*. Only *Bosmina fatalis* was identified from samples collected for this current study. It is one of the well-distributed cladocerans in the Philippines including many parts of Luzon, Mindoro, Negros and Mindanao (Fig. 3). The distribution of *B. fatalis* in the archipelago validates all past literatures that the species is common in East Asian lakes

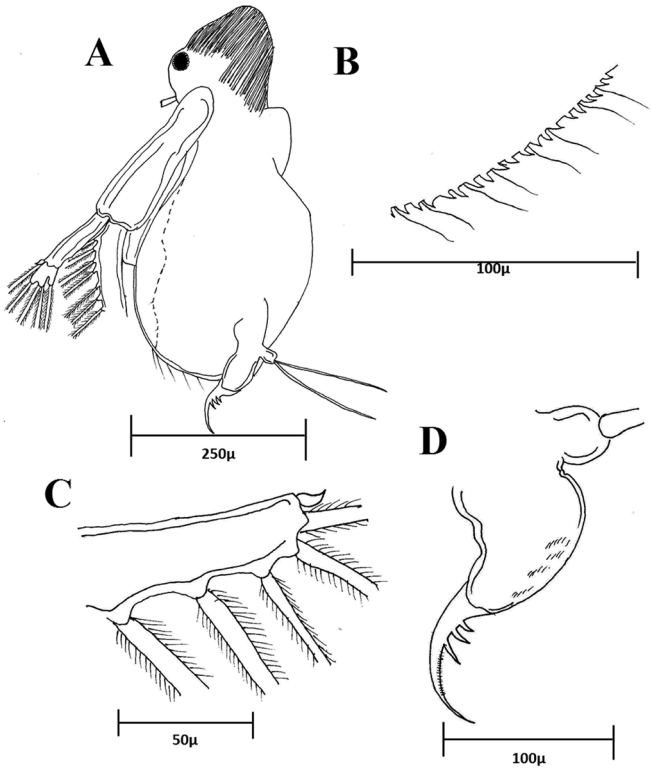

Fig. 29. *Diaphamosoma tropicum* parthenogenic female. A, habitus; B, postero-ventral valve margin; C, distal part of second segment of upper 2-segmented antennal branch; D, post abdomen.

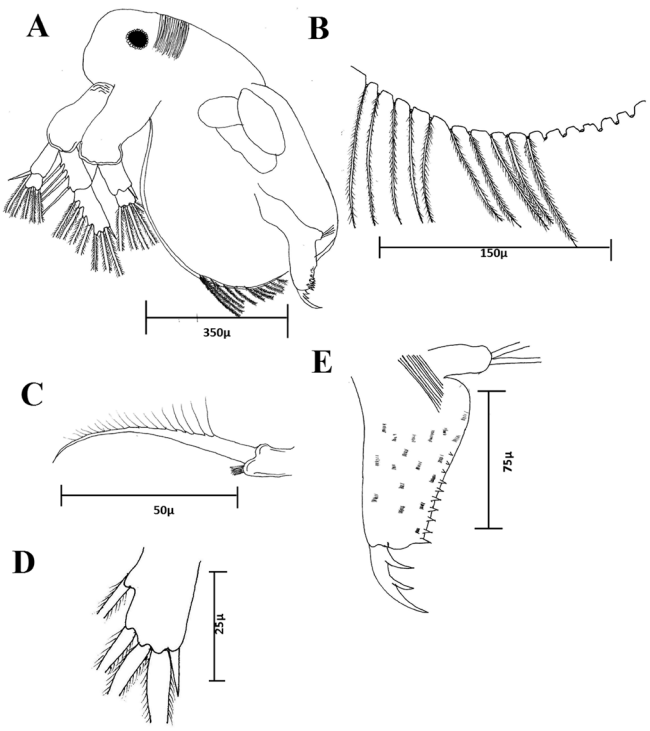

Fig. 30. *Latonopsis australis* parthenogenic female. A, habitus; B, postero-ventral valve margin; C, antennule; D, distal part of second segment of upper 2-segmented antennal branch; E, postabdomen.

Table 1. List of the different sampling localities included in this study.

Site No.	UST ZRC Ref. No.	Name	Municipality/ City	Province	Island
1	154–151	Lake Nalbuan	Buguey	Cagayan	Luzon
2	152–158	Lake Calig	Buguey	Cagayan	Luzon
3	159–162	Lake Bangalau	Sta. Teresita	Cagayan	Luzon
4	163–165	Binag Dam	La–lo	Cagayan	Luzon
5	171–172	Lake Cansiritan	Cansiritan	Cagayan	Luzon
6	166–170	Lake Nagatutuan	Gattaran	Cagayan	Luzon
7	173–175	Cagayan River	Tuguegarao	Cagayan	Luzon
8	176–177	Lake Cassily	Tuao	Cagayan	Luzon
9	178–180	Callao Caves	Penablanca	Cagayan	Luzon
10	185–188	Chico River (Upstream)	Pinukpuk	Kalinga	Luzon
11	189	Temporary Pool	Asibanglan	Kalinga	Luzon
12	191–192	Limos Stream	Limos	Kalinga	Luzon
13	193–194	Laoagan Resort Fish Pond	Tabuk	Kalinga	Luzon
14	001–007	*Lake Paoay	Paoay	Ilocos Norte	Luzon
15	198–200	Lake Danum	Sagada	Mt. Province	Luzon
16	194–195	Underground River	Sagada	Mt. Province	Luzon
17	196–197	Bokong Falls	Sagada	Mt. Province	Luzon
18	203–204	Sumaging Cave	Sagada	Mt. Province	Luzon
19	201–202	Chico River (Downstream)	Bontoc	Ifugao	Luzon
20	181–184	Ambuklao Dam	Bokod	Benguet	Luzon
21	114	Pangasinan Fish Pond	Burgos	Pangasinan	Luzon
22	112–113	Lake Pantabangan	Pantabangan	Nueva Ecija	Luzon
23	137–144	Lake Mapanuepe	San Marcelino	Zambales	Luzon
24	133–136	Mt. Pinatubo Crater Lake	Mt. Pinatubo	Zambales	Luzon
25	122–125	Lake Tambo	Santa Juliana	Tarlac	Luzon
26	116–121	Candaba Swamp	Pampanga	Pampanga	Luzon
27	115	Marikina River	Marikina	Metro Manila	Luzon
28	32,38	*Pasig River	Metro Manila	Metro Manila	Luzon
29	422–424	Imus River	Imus	Cavite	Luzon
30	28	*Laguna de Bay	Several municipalities & cities	Metro Manila, Laguna & Rizal	Luzon
31	20–21	*Lake Tadlak	Tadlak	Laguna	Luzon
32	25–27	*Lake Caliraya	Lumban–Cavinti–Kalayaan	Laguna	Luzon
33	22–24	*Lake Lumot–Mahipon	Lumban–Cavinti–Kalayaan	Laguna	Luzon
34	17–19	*Lake Sampalok	San Pablo	Laguna	Luzon
35	08–10	*Lake Bunot	San Pablo	Laguna	Luzon
36	11	*Lake Yambo	San Pablo	Laguna	Luzon
37	12,13	*Lake Mohikap	San Pablo	Laguna	Luzon
38	14–15	*Lake Palakpakin	San Pablo	Laguna	Luzon
39	16	*Lake Pandin	San Pablo	Laguna	Luzon
40	425–430	Lake Calibato	San Pablo	Laguna	Luzon
41	229–235	*Lake Taal	Several municipalities & cities	Batangas	Luzon
42	301–302	Daet River	Daet	Camarines Norte	Luzon
43	302–303	Bicol River	Naga	Camarines Sur	Luzon
44	63, 66, 59	*Lake Buhi	Buhi	Camarines Sur	Luzon
45	61,62,65	*Lake Bato	Iriga	Camarines Sur	Luzon
46	60	*Lake Baao	Baao	Camarines Sur	Luzon
47	304–305	Lake Danao	Albay	Camarines Sur	Luzon
48	42,64	*Lake Bulusan	Mt. Bulusan	Sorsogon	Luzon
49	73–78	Lake Malbato	Coron	Palawan	Luzon
50	79–81	Lake Kayangan	Coron	Palawan	Luzon
51	67–72	Calbiga River	Calbiga	Eastern Samar	Visayas
52	287	Lulugayan Falls	Calbiga	Eastern Samar	Visayas
53	288–289	*Lake Danao	Ormoc	Leyte	Visayas
54	53	Lake Bito	McArthur	Leyte	Visayas

Table 1. Cont'd.

Site No.	UST ZRC Ref. No.	Name	Municipality/ City	Province	Island
55	290–293	*Lake Danao	Danao	Cebu	Visayas
56	50,52,55	Malinao Dam	Pilar	Bohol	Visayas
57	223–228	*Lake Danao	Dumaguete	Negros Oriental	Visayas
58	53,43–45	*Lake Balinsasayaw	Dumaguete	Negros Oriental	Visayas
59	54,49,36	*Lake Kabalin–an	Mt.Talinis	Negros Oriental	Visayas
60	48	*Lake Naujan	Naujan	Oriental Mindoro	Visayas
61	40–41	*Lake Mainit	Mainit	Agusan del Norte	Mindanao
62	281	Fish Pond	Magsaysay	Misamis Oriental	Mindanao
63	283	Agusan River	Butuan	Agusan del Norte	Mindanao
64	277	Gingoong River	Gingoong	Misamis Oriental	Mindanao
65	278	Cold Springs	Albuig	Misamis Oriental	Mindanao
66	262–263	Cagayan River	Kabugapit	Misamis Oriental	Mindanao
67	279	Rice Field	Longalog	Misamis Oriental	Mindanao
68	264	Magkaambos Cave	Magkaambos	Misamis Oriental	Mindanao
69	280	Kabulig River	Kabulig	Misamis Oriental	Mindanao
70	271	Lake Danao	Jasaan	Misamis Oriental	Mindanao
71	267–270	Lake Gumaod	Jasaan	Misamis Oriental	Mindanao
72	266	Tagaloan River	Tagaloan	Misamis Oriental	Mindanao
73	246	Tubod–Mayahay River	Iligan City	Lanao del Norte	Mindanao
74	238	Tumuga Bridge	Iligan City	Lanao del Norte	Mindanao
75	239–241	Ma. Cristina Falls	Iligan City	Lanao del Norte	Mindanao
76	244–245	Agos IV Dam	Iligan City	Lanao del Norte	Mindanao
77	236	Tinago Falls	Iligan City	Lanao del Norte	Mindanao
78	73–105	Lake Lanao	Marawi	Lanao del Sur	Mindanao
79	260–261	Lake Napalit	Pangantucan	Bukidnon	Mindanao
80	247–250	Lake Apo	Valencia	Bukidnon	Mindanao
81	251–254	Lake Pulangi	Valencia	Bukidnon	Mindanao
82	258–259	Lake Tutay	Don Carlos	Bukidnon	Mindanao
83	255–257	Lake Pinamaloy	Don Carlos	Bukidnon	Mindanao
84	47	*Lake Siloton	General Santos	South Cotabato	Mindanao
85	39	*Lake Lahit	General Santos	South Cotabato	Mindanao
86	37	*Lake Sebu	General Santos	South Cotabato	Mindanao

*Samples deposited in the UST–ZRC collected between 2006 and 2012

and reservoirs including the Philippines (Fernando, 2002).

Previous and present studies highlight almost the same distribution pattern of the species in Luzon, Visayas and Mindanao (Fig. 3). This study also confirms previous records of *Bosminopsis deitersi* in the islands of Luzon and Mindoro. New records for *Bosminopsis deitersi* were noted in Lakes Bangalau, Bato, and Baao. Sididae genera found in past literatures in the Philippines include *Diaphanosoma* (at least four species), *Latonopsis* (one species) and *Pseudosida* (one species). Irregularities in the presence and distribution of Sididae in past literatures have been observed in several present collections. Recent researches in Lake Paoay (Aquino et al., 2008) and Lake Taal (Papa et al., 2012) noted the presence of *Latonopsis* and *Pseudosida* but were not present in more recently examined samples. Four species from the genus *Diaphanosoma* and one in the genus *Latonopsis* have been found in the course of the study. *Diaphanosoma sarsi* was the most common species under the family in the Philippines that was found in several lakes and rivers in six major islands including Luzon, Mindoro, Leyte, Negros, Bohol and Mindanao. The distribution of *D. sarsi* confirms the study of Korovchinsky (1992) noted that the species is common in the tropics. *D. modigliani* which was previously noted by Woltereck et al. (1941) has been re-identified as *D.orghidani transmurensis* by Korovchincky (2000) from the collected samples in Lake Lanao, Mindanao. It was mentioned that *D. orghidani* was seen in the south of far east Asia, but the species was not encountered in any of the 86 inland waters that have been sampled in this study especially in Lake Lanao. *D. excisum* was identified in 35 inland waters that are mostly found in Luzon (Fig. 4). Similar to *D. sarsi*, *D. excisum* was mostly found in lakes, some rivers, reservoirs and fish ponds. Thus, confirming the studies of Mamaril & Fernando (1978), Mamaril (2001) and Papa & Zafaralla (2011) on the presence of *D. excisum* in Lakes Taal, Laguna de Bay, as well as in Buguey, Cagayan and Ilocos Norte. Other studies suggest that most of the areas where *D. excisum* was present have a high acidity, turbidity or salinity content (Korovchinsky, 2000). Laguna de Bay is highly turbid and often has saltwater intrusions related to the influx of saltwater from Manila Bay while Lake Taal has

high conductivity due to its volcanic nature (>1800 μS cm^{-1}) (Papa et al., 2011). Meanwhile, the town of Buguey (Cagayan) has many brackishwater marshes owing to its proximity to the coast. Interestingly, *D. tropicum* which was previously described in Lake Taal (Papa & Zafaralla, 2011; Papa et al., 2012) is now found in 11 other lakes in Luzon Island. *D. dubium* which was only described in 2000 by Korovchinsky from Isabela province is at present found in 10 lakes in Luzon and one river in the island of Mindanao. The result suggests new localities where most of the species from this family were found (Fig. 4). The presence of *D. dubium* in Luzon supports the record of Korovchinsky (2000). We also confirm the presence of *Latonopsis australis* described by Brehm (1938) and Mamaril & Fernando (1978) in the north, central and southern Philippines (See Fig. 7–8). Among all the three families in order Anomopoda, family Sididae has the most number of species found in the Philippine archipelago.

The largest family of anomopods, Chydoridae includes more than 200 described species. There are two subfamilies recognised: Chydorinae and Aloninae. Family Chydoridae includes the largest cladoceran genus *Alona* found in sub-Antarctic to the tropics sometimes restricted to ancient lakes and are often highly specialised. Among ctenopods, chydorids show a wider range of morphological differences between parthenogentic females and the rare male population (Smirnov, 1967). Several species can even be found in cave water springs and ground water. From a total of 28 species that were reported in previous literatures by Brehm (1938), Woltereck et al. (1941), Tsi-Chung & Clemente (1954), Mamaril (1978, 2001), Petersen & Carlos (1984); Fernando (1980), Korovchinsky (2000), Aquino et al. (2008), Papa et al. (2011), Papa and Zafaralla (2011), Papa et al. (2012), only seven species belonging to seven genera have been encountered. This may be attributed to recent anthropogenic impacts to the littoral zones of many freshwater ecosystems. Littoral zones are the first avenue of nutrient introduction from various sources (Papa et al., 2008). Chydorids are sensitive to physic-chemical parameters of water that they prone to the effect of eutrophication. The clearing of macrophytes that serve as habitat and protection from predators are being cleared from several sampled inland water bodies. This increases predation pressure on littoral zooplankton. Loss of large chydorid species (*Leydigia*, *Euryalona* etc.) can also be attributed to this. Introduction of aquaculture in lakes may have also increased both predation pressure as well as the overall water quality of freshwater ecosystems.

Zooplanktivorous fishes both introduced and native have larval stages that stay in the littoral zones thus increase in their number will reduce their population (Papa et al. 2008). Several genera also have to be further re-assessed. The genus *Alona* itself had been divided into several other genera (*Karualona*, *Coronatella*, etc.) in the past few years. The *Anthalona* sp. found in Lake Lanao, Lake Calig and Chico River is probably an undescribed species due to varying morphological characters such as the structure of its P1 and other limb structuires but further analysis is needed to determine its species Its terminal claw looks reminiscent of a poorly described species, *A. alonopsiformis* by Brehm in Lake Dagiangan in Lanao del Sur. Recent revisions on their taxonomy and evaluation of morphological structures by use of better microscopy may have led to a decline in species richness as many species are already synonyms or transferred to other genera (Frey 1982; Van Damme et al., 2011). Still plenty of the genera are still questionable and are still under a species group status like *C. hermanni* which is considered as nearly invalid or vague (Korovchinsky, 2013). The confusion on the taxonomy of chydorids also adds to the difficulty in the mapping of their distribution. The last published study on chydorids (Mamaril, 2001) has only re-listed the species and no further re-evaluation of morphological structures has been done. The lack of update on the taxonomy and distribution among chydorids had been a handicap in assessing the status of their presence in Philippine inland waters (Papa et al., 2012).

Our results suggests that anthropogenic activities in inland waters may serve as a major factor in the loss of its zooplankton diversity since most freshwater ecosystems sampled in the study were used for aquaculture. Furthermore, selective predation by aquaculture fishes may also affect the diversity of large zooplankton (Cózar, 2003) like moinids and sidids. Removal of macrophytes in the water may also a reason of the diminished diversity of small cladocerans like bosminids and chydorids in the Philippines.Cosmopolitan records should be carefully examined because many of the described taxa represent different species.

Our study presents an overview of cladoceran species richness in inland waters of the three major island groups in the Philippine archipelago. The 16 species identified from more sampling sites compared to previous studies, is far less than the previously reported 56 species. Less species were encountered in most freshwaters in the major islands of Visayas in comparison to the cladoceran species richness in Luzon and Mindanao with families Sididae and Chydoridae more distributed throughout the archipelago. Passive dispersal of cladocerans through channels, rivers or through aquaculture may also be one of the primary factors for higher number cladoceran species in the Luzon and Mindanao islands. Furthermore, freshwater aquaculture is also less practiced in the Visayas due to its greater dependence on marine fisheries products. This may have inhibited the passive transport of native and / introduced zooplankton from the larger islands through aquaculture. Though no novel species have been identified from these four families so far, our study already provides a better understanding of distribution patterns as we have collected samples from areas where no previous records on freshwater zooplankton exist which led to the addition of 78 new locality records for families Moinidae, Bosminidae, Chydoridae and Sididae.

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