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# Taxon richness and biogeography of the Cladocera (Crustacea: Ctenopoda, Anomopoda) of Thailand

S. Maiphae[1]*, P. Pholpunthin[2], H.J. Dumont[3]

[1]Department of General Science, Faculty of Science, Prince of Songkla University, Hatyai, Songkhla, Thailand
[2]Department of Biology, Faculty of Science, Prince of Songkla University, Hatyai, Songkhla, Thailand
[3]Animal Ecology, Gent University, Ledeganckstraat 35, B-9000, Gent, Belgium

At present, 99 species of cladocerans are known from Thailand, but up to ten more have not been identified to species, particularly in *Chydorus*, *Ephemeroporus* and *Pleuroxus*. Cosmopolitan species are a minority, while wide-ranging circumtropical taxa are an important element, beside species that only occur in the tropics-subtropics of two continents. At least three species are suspected of a neotropical - southeast Asian disjunction, while three more are provisionally considered endemic of Thailand. *Daphnia*, as usual in the tropics, is rare and reduced to the single *D. lumholtzi*.

Keywords: Cladocera, Taxonomy, Biogeography, Thailand, Southeast Asian - Neotropical disjunction

## Introduction

Slowly, the Cladocera of tropical and subtropical regions are becoming better known. In Asia, classical works were published in the 1970-80s: India (Michael & Sharma 1988), China (Chiang & Du 1979), the Philippines (Mammaril & Fernando 1978), Nepal (Dumont & Van de Velde 1977), Sri Lanka (Fernando 1980) and Malaysia (Idris & Fernando 1981, Idris 1983), and there has been little progress since. In Thailand, in contrast, studies only started in 1984 (Boonsom 1984), but later decades saw faunistic knowledge on the Cladocera boom (Pholpunthin 1997, Sanoamuang 1998, Pipatcharoenchai 2001, Saeng-aroon 2001, Sa-ardrit 2002, Kotov & Dumont 2000, Kotov & Sanoamuang 2004a, Kotov & Sanoamuang 2004b, Sa-ardrit & Beamish 2005, Sanoamuang & Faitakum 2005, Maiphae 2005, Maiphae et al. 2005, Kotov et al. 2005a, 2005b Sinev et al., 2007), ultimately overshooting the 100 species mark. However, the classification and level of morphological resolution during this period was revolutionized (Kotov 2003, Van Damme et al. 2003, Kotov & Hollwedel 2004, Van Damme et al. 2005), such that the validity of a number of named taxa needs re-evaluation. The present study aims to update the species list of Thailand. We examine the validity of suspect or critical taxa, and include notes on the biogeography of the Thai cladoceran fauna.

*Corresponding author: E-mail: supiyanit.m@psu.ac.th

## Materials and methods

### The study area

Thailand is situated on the Indo-Chinese Peninsula between latitude 97°30°E to 105° 45°E, and longitude 5°45°N to 20°30°N. The climate is hot and rather humid, with a monsoonal regime: 80 percent of total annual rainfall occurs between May and October. The country is divided into five regions: the north, the northeast, the west, the center and the south.

### Examination of specimens

Our investigation is based on about 900 qualitative plankton samples, collected from 96 sites in Thailand (Fig. 1) during 1999-2007 by Maiphae. Of which, 66 sites from the south (S01-S066), nine sites from the north (N01-N09), nine sites from the center (C01-C09) and 12 sites from northeast Thailand (NE01-NE012), including specimens from Kudthing swamp, northeastern Thailand (Saeng-aroon 2001), and voucher specimens of *Alona affinis*, *A. cambouei*, *A. cheni*, *A. karelica*, *A. verrucosa*, *Macrothrix paulensis*, *M. triserialis* and *M. spinosa*, from Singapore, Malaysia, Burma, Brazil, Czechoslovakia and Spain. In addition, data from

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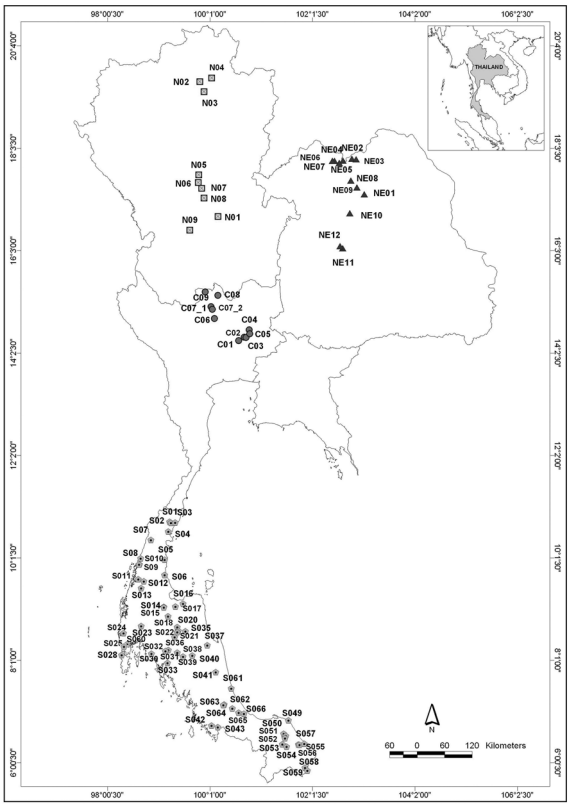



Fig. 1. Sampling sites

Pholpunthin (1997), Sanoamuang (1998), Saeng-aroon (2001), Sa-ardrit (2001), Pipatcharoenchai (2001), Sa-ardrit & Beamish (2005), Kotov & Sanoamuang (2004), Maiphae (2005), Maiphae et al. (2005a, 2005b), Sanoamuang & Faitacum (2005), Kotov et al. (2005) and Sinev et al. (2007) were used for the comparison.

The taxonomic status of species was examined and re-evaluated by a detailed morphological study. Permanent slides of complete and dissected specimens were prepared and deposited in the PSU Natural History Museum, Prince of Songkla University, Thailand (Catalogue Code: PSUZC-PK1SM). Drawings were made using a camera lucida connected to a compound microscope. The species richness count is based only on fully named species.

The distribution range of each species is evaluated by biogeographical regions: Oriental, Palearctic, Australian, African, Neotropical and Nearctic regions. An attempt is made to discuss the events that may have led to present-day cladoceran distribution. Information from studies such as Chiambeng (2004) and Chiambeng & Dumont (2005) was included in the analysis.

### Abbreviations

The following abbreviations are used in all illustrations: EX=Exopodite, EN=Endopodite, IDL=Inner distal lobe, ODL=Outer distal lobe

## Results and Discussions

The list of cladoceran species from Thailand has been changing with the level of morphological resolution. A total of 99 species in 38 genera and seven families are now on record (Table 1). The species lists still represent an underestimate, since a number of species remain inadequately defined (Maiphae et al. 2005, Adamowicz & Purvis 2005). A brief discussion of morphological and biogeographical notes is presented below.

### Notes on taxonomy of some taxa

Some specimens cannot currently be identified to species: *Karualona* sp.1 (Sa-ardrit 2001), *Karualona* sp.2 (Sa-ardrit & Beamish 2005), *Leydigia* sp. (Maiphae 2005 and Maiphae et al. 2005), *Leydigiopsis* sp. (Sanoamuang 1998, Sa-ardrit 2001, Maiphae 2005 and Maiphae et al. 2005) and *Macrothrix* sp.1 and *Macrothrix* sp.2 (Sa-ardrit 2001). These have been found in too few specimens to evaluate their status. The rarity of such species and limited available material are major problems. To overcome these, further intensive sampling should be made. From the present data, however, it appears that some "species" are made up of more than one taxon. For example, the *Alona verrucosa* from southern Thailand clearly represents two species, roughly separable by the following combination of characters: 1) shape ovoid, ventral setae relatively short, antennule compact and postanal margin of postabdomen longer than anal margin (PK1SM004-01: Fig. 2a); and 2) shape rounded, ventral setae relatively longer posteriorly, antennule elongated and postanal margin of postabdomen as long as anal margin (PK1SM004-02: Fig. 2b). However, these data are insufficient to define their status. More detailed morphological information is needed. If all species in the list above were fully identified, the cladoceran fauna in Thailand would reach close to 110 species.

Some species had previously been given a wrong name. This applies to *Alona cheni* Sinev, 1999, *Alona archeri* Sars, 1888 and *Alona* cf. *cambouei* De Guerne & Richard, 1893. In the case of *Alona cheni*, the name "*Alona costata*" had been used previously. Following the key for Malaysia (Idris 1983), which shows sac-like lateral head pores as the main diagnostic characters, any *Alona* with this character was formerly named *Alona costata*.

Table 1. The Cladocera found in Thailand and distribution of each species. (Reference code: 1=Pholpunthin, 1997; 2=Sanoamuang, 1998; 3=Saeng-aroon, 2001; 4=Sa-ardrit, 2001; 5=Pipatcharoenchai, 2001; 6=Sa-ardrit & Beamish, 2004; 7=Kotov & Sanoamuang, 2004; 8=Kotov, Maiphae & Sanomuang, 2005; 9=Maiphae, 2005; 10 =Maiphae et al., 2005; 11=Sanoamuang & Faitacum, 2005; 12=Kotov, Stifter & Sanoamuang, 2005; 13=Sinev et al.,2007: Geographical distribution code: O= Oriental; P= Palearctic; A= Australian; Af=African; N=Neotropics, Ne= Nearctic).

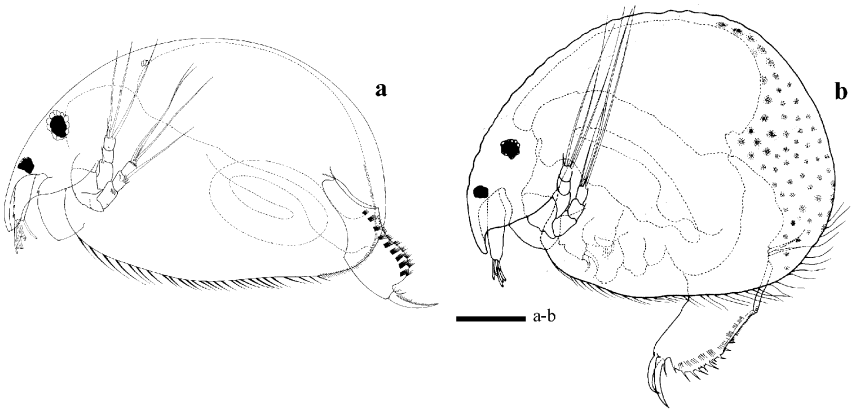
| | Species | Distributions | | | | | | Notes |
|---|---|---|---|---|---|---|---|---|
| | | O | P | A | Af | N | Ne | |
| | **Order Anomopoda** | | | | | | | |
| | **Family Bosminidae** | | | | | | | |
| 1 | *Bosmina fatalis*: 5 | + | | | | | | |
| 2 | *B. longirostris*: 5, 9, 10 | + | + | + | + | + | + | circumtropical |
| 3 | *B. meridionalis*: 2, 5, 6, 9, 10, 11 | + | | | | | | |
| 4 | *Bosminopsis deitersi*: 1, 2, 3, 4, 5, 6, 9, 10, 11 | + | | + | + | + | | cosmopolitan |
| | **Family Chydoridae** | | | | | | | |
| 5 | *Alona affinis*: 2, 3, 4, 6, 9, 10, 11 | + | + | + | + | + | | |
| 6 | *A. archeri*: 1,9,10 | + | | + | | | | |
| 7 | *A.* cf. *cambouei*: 2, 9 | + | | | + | | | |
| 8 | *A. cheni*: 9 | + | | | | | | |
| 9 | *A.* cf. *dentifera*: 9, 10 | + | | | | + | + | records in SEA need to be revised |
| 10 | *A. guttata*: 3, 4, 6, 9, 10, 11 | + | + | | + | | | |
| 11 | *A. intermedia*: 3, 4 | + | + | + | + | + | | |
| 12 | *A. milleri*: 2 | + | | | | | | rare and local species |
| 13 | *A. monacantha*: 2, 3, 4, 9, 10, 11 | + | | | + | | | |
| 14 | *A. quadrangularis*: 2, 3, 9, 10, 11 | + | + | | + | | | |
| 15 | *A. rectangula*: 1, 2, 4, 5, 6, 9, 10 | + | + | + | + | + | | |
| 16 | *A. verrucosa*: 2, 3, 4, 5, 6, 9, 10, 11 | + | | + | + | + | | |
| 17 | *A. pulchella*: 2, 3 | + | | + | + | + | | |
| 18 | *A. sarasinorum*: 9, 10 | + | | | | | | |
| 19 | *Alonella clathratula*: 2, 3, 9, 10, 11 | + | + | + | + | | + | |
| 20 | *A. excisa*: 1, 2, 3, 4, 9, 10, 11 | + | + | + | + | + | + | cosmopolitan |
| 21 | *A. nana*: 4, 9, 10 | + | + | + | | | + | |
| 22 | *Acroperus harpae*: 2, 3, 4, 9, 10 | + | + | + | + | | | |
| 23 | *Armatoalona macrocopa:*13 | + | | + | | | | at present in oriental region, it was recorded from Thailand only |
| 24 | *Camptocercus australis*: 3, 4, 6, 9, 10, 11 | + | | + | | | | |
| 25 | *C. uncinatus*: 1, 2, 5 | + | + | + | + | + | | |
| 26 | *Chydorus eurynotus*: 1, 2, 3, 4, 5, 6, 9, 10, 11 | + | | + | + | + | | circumtropical |
| 27 | *C. obscurirostris*: 4, 9, 10, 11 | + | | + | | | | |
| 28 | *C. opacus*: 4 | + | | + | | | | |
| 29 | *C. parvus*: 2, 3, 4, 5, 6, 9, 10, 11 | + | | + | + | | | |
| 30 | *C. pubescens*: 2, 4, 6, 9, 10, 11 | + | | | + | + | | circumtropical |
| 31 | *C. reticulatus*: 2, 4, 5, 9, 10, 11 | + | | | | | | |

Table 1. (continued)

| | Species | Distributions | | | | | | Notes |
|---|---|---|---|---|---|---|---|---|
| | | O | P | A | Af | N | Ne | |
| 32 | *C. sinensis*: 2, 3, 11 | + | + | | | | | |
| 33 | *C. sphaericus*: 9, 10 | + | + | + | + | + | + | species complex, cosmopolitan |
| 34 | *C. ventricosus*: 2, 4, 6, 9, 10, 11 | + | | | + | + | | circumtropical |
| 35 | *Dadaya macrops*: 2, 3, 4, 6, 9, 10, 11 | + | | | + | + | | circumtropical |
| 36 | *Disparalona caudata*: 2, 9, 10 | + | | + | | | | |
| 37 | *D. hamata*: 2, 3, 4, 6, 9, 10, 11 | + | + | + | + | + | + | cosmopolitan |
| 38 | *D. rostrata*: 4, 11 | + | + | | + | | | records in Africa need to be revised |
| 39 | *Dunhevedia crassa*: 1, 2, 3, 4, 5, 6, 9, 10, 11 | + | + | + | + | + | + | cosmopolitan |
| 40 | *D. serrata*: 2, 3, 4, 6, 9, 10, 11 | + | | | + | + | | |
| 41 | *Ephemeroporus barroisi*: 1, 2, 3, 4, 5, 6, 9, 10, 11 | + | | + | + | | + | circumtropical |
| 42 | *E. hybridus*: 9, 10 | + | | | + | + | + | |
| 43 | *E. phintonicus*: 4, 9, 10 | + | | + | | | | |
| 44 | *E. tridentatus*: 9, 10 | + | | | | + | | |
| 45 | *Euryalona orientalis*: 1, 2, 3, 5, 6, 9, 10, 11 | + | | | + | + | | |
| 46 | *Graptoleberis testudinaria*: 2, 4 | + | + | + | + | | | |
| 47 | *Indialona macronyx*: 2, 4, 9, 10 | + | | | | | | |
| 48 | *Karualona iberica*: 9, 10 | + | + | + | + | | | |
| 49 | *K. karua*: 11 | + | | + | | | | |
| 50 | *Kurzia brevilabris*: 11 | + | | + | + | + | + | |
| 51 | *K. longirostris*: 2, 3, 4, 5, 6, 9, 10 | + | | + | + | | | |
| 52 | *Leberis diaphanus*: 1, 2, 3, 4, 6, 9, 10, 11 | + | | + | + | + | | |
| 53 | *Leydigia acanthocercoides*: 2, 5, 6 | + | + | | + | | | |
| 54 | *L. ciliata*: 1, 11 | + | | + | + | + | | |
| 55 | *L. laevis*: 2 | + | | | | | | |
| 56 | *L. australis*: 4 | + | | + | | | | |
| 57 | *Nicsmirnovius eximius*: 6, 9, 10, 11 | + | | + | | | | |
| 58 | *Notoalona globulosa*: 2, 3, 4, 9, 10, 11 | + | | | + | | | |
| 59 | *N. freyi*: 4, 9, 10 | + | | | | | | |
| 60 | *Oxyurella singalensis*: 2, 3, 4, 6, 9, 10, 11 | + | | | + | | | |
| 61 | *Pleuroxus uncinatus*: 9, 10 | + | + | | | | + | |
| 62 | *P. quasidenticulatus*: 4, 6 | + | + | + | | + | | |
| 63 | *P. laevis*: 2, 4, 6, 9, 10, 11 | + | + | + | | | | |
| 64 | *Pseudochydorus globosus*: 11 | + | + | + | + | + | | cosmopolitan |
| | **Family Daphniidae** | | | | | | | |
| 65 | *Ceriodaphnia cornuta*: 2, 3, 4, 5, 6, 9, 10, 11 | + | | + | + | + | | |
| 66 | *Daphnia lumholtzi*: 2, 3, 5, 6, 11 | + | | + | + | | | |

Table 1. (continued)

| | Species | Distributions | | | | | | Notes |
|---|---|---|---|---|---|---|---|---|
| | | O | P | A | Af | N | Ne | |
| 67 | *Scapholeberis kingi*: 2, 3, 4, 5, 6, 9, 10, 11 | + | | + | + | + | | |
| 68 | *Simocephalus exspinosus*: 2, 3, 11 | + | + | + | | | | |
| 69 | *S. heilongjiangensis*: 2, 3, 4, 6, 9, 10, 11 | + | | | | | | |
| 70 | *S. vetulus*: 2 | + | + | + | + | + | | |
| 71 | *S. serrulatus*: 2, 3, 4, 6, 9, 10, 11 | + | + | + | + | + | | |
| | **Family Ilyocryptidae** | | | | | | | |
| 72 | *Ilyocryptus* cf. *bhardwaji*: 7 | + | | | | + | | |
| 73 | *I.* cf. *raridentatus*: 7 | + | | | | + | | |
| 74 | *I. spinifer*: 2, 3, 4, 5, 6, 9, 10, 11 | + | | + | + | + | | |
| 75 | *I. thailandensis*: 7 | + | | | | | | at present, it was recorded from Thailand only |
| 76 | *I. isanensis*: 12 | + | | | | | | at present, it was recorded from Thailand only |
| | **Family Macrothricidae** | | | | | | | |
| 77 | *Grimaldina brazzai*: 4, 5, 11 | + | | + | + | + | | circumtropical |
| 78 | *Guernella raphaelis*: 2, 4, 6, 9, 10, 11 | + | | + | + | + | | circumtropical, including China |
| 79 | *Macrothrix* cf. *laticornis*: 2, 4, 5, 6, 9, 10 | + | + | + | | + | | records in SEA need to be revised |
| 80 | *M.* cf. *gauthieri*: 10 | + | | + | + | | | records in SEA need to be revised |
| 81 | *M. paulensis*: 2, 9, 10 | + | | | | + | | at present in SEA, it was recorded from Thailand only |
| 82 | *M. malaysiensis*: 9, 10 | + | | + | | | | |
| 83 | *M. odiosa*: 3, 4, 9, 10, 11 | + | | + | | | | |
| 84 | *M. pholpunthini*: 8 | + | | | | | | at present, it was recorded from Thailand only |
| 85 | *M. spinosa*: 1, 2, 3, 4, 6, 9, 10, 11 | + | | + | + | + | | circumtropical |
| 86 | *M.* cf. *superaculeata*: 9, 10 | + | | | | + | | records in SEA need to be revised |
| 87 | *M. triserialis*: 1, 2, 4, 5, 6, 9, 10, 11 | + | | + | + | + | | circumtropical |
| 88 | *Strebloceras pygmaeus*: 2, 4, 5, 9, 10 | + | | | | + | | |
| | **Family Moinidae** | | | | | | | |
| 89 | *Moina micrura*: 2, 3, 4, 5, 6, 9, 10, 11 | + | + | + | + | + | + | |
| 90 | *Moinodaphnia macleayi*: 2, 4, 9, 10, 11 | + | | + | + | + | + | circumtropical |
| | **Order Ctenopoda** | | | | | | | |
| | **Family Sididae** | | | | | | | |
| 91 | *Diaphanosoma dubia*: 11 | + | + | | | | | mainly in Far East |
| 92 | *D. excisum*: 1, 2, 3, 4, 5, 6, 9, 10, 11 | + | | + | + | | | circumtropical |
| 93 | *D. volzi*: 2, 3, 4, 11 | + | | + | + | | | rare species |
| 94 | *D. sarsi*: 2, 3, 6, 9, 10 | + | + | + | + | + | | circumtropical |
| 95 | *Latonopsis australis*: 2, 3, 4, 6, 9, 10, 11 | + | | + | + | + | + | species complex, cosmopolitan |
| 96 | *Pseudosida bidentata*: 2, 4, 6, 9, 10, 11 | + | | + | + | + | + | |
| 97 | *P. ramosa*: 2, 9, 10 | + | | + | | + | | |
| 98 | *Sarsilatona serricauda*: 4 | + | + | | | + | + | |
| 99 | *Sida crystallina:* 3, 9, 10, 11 | + | + | + | | + | | |




Figs 2a-b. *Alona verrucosa* Sars, 1901: parthenogenetic females from Thungtong swamp (S019), Suratthani Province, southeastern Thailand. Figures a-b, adult females in lateral view. Scale bars denote 100 µm.

However, after checking specimens from southern (PK1SM003-01) and northeastern Thailand (PK1SM003-02), Malaysia (PK1SM003-03) and Singapore (PK1SM003-04), all records were found to belong to *A. cheni* (Fig. 3a), on account of the semi-circular pockets below the lateral pores (Figs 3b-c), the main character that separates *A. costata* from *A. cheni* (Sinev 1999). It is probable that all previous Thai records of *A. costata* actually represent *A. cheni*, and the former species is not present in the region.

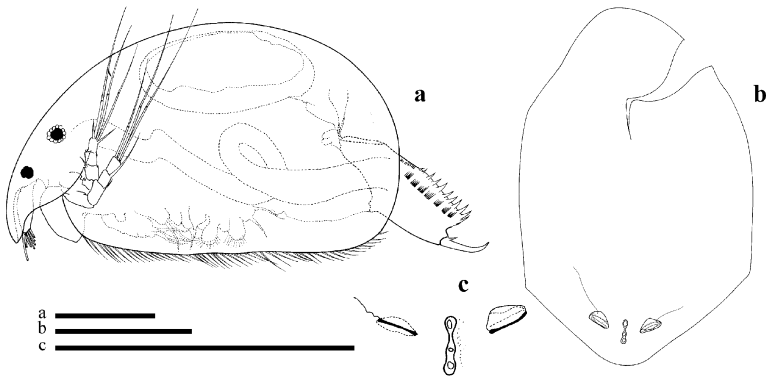
*Alona archeri* Sars, 1888 was originally described from Australia. After its initial description it was reported from Indonesia (Brehm 1933), Tadzhikistan (Mukhamediev 1986), Queensland, New South Wales and Tasmania (Smirnov & Timms 1983). Sinev redescribed it in 2002, based on G. O. Sars' original sample and one slide from Australia. Pholpunthin (1997) recorded it from Thalenoi marsh (S041), Pattalung Province, southern Thailand, the first record from Thailand, but he did not illustrate its morphology. Upon checking, it was found that the specimens from S060 (PK1SM001-02) and specimens recorded as *A.* aff. *karelica* from S042 (PK1SM001-01, in Maiphae 2005 and Maiphae et al. 2005) are all *A. archeri* (Figs 4-5), on account of their narrow postabdomen (Figs 4i-j) with parallel margins, well developed denticles on distal angle, proximally replaced by short setules, fascicles narrow and wide gaps between them, and long basal spine of postabdominal claw (1/3 or 1/4 of claw). The latest character separates *A. archeri* from true *A. karelica* (spine 1/5 of claw or hardly visible).

There are differences between specimens from Australia (Sinev 2002) and southern Thailand: 1) length 1.4-1.6 times maximum height in Sinev (2002) but about 1.4-1.8 times in Thai specimens (Figs 4a-c); 2) antennule not reaching tip of rostrum in Sinev (2002) but reaching that tip in Thai specimens (Fig. 4b); 3) longest aestetasc about 0.5 length of antennule in Sinev (2002) but about 0.8 length of antennule in Thai specimens (Fig. 4e); 4) labral keel with re-curve rounded apex in Sinev (2002) but more round in Thai specimens (Fig. 4d); 5) basal spine of postabdomen 1/3 of claw length in Sinev (2002) but 1/4 in the present study (Figs 4i-j), and 6) 1st and 2nd scrapers of the same length in Sinev (2002) but 1st scraper shorter than 2nd in Thai specimens (Fig. 5b). We here refrain from giving these a taxonomic weight.

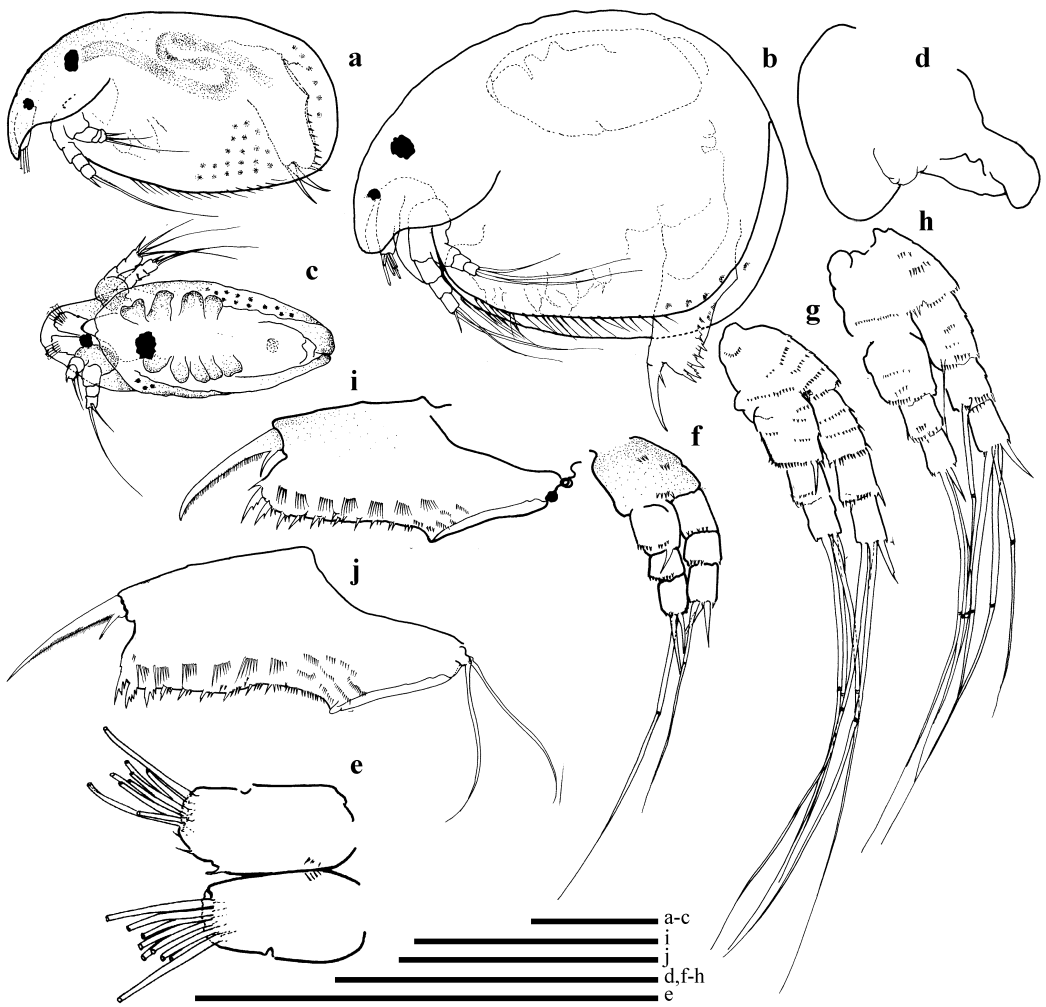
*Alona* cf. *cambouei* (Figs 6a-e) from the South (PK1SM002-01) shows characters different from *A. pulchella* and shared with *A. cambouei*, as understood by Sinev (1999), e.g. 3 central pores round and disconnected. Specimens from the northeast (PK1SM002-02) present the same. However, we still lack data on specimens from other parts of country and, because *A. cambouei* was originally described from Madagascar, it should be redescribed from topotypical material to set a modern standard for comparison. Thus, we keep both species in the list till further comparisons can be made.

**Notes on biogeography**

The distribution of Thai Cladocera varies from cosmopolitan to a range shared between several regions, to one restricted to a single region or even habitat (table 1). True cosmopolitan species are few (Frey 1987, Dumont 1980, Dumont & Negrea 2003). As their morphological definition improves, species-groups can be distinguished, composed of related, but distinct taxa, each with a limited geographical range. On the other hand taxa such as families are essentially cosmopolitan, because the ecologi-




Figs 3a-e. *Alona cheni* Sinev, 1999: parthenogenetic female from Thungtong swamp (S019), Suratthani Province, southeastern Thailand. Figure a, adult female in lateral view; Figures b-c, head shield and its head pores. Scale bars denote 100 m.

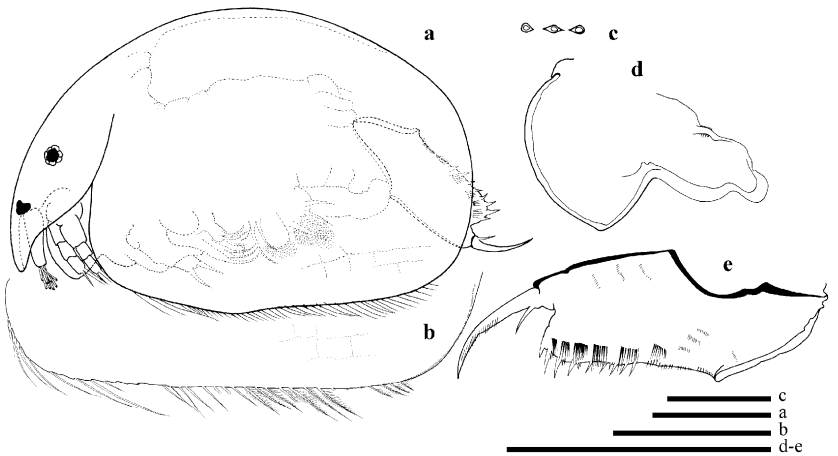



Figs 4a-j. *Alona archeri* Sars, 1888: parthenogenetic females from Kalai swamp (S060), Phang-nga Province, southwestern Thailand. Figures a-b, adult females in lateral view; Figure c, adult female in ventral view; Figure d, labrum; Figure e, antenna 1; Figures f-h, antenna 2; Figures i-j, postabdomen. Scale bars denote 100 m.


Figs 5a-i. *Alona archeri* Sars, 1888: appendages of parthenogenetic females from Kalai swamp (S060), Phang-nga Province, southwestern Thailand. Figure a, trunk limb 1; Figures b-c, trunk limb 2; Figures d-e, trunk limb 3; Figures f-g, trunk limb 4; Figures h-i, trunk limb 5. Scale bars denote 100 m.

cal diversity within these groups is broad enough for them to exist in most aquatic habitats, and also because these groups are old enough to have had opportunities to colonize the world.

Of the 99 species, 13 are restricted to oriental region, 14 are circumtropical (*Bosmina longirostris*, *Bosminopsis deitersi, Chydorus eurynotus, C. pubescens, C. ventricosus, Dadaya macrops, Ephemeroporus barroisi,*




Figs 6a-e. *Alona* cf. *cambouei* Guerne & Richard, 1893: parthenogenetic females from Maikhao peatswamp (S028), Phuket Province, southwestern Thailand. Figure a, adult female in lateral view; Figure b, ventral margin of valve; Figure c, head pores; Figure d, labrum; Figure e, postabdomen. Scale bars denote 100 m.

*Grimaldina brazzai, Guernella raphaelis, M. spinosa, M. triserialis, Moinodaphnia macleayi Diaphanosoma excisum and D. sarsi*), three have a neotropical affinity (*Ephemeroporus tridentatus*, *Macrothrix* cf. *laticornis* and *Macrothrix paulensis*), six have a wide range (*Bosmina longirostris*, *Alonella excisa, Chydorus sphaericus, Dunhevedia crassa, Pseudochydorus globosus* and *Latonopsis australis*) and three are possible endemics (*Ilyocryptus thailandensis, I. isanensis* and *Macrothrix pholpunthini*). The class restricted to a single region contains about 12 % of all species: *Bosmina fatalis*, *B. meridionalis*, *Alona cheni*, *A. milleri*, *Chydorus reticulatus*, *Indialona macronyx*, *Leydigia laevis, Notoalona freyi*, *Simocephalus heilongjiangensis, Ilyocryptus thailandensis, I. isanensis, Macrothrix odiosa* and *M. pholpunthini*. This may reflect the isolation of the region since the late Precambrian (Scotese 2001).

Some taxa found in Thailand have been recorded disjunctly from other regions, including the Holartic, Mediterranean and even the Neotropics as mentioned above: *Alonella nana, Ephemeroporus tridentatas, E. hybridus, E. phintonicus, Leydigiopsis* sp., *Macrothrix* cf. *laticornis*, *M.* cf. *superaculeata, M. paulensis* and *Streblocerus pygmaeus*. However, most of them except *A. nana* are rare. One hypothesis to explain the existence of these species in Thailand is that they are relicts of a continuous Pre-Pleistocene distribution rather than descendants of inocula that reached the rainforest during the humid periods of the Pleistocene (Korovchinsky, 2006). A similar species composition occurs in some acid, black waters, covered with sedge, in Brazil (Van Damme 1998) and in southern Thailand. That some Thai (e.g. *Leydigiopsis* sp.) and South American taxa found here are congeneric and related but not conspecific rules out recent passive dispersal. Coupled to the fact that cladocerans evolve slowly, a Gondwanian origin of such taxa appears likely, combined with a Cenozoic extinction of similar taxa in the intervening continent of Africa (Chiambeng & Dumont 2005).

*Macrothrix pholpunthini* Kotov, Maiphae & Sanoamuang, 2005, *Ilyocryptus thailandensis* Kotov & Sanoamuang, 2005 and *I. isanensis* Kotov, Stifter & Sanoamuang, 2005 are apparently endemic although it cannot be excluded that further faunistic study in neighbouring countries may find them there as well. At least some of the still unidentified species may be new species, and may in future increase the number of endemics in the country.

*Daphnia* is rare, with only *D. lumholtzi* on record (Sanoamuang 1998, Saeng-aroon 2001, Sa-ardrit 2002, Sa-ardrit & Beamish 2005). This is a multifactor phenomenon. Dumont (1980) and Chiambeng & Dumont (2005) attribute its scarcity in tropical lowlands to high levels of predation by fish, more numerous in the tropics than elsewhere. Also, the temperature-dependency of predation is a pivotal variable (Dumont 1994), as well as the absence of seasonal succession in the tropics, exacerbating not only predation but also competition. Finally, the absence of suitable carriers for passive dispersal (e.g. migratory birds) in the rare environments suitable for *Daphnia* in the tropics (e.g. high mountain lakes) makes its colonisation there improbable and slow.

From all the above, it appears that *Alona* is currently the best studied group in Thailand but a number of other genera and species still await revision. Particularly, chydorids such as *Chydorus*, *Ephemeroporus* and *Pleuroxus* show a high diversity in Thailand that merits further scrutiny.

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