รายงานวิจัยฉบับสมบูรณ์

โครงการ อนุกรมวิธานของแพลงก์ตอนสัตว์อันดับใหญ่คลาโดเซอรา Family Chydoridae ในประเทศไทย

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พฤษภาคม 2551

สัญญาเลขที่ MRG4980039

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รหัสโครงการ : MRG4980039
ชื่อโครงการ : อนุกรมวิธานของแพลงก์ตอนสัตว์อันดับใหญ่คลาโดเซอรา Family Chydoridae ในประเทศไทย
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บทคัดย่อ

ศึกษาลักษณะทางสัณฐานวิทยาของคลาโดเซอราวงศ์ Chydoridae 34 ชนิด โดยศึกษาตัวอย่างจากแหล่งน้ำจืด 96 แหล่งของประเทศไทย รวมทั้งตัวอย่างจากประเทศต่างๆ จากการศึกษาพบความแปรผันของลักษณะทางสัณฐานวิทยาทั้งภายนอกและภายใน โดยสามารถจำแนกปัญหาอนุกรมวิธานได้เป็น 4 กลุ่ม คือ ชนิดที่มีการจำแนกชนิดผิดพลาด ชนิดที่มีชื่อซ้ำซ้อน ชนิดที่มีความซับซ้อนทางสัณฐานวิทยาและชนิดที่มีปัญหาสถานะทางอนุกรมวิธาน โดยในการศึกษาครั้งนี้สามารถพิสูจน์ได้ว่า *Alona* aff. *karelica* Stenroos, 1897 ไม่ปรากฏจริงในประเทศไทย และ *Alona taraporevalae* Shirgue and Naik, 1977 เป็นชนิดที่มีความซ้ำซ้อนกับ *A. sarasinorum* Stingelin, 1900 นอกจากนี้ยังพบว่าของ *A. sarasinorum* มีปัญหาสถานะทางอนุกรมวิธานระดับสกุลเนื่องจากพบลักษณะทางสัณฐานวิทยาที่มีความเฉพาะและมีความแตกต่างจาก *Alona* ชนิดอื่นหลายลักษณะ จากผลการศึกษาจึงสามารถสรุปได้ว่ามีคลาโดเซอราวงศ์ Chydoridae 1 ชนิดที่ซ้ำซ้อนกับชนิดอื่น และ 1 ชนิด ไม่ปรากฏอยู่จริงในประเทศไทย ดังนั้น Chydorids ในประเทศไทยจึงมีทั้งสิ้น 60 ชนิด โดยในการศึกษาครั้งนี้ได้เสนอคู่มือการจำแนกชนิดคลาโดเซอราวงศ์ Chydoridae ที่พบในประเทศไทยด้วย

คำสำคัญ: อนุกรมวิธาน, คลาโดเซอรา, ประเทศไทย

Project Code : MRG4980039

Project Title : Taxonomy of the the Family Chydoridae (Crustacea: Branchiopoda: Cladocera) in Thailand

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Abstract

Detailed morphological characters of 34 chydorids were investigated based on specimens collected from 96 localities throughout Thailand including voucher specimens from various countries. Key to all known chydorids in the country is proposed. The great variation in differences of the morphology was found in both external and internal characteristics. Morphological comparisons of different population were made so that the taxonomic status of the species level can be reviewed. Of which, among those species, the taxonomic problems can be identified into four categories: misidentified species, synonymy species, species-group and generic status is questioned. We are successful in proving that *Alona* aff. *karelica* Stenroos, 1897 is not valid in Thailand and *A. taraporevalae* Shirgue and Naik, 1977 is a synonym of *A. sarasinorum* Stingelin, 1900. However, the generic status of *A. sarasinorum* is still doubtful because the presence of a number of unique characters among other *Alona*. To revise its generic status, more information is need.

At present, one species in current list are no longer valid and two species are not valid anymore in Thailand. Thus, number of chydorids species in the proposed list has reduction to 60 species.

Keywords : Taxonomy, Cladocera, Chydoridae, Thailand

Executive Summary

The present study was aimed to perform a detailed morphological study of chydorids in Thailand and construct the key to species level. The chydorid specimens were collected from 96 freshwater habitats throughout Thailand including voucher specimens from various countries. Detailed morphological characters were examined both external and internal parts, of which drawings and SEM were applied for studying fine characters. At present, 34 chydorids species were examined in detail. The great variation in differences of the morphology was found in both external and internal characteristics. Morphological comparisons of different population were made so that the taxonomic status of the species level can be reviewed. Of which, among those species, the taxonomic problems can be identified into four categories: misidentified species, synonymy species, species-group and taxonomic status is questioned. It was found that *Alona* aff. *karelica* Stenroos, 1897 is misidentified thus it is success in proving that this species is presently not valid in Thailand. Moreover, it was found that *A. taraporevalae* Shirgue and Naik, 1977 is a synonym of *A. sarasinorum* Stingelin, 1900. However, the generic status of *A. sarasinorum* is still doubtful because the presence of a number of unique characters among other *Alona*. To revise its generic status, more information is need.

Keys to 20 genera of Chydoridae, including keys to all known chydorids in Thailand were proposed. The selected characters used in the keys was more practical to separated the taxa, and not the characters that show the phylogenetic relationship.

However, a rather large number of species still await confirmation of their taxonomic status, redescription or revision. Particularly, the monospecific genera which mainly occur in the tropical rainforest (*Guernella, Grimaldina, Dadaya*) and some other confusing megagenera which a lack of studies (*Alonella, Chydorus*) should be investigated in more details. Additionally, the information of molecular study is also being an important tool to clarify the phylogenetic relationship especially at family and genus level. Moreover, functional-morphological studies are needed as they may throw more light on cladoceran evolution. Finally, the zoogeography of the Cladocera, a field that has remained underdeveloped, should be further developed.

Contents

Chapter 1 Introduction

The significance of the Cladocera in every subject of study, especially in taxonomical work, has not been fully recognized for several reasons. Their microscopical size, its phenotypic variability and the fact that keys are out of date, including the historical factors makes it hard to distinguish them. (Korovchinsky,1997). The proportion of pure morphological studies was small relative to the rapidly increasing mass of the studies on ecology, aquaculture and genetics.

A major confusion about their taxonomy arose from the idea of cosmopolitanism. Many taxa are often cited under the same name on different continents but have been found to represent different species level later (Frey, 1995). Although cosmopolitanism is refused by more and more observations, and some peculiar species occur in habitats such as ground waters, caves and terrestrial habitats, a base for chronic mistakes had been laid. Another problem is their great morphological variation, a classical problem in cladoceran taxonomy. On species level, the characters in single specimen seem to be quite constant while animals in one population seem to have a high morphological flexibility and variation. Instar variability between populations and cyclomorphic changes are also strong factors that complicate cladoceran systematics. The importance of characters appears to be taxon-specific. The most important taxonomical characters for each group are still unclear so taxonomists should examine all parts of their body, to avoid the mistakes from using different criteria for their identification. Furthermore poor descriptions make taxonomy a time consuming and frustrating task. Most original descriptions of cladocerans are incomplete; lacking either a detailed clear description of useful features or good illustrations that used for comparison. Because of all mentioned above, wrong names have uncritically been applied all over the world.

The study of morphological variation is important for each morphological comparative study, especially for work on problems about the species group. For the last 20 years, however, the approach has considerably evolved especially at the species level. It has become clear that many former cosmopolitan species are in fact a species-group, of morphologically related species. On the other hand, some must be

treated as an infra-specific unit. Moreover, descriptions of most species are out of date, incomplete and lacking many important details. Part of the identification problem is due to the use of foreign keys, mostly from Europe, North America instead of using local keys. Thus the first task in any taxonomical study is to develop a good description of the original taxon and to construct the good key for the local species. However, what are the most important taxonomically significant characters? We do not know in advance which characters will become the most useful for identification.

The development of morphological studies started from the second half of the seventieth century. The researchers focused on external characters: head, head shield ornamentation, head pore, valve, body shape, first and second antennae. Also considered were postabdomen, its shape, seta natatoria, its size, anal teeth, position of anus and rows of spines, end-claw and pectens. Some also paid attention to the ephippial egg and its ornamentation. Important characters such as type of valve reticulations, similarity or dissimilarity in size of the terminal aesthetasc of the antennules, presence of an abdominal projection, reticulation on the postabdomen, length and armature of male seta on the antennule, head pores and, especially, the structure of trunk limbs were rarely used in the systematics of the cladoceran. Since 1960, researchers have begun to focus on the fine morphology of thoracic limbs structure and their functions (Smirnov, 1966, 1972; Fryer, 1968, 1974). Cladocera have 5-6 pairs of trunk limbs. These limbs are widely diverse in forms and functions. Some function in grasping, scraping, mechanically transferring food particles and filtration, or some combination of these. The first pair is used mostly in locomotion. The food groove tends to be deep and narrow. There are never any postgenital limbs and the telson or postabdomen terminates in a pair of strong terminal claws and bears a pair of dorsal sensory setae (seta natatoria). Currently, many researchers accept that these organs are important in their evolution. However, only few cladocerologists (Alonso, 1996; Fryer, 1974; Paggi, 1979 and Kotov, 2000) rely mainly on only trunk limbs in their species descriptions. On the evidence of trunk limbs structure, many changes occurred in the systematics. For example Smirnov (1992) removed the Ilyocryptidae from the Macrothricidae because of their distinctly different trunk limbs. In addition, because of the study on the details of trunk limbs, many revisions of “old” species are now underway. Detailed trunk limb morphology also resolved

problems at the species-group level, which is demonstrated using several groups in Family Chydoridae such as *Alona eximia*-group (before Van Damme *et al.*, 2003) and *Alona costata*-group (Sinev, 1999). Some species need to be synonymised, other are shown to consist of many individual species, each with apparently restricted geographical range.

Slowly, the Cladocera in tropical and subtropical regions are beginning to become better known, although the available literature mostly deals with the diversity, systematics and life histories of a few selected species. For Asia, classical works were published in the 1980s: India (Michael & Sharma, 1988), China (Chiang & Du, 1979), the Philippines (Mamaril & Fernando, 1977), Nepal (Dumont & Van de Velde, 1977), Sri Lanka (Fernando, 1980) and Malaysia (Idris, 1983) but there has been little progress after that. In Thailand, in contrast, studies only started in 1984 (Boonsom, 1984), but the decades after that saw faunistic knowledge on the Cladocera boom (Pholpunthin, 1997; Sirimongkonthaworn, 1997; Sanoamuang, 1998; Pipatcharoenchai, 2001; Saeng-aroon, 2001; Sa-ardrit, 2002; Faitacum, 2003; Kotov & Sanoamuang, 2004; Sa-adrit & Beamish, 2004; Maiphae, 2005; Maiphae *et al.*, 2005), ultimately reaching and 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 now needs re-evaluation.

Objectives

To contribute to the taxonomy of the Cladocera, Family Chydoridae in Thailand by

1) Performing a detailed morphological study of representatives of all taxa in Thailand

2) Constructing the key to species of Chydorids in the country

Chapter 2 Materials and methods

Chydorids sampling

Specimens used in the present study obtained from the previous sampling throughout southern Thailand during 1999-2000 (Maiphae, 2005). Specimens from the other parts of Thailand were obtained from samples sampling in freshwater localities throughout Thailand during this study period during 2006-2007. (figure 1, Table 1). All samples are qualitatively collected using standard plankton nets of mesh size 20 µm and 60 µm and they are immediately preserved in 4% formaldehyde and 96% alcohol.

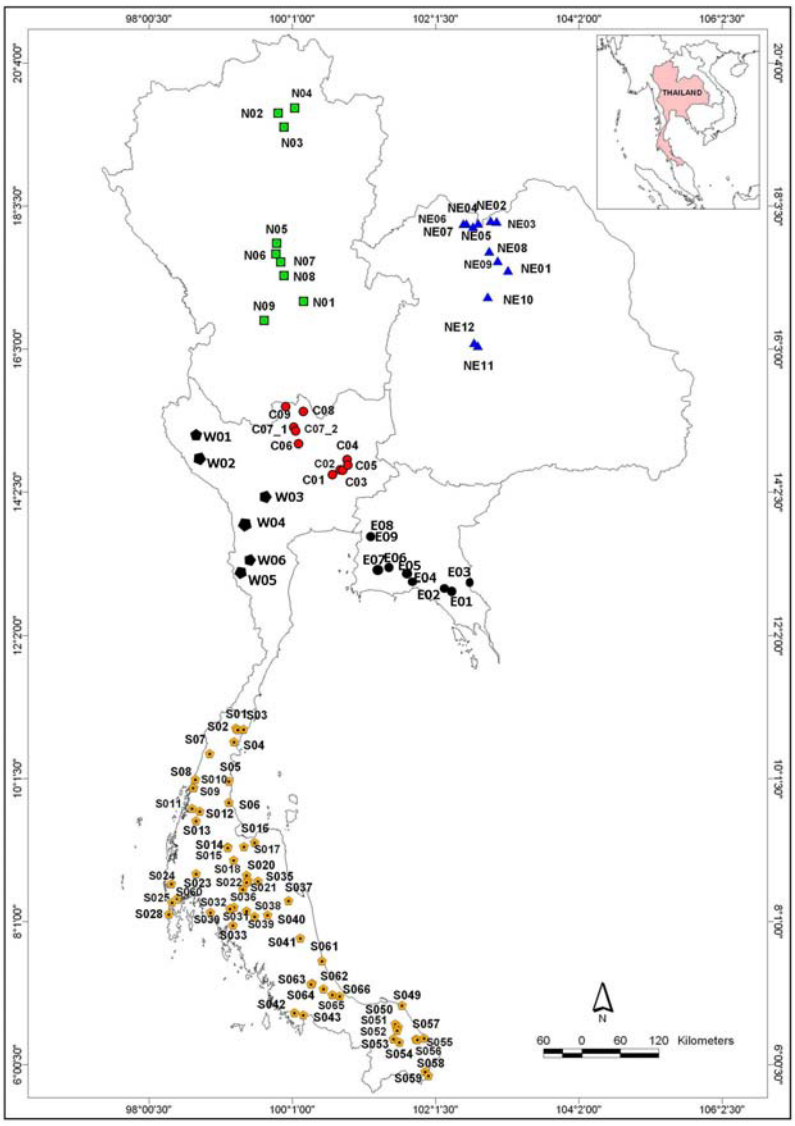


Figure 1 Sampling sites

Table 1 Sampling sites in Thailand

Site code	Ordination		Site name	Province
N01	16°42.797'	100°10.443'	Roadside swamp 1	Payao
N02	19°21.592'	99°49.022'	Lengsai	Payao
N03	19°09.857'	99°53.822'	KwanPayao	Payao
N04	19°25.969'	100°02.779'	Roadside swamp 2	Payao
N05	17°31.970'	99°47.629'	Hin	Sukothai
N06	17°22.991'	99°47.078'	Maerawing	Sukothai
N07	17°16.047'	99°50.979'	Plamor	Sukothai
N08	17°04.759'	99°54.013'	Yai	Sukothai
N09	16°26.942'	99°37.211'	Samvai	Kampaengpeth
C08	15°42.632'	100°10.432'	Borapet	Kampaengpeth
C09	15°46.806'	99°55.562'	Eneing	Kampaengpeth
C01	14°16.948'	100°34.871'	site 1	Ayutthaya
C02	14°21.240'	100°41.418'	site 2	Ayutthaya
C03	14°20.894'	100°43.528'	site 3	Ayutthaya
C04	14°29.742'	100°47.240'	site 4	Ayutthaya
C05	14°25.083'	100°47.718'	site 5	Ayutthaya
C06	14°42.950'	100°06.372'	site 6	Ayutthaya
C07_1	14°56.943'	100°02.358'	Chawak	Supanburi
C07_2	14°53.881	100°03.881'	Chawak	Supanburi
NE01	17°09.253'	103°02.449'	Han	Udonthani
NE02	17°51.115'	102°48.116'	Nhongkai	Nhongkai
NE03	17°50.360'	102°53.020'	Muk	Nhongkai
NE04	17°48.804'	102°37.552'	Saeng	Nhongkai
NE05	17°46.095'	102°33.069'	Srakum	Nhongkai
NE06	17°48.481'	102°27.557'	Sangtindong	Nhongkai
NE07	17°48.496'	102°24.903'	Ngam	Nhongkai
NE08	17°25.243'	102°46.837'	Prajak	Udonthani
NE09	17°17.421'	102°53.817'	Natan	Udonthani

Table 1. (continued)

Site code	Ordination		Site name	Province
NE10	16°46.943'	102°45.620'	Boak	Khon Kean
NE11	16°05.835'	102°37.202'	Kongkaew	Khon Kean
NE12	16°08.402'	102°34.122'	Kudkow	Khon Kean
E01	12°40.664'	102°12.181'	Tapan swamp	Chantaburi
E02	12°39.542'	102°07.837'	Lummasung swamp	Chantaburi
E03	12°41.123'	102°56.320'	Samed swamp	Chantaburi
E04	12°48.331'	101°38.937'	Whan swamp	Rayong
E05	12°52.792'	101°33.400'	Numdum swamp	Rayong
E06	12°57.020'	101°17.311'	Plalai swamp	Rayong
E07	12°55.093'	101°11.137'	Nhongdoggray swamp	Rayong
E08	13°26.512'	101°06.187'	Panthong swamp	Cholburi
E09	13°26.559'	101°06.378'	Bansra swamp	Cholburi
W01	16°42.376'	098°36.920'	Roadside swamp 1	Tak
W02	16°24.154'	099°00.687'	Roadside swamp 2	Tak
W03	14°19.604'	099°39.553'	Kum swamp	Kanchanaburi
W04	13°37.6015'	099°36.780'	Lotus marsh	Kanchanaburi
W05	13°32.393'	099°22.681'	Krajab marsh	Rachaburi
W06	13°32.345'	099°22.815'	Roadside swamp 3	Rachaburi
S01	10°43.87'	99°13.60'	Ta-kein	Chumphon
S02	10°42.82'	99°15.06'	Thalezub	Chumphon
S03	10°42.89'	99°20.15'	Yao	Chumphon
S04	10°32.49'	99°12.02'	Yai	Chumphon
S05	9°59.40'	99°07.75'	knongkla	Chumphon
S06	9°41.49'	99°07.67'	Lum	Chumphon
S07	10°22.65'	98°51.52'	Bogkry	Chumphon
S08	10°00.97'	98°39.47'	Bangnon	Chumphon
S09	9°53.69'	98°37.95'	Suansomdet	Chumphon
S10	9°53.65'	98°37.87'	A	Chumphon

Table 1 (continued).

Site code	Ordination		Site name	Province
S11	9°36.59'	98°36.73'	Hoai-knongyai	Chumphon
S12	9°33.93'	98°43.38'	Hoai-kieat	Chumphon
S13	9°25.90'	98°40.35'	Banna	Suratthani
S14	9°03.95'	99°06.76'	Huawang	Suratthani
S15	9°03.17'	99°06.89'	Nhongdo	Suratthani
S16	9°07.53'	99°29.37'	Kradae	Suratthani
S17	9°04.26'	99°20.53'	Khunthale	Suratthani
S18	8°52.66'	99°11.83'	Nakae	Suratthani
S19	-	-	Thungtong	Suratthani
S20	8°39.98'	99°22.51'	Naneng	Suratthani
S21	8°35.88'	99°23.88'	Torseid	Phang-nga
S22	8°34.10'	99°22.54'	Lein	Phang-nga
S23	8°40.47'	88°15.41'	Moontakua	Phang-nga
S24	8°33.07'	98°19.48'	Nalom	Phang-nga
S25	8°19.90'	98°23.78'	Bangjum	Phang-nga
S26	No data	No data	Kangkao	Phang-nga
S27	No data	No data	Hoaimuang	Phang-nga
S28	8°07.21'	98°17.34'	Maikhao	Phuket
S29	-	-	Soanluang	Phuket
S30	8°08.70'	98°52.14'	Kok	Krabi
S31	8°13.17'	99°12.09'	Bangkumprad	Krabi
S32	8°11.86'	99°08.73'	Preu	Krabi
S33	7°58.07'	99°11.19'	Hoai numkaew	Krabi
S34	-	-	Ban thungkok	Krabi
S35	8°35.11'	99°32.38'	Kratoontai	Nakhon Si Thammarat
S36	8°28.42'	99°19.58'	Thungknongkwai	Nakhon Si Thammarat
S37	8°18.73'	99°57.99'	Changsai	Nakhon Si Thammarat
S38	8°10.03'	99°22.60'	Thalepron	Nakhon Si Thammarat

Table 1 (continued).

Site code	Ordination		Site name	Province
S39	8°05.42'	98°89.52'	Thale	Krabi
S40	8°06.54'	99°40.16'	Samed	Krabi
S41	7°47.15'	100°07.79'	Thale-noi	Pattalung
S42	6°44.34'	100°02.75'	Pluckpraya	Satun
S43	6°42.51'	100°10.35'	Thalebun	Satun
S44	-	-	Prayod	Songkhla
S45	-	-	Taew	Songkhla
S46	-	-	Pluck klayai	Songkhla
S47	-	-	Maetae	Songkhla
S48	-	-	Jumrai	Songkhla
S49	6°50.33'	101°33.44'	Kaekae	Yala
S50	6°34.75'	101°27.74'	Lankwai	Yala
S51	6°32.15'	101°30.17'	Kabae	Yala
S52	6°29.47'	101°29.33'	Numsai	Yala
S53	6°22.17'	101°26.20'	Paumi	Yala
S54	6°19.37'	101°31.13'	Buabakong	Narathiwas
S55	6°21.80'	101°45.25'	Juddang	Narathiwas
S56	6°21.57'	101°46.38'	Nabayo	Narathiwas
S57	6°22.77'	101°51.95'	Klaiban	Narathiwas
S58	5°54.75'	101°52.80'	Laha	Narathiwas
S59	5°51.31'	101°55.62'	Kubaekata	Naratiwas
S60	-	-	Kalai swamp	Phang-nga
S61	07°28.018'	100°26.222'	Satingpra	Songkhla
S62	07°04.468'	100°27.330'	Bangklum	Songkhla
S63	07°08.879'	100°17.625'	Khuan-neang	Songkhla
S64	07°08.299'	100°16.734'	Rattaphum	Songkhla
S65	06°59.472'	100°34.692'	Namom	Songkhla
S66	06°58.151'	100°41.114'	Jana	Songkhla

Measurement of environmental factors

Six environmental variables: temperature, turbidity, pH, DO, conductivity and salinity are measured in each at the sampling stations, using water analysis equipment (calibrated water analysis checker) and the characteristics of each habitat such as types of habitats and percentage of vegetation cover, are recorded.

Preparation of the specimens for investigation

1. Sorting specimens

Specimens are sorted under a stereo microscope (Olympus SZ-40), and the cladocerans are picked from the samples for identification and counting. The morphological details are examined using an Olympus CH-2 compound microscope. Completed and dissected cladocerans are prepared on permanent glass slides. The specimens are put in glycerin, mixed with few drops of formaldehyde. Glycerin helps to preserve their shape and to protect them from drying out (Haney and Hall, 1973 referred by Duigan, n.d.). Before the specimens are covered with cover slide, small pieces of clay are placed in each corner of the cover slide in order to protect them from pressure. The cover slide is then sealed with nail enamel.

2. Identification and morphological study

The Chydorids are identified to species level by using several keys: Idris, 1983; Korovchinsky, 1992; Smirnov, 1992, 1996; Smirnov and Timms, 1983 including up to date keys in recent publications: Dumont and Silva-Briano, 1998, 1999; Van Damme *et al*., 2003; Kotov et al.,2005 and Maiphae, 2005. The identification mostly uses both outer and inner morphological characteristics but in the morphological study, including the measurement of each character, more detailed examination of inner and fine characteristics is needed, so the dissection method is applied.

The dissections are carried out under a stereo microscope using an insect pin/sharpen tungsten to dissect each appendage. The process starts with open valves, followed by splitting the two sides of the body and then cutting each part; head, antennule, antenna, labrum, postabdomen and trunk limbs, separately. The slides are made without using the clay in the method described above.

3. Drawing

The drawings are made from completed and dissected specimens, slides are prepared as described in 1-2, using a camera lucida connected with a compound microscope.

4. Preparing specimens for taking Scanning Electron Micrographs

A Scanning Electron Microscope (SEM) is applied for studying the details of fine characteristics. Samples are prepared using the following method; field samples are preserved with 4% formaldehyde. After they are sorted, cleaned and identified, they will be dehydrated (complete or dissected specimens) in a series of increasing alcohol concentration; 10%, 30%, 50%, 70%, 90%, 95%, 96% and 100%. Each dehydration series takes two times and each time takes 30 minutes (Duigan, 1992 referred by Korovchinsky and Smirnov, 1996). Then, the specimens are passed to the process of Critical Point Drying (CPD), mounted on 10 mm stubs and coated with gold. SEM photographs are taken using a Scanning Electron Microscope (JSM-5800LV, JEOL) to show details of anatomy of the species.

Chapter 3 Results and Discussions

As stressed before, to perform any meaningful assessment of biological diversity, biogeography, ecology or conservation status, good taxonomy is indeed required. The first task in any taxonomic study is to develop a good description, and two other, difficult ones are to select in advance which characters will be the most useful or are likely to change with ontogeny, and to define the range of variation in each characteristic. Thus we have to study all the characters from a number of specimens, such that variability also can be discussed. Rapid recent progress and higher standards with systematics of the Cladocera (Chiambeng and Dumont, 1999; Dumont and Silva-Briano, 2000; Kotov, 2000; Sinev, 1998, 1999; Sinev and Kotov, 2000) leads to the discovery of small detailed characters and micro-characters.

This is the first attempt to clarify the status of chydorid species found in the country. The study mainly focuses on the taxonomical study of the representatives of 20 genera: *Acroperus, Alona*, *Alonella, Camptocercus, Chydorus, Dadaya, Disparalona, Dunhevedia, Ephemeroporus, Euryalona, Karualona, Kurzia, Leberis, Leydigia, Leydigiopsis, Nicsmirnovius, Notoalona, Oxyurella, Pleuroxus* and *Pseudochydorus*. Although the result is not cover all chydorid taxa found in Thailand but the representative taxa of all genera are studied (Table 1).

Table 1 The Chydoridae found in Thailand

NO.	Species	References
1	*Acroperus harpae*	
2	*Alona affinis*	
3	*A. archeri*	
4	*A.* cf. *cambouei*	
5	*A. cheni*	
6	*A.* cf. *dentifera*	
7	*A. guttata*	
8	*A. intermedia*	
9	*A. milleri*	
10	*A. monacantha*	
11	*A. pulchella*	
12	*A. quadrangularis*	

Table 1 (continued.)

NO.	Species	References
13	*A. rectangula*	
14	*A. sarasinorum*	
15	*A. verrucosa*	
16	*Alonella clathratula*	
17	*Alonella excisa*	
18	*Alonella nana*	
19	*Armatoalona macrocopa*	
20	*Chydorus eurynotus*	
21	*C. obscurirostris*	
22	*C. opacus*	
23	*C. parvus*	
24	*C. pubescens*	
25	*C. reticulatus*	
26	*C. sinensis*	
27	*C. sphaericus*	
28	*C. uncinatus*	
29	*C. ventricosus*	
30	*Camptocercus australis*	
31	*Dadaya macrops*	
32	*Disparalona caudata*	
33	*D. hamata*	
34	*D. rostrata*	
35	*Dunhevedia crassa*	
36	*D. serrata*	
37	*Ephemeroporus epiaphantoii*	
38	*E. hybridus*	
39	*E. phintonicus*	
40	*E. tridentatus*	
41	*Euryalona orientalis*	
42	*Graptoleberis testudinaria*	
43	*Indialona macronyx*	
44	*Karualona iberica*	
45	*Karualona karua*	
46	*Kurzia brevilabris*	
47	*Kurzia longirostris*	

Table 1 (continued.)

NO.	Species	References
48	*Leberis diaphanus*	
49	*Leydigia acanthocercoides*	
50	*L. ciliata*	
51	*L. laevis*	
52	*L. australis*	
53	*Nicsmirnovius eximius*	
54	*Notoalona globulosa*	
55	*N. freyi*	
56	*Oxyurella singalensis*	
57	*Pleuroxus laevis*	
58	*Pleuroxus uncinatus*	
59	*P. quasidenticulatus*	
60	*Pseudochydorus globosus*	

Note: Reference codes:

Key to 20 genera found in southern Thailand

1 a. body oval, wide is about 1.5-1.7 times height……..2

b. body global, wide is about 1-1.2 times height.……..…..…18

2 a. postanal portion of postabdomen long and narrow……..……...3

b. postanal portion of postabdomen not long and narrow.……..……...…….8

3 a. two or three distal anal teeth of postabdomen especially long……..…..**1. *Oxyurella* Dybowski & Grochowski, 1894**

b. distal anal teeth of postabdomen similar in size ……...…….4

4 a. postabdomen tapering distally……...…..5

b. postabdomen not tapering distally…….……...…7

5 a. rostrum long, point (fig.66c)....…...… **2. *Kurzia* Dybowski & Grochowski, 1894**

b. rostrum blunt……...…….…..……..6

6 a. postabdominal claw with a long basal spine.....**3. *Camptocercus* Baird, 1843**

b. postabdominal claw with a short basal spine…...……...**4. *Euryalona* Sars, 1901**

7 a. rostrum long, point downward……...**5. *Disparalona* Fryer, 1968 (see 2.1)**

b. rostrum blunt (fig.66d).……..……**6. *Acroperus* Baird, 1843**

8 a. postabdomen rounded, wide, enlarged, postanal portion leaf-like, with numerous well developed anal denticles; rostrum elongated, directed ventrally, reach lower than ventral portion.....……..……...……9

b. postabdomen various shaped……..…….…..10

9 a. postabdomen with long lateral setae and small anal teeth (hardly noticeable); 3 interconnected major head pores, closely spaced..……**7. *Leydigia* Kurz, 1875**

b. postabdomen with small lateral setae and large anal teeth; long rostrum; 2 major head pores with wide connection between them..…….....**8. *Leydigiopsis* Sars, 1901**

10 a. posterior edge of valves less than or equal half the total height of the shell..……....11

b. posterior edge of valves greater than half the total height of the shell……..….....14

11 a. postanal portion of postabdomen oval; postabdomen wide and almost parallel; setae on the posterior half of ventral margin of the valves inserted on its inner surface……..……..**9. *Dunhevedia* King, 1853 (see 2.2)**

b. postanal portion of postabdomen elongate; all ventral setae of valves inserts on its edge ……..……...12

12 a. posterior edge of valves equal the half the total height of the valve…….....**10. *Alonella* Sars, 1862 (see 2.3)**

b. posterior edge of valves less than half the total height of the valve…….....….13

13 a. body more elongated; postabdomen relatively long, elongated and slightly bent, postanal slightly concave; antennule without a peg at its base**…….11. *Picripleuroxus* Frey, 1993**

b. body more oval; postabdomen relatively short.……...**12**. ***Pleuroxus* Baird, 1843**

14 a. midline of head shield with no major pores, only two minor pores.....…**13. *Notoalona* Rajapaksa & Fernando, 1987 (see 2.4)**

b. midline of head shield with 2-3 major pores, minor pores laterally……15

15 a. valve with small denticles at the postero-ventral angle of valve; two interconnected major head pores..……...**14. *Karualona* Dumont & Silva-Briano, 2000**

b. valve without denticles at the postero-ventral angle of valve……. ……16

16 a. *5*-shaped postabdomen (fig.69b); fifth and sixth exopodite setae on fourth trunk limb with blunt spoon-like apex…….....**15. *Nicsmirnovius* Chiambeng & Dumont, 1999** (see Van Damme *et al.*, 2003)

b. postabdomen various shaped..……..……**16. *Alona* Baird, 1843 (see 2.5)**

17 a. eye and ocellus large; labrum elongated and narrow (peculiar structure, fig.67a); first antenna attached near tip of rostrum and protruding beyond tip of rostrum……..…….....**17. *Dadaya* Sars, 1901**

b. eye and ocellus comparatively small……..…….……18

18 a. labrum serrated with 1-4 teeth (fig.67b); proximal denticles on postanal margin of postabdomen longer than distal denticles……..**18. *Ephemeroporus* Frey, 1982 (see 2.6)**

b. labrum not serrated; proximal denticles on postanal margin of postabdomen same size or smaller than distal denticles……..**19. *Chydorus* Leach, 1816 (see 2.7)**

Genus *Acroperus* Baird, 1843

The genus *Acroperus* contains two species routinely found in surface samples. However, there is only one species of genus *Acroperus* Baird, 1843 has been found in Thailand, *Acroperus harpae* (Baird, 1843).

1. *Acroperus harpae* (Baird, 1843)

Material examined:

Northeastern Thailand: one male from Nhongkai marsh (N02), Nhongkai Province, specimen collected by SM.

: two parthenogenetic females from Kongkaew swamp (NE11), Khon Kean Province, specimen collected by SM.

The details of morphological study

Species description (figures 2-3)

Male

General shape (fig.2a): subquadrangular in lateral view, maximum height at ¼ of body. Length 0.12 mm, about 1.2 times maximal height (n=1). Dorsal margin forms curve anteriorly. Postero-dorsal and postero-ventral angles form 100^{o} and 90^{o}, respectively. Posterior margin slightly straight, Ventral carapace margin almost straight, ventral setae relatively short, ending before posteroventral corner, followed by short setules posteriorly. Antero-ventral corner rounded. Ventral margin almost straight, slender ventral setae gradually decreasing in length toward posterior end.

Head (fig.2a)**:** Relatively large. Rostrum long, concave and pointing downward. Compound eye present, larger than ocellus, distance between eye and ocellus shorter than distance from tip of rostrum to ocellus.

Parthenogenetic females

General shape (fig.2b)**:** Posteriorventral corner with minute spines, 5-6 short setules between them.

Headpores (fig.2e): three central headpores.

Postabdomen (fig.2f)**:** long, about 4 times as long as high, distal part about 2.5 times longer than preanal portion. Proximal portion gradually narrowing distally. Anal margin relatively straight, with no distinct pre-and postanal corner and bearing 4-5 rows of small setules, each row consisting of 2-6 setules. Lateral fascicles: 10-11 postanal groups, each consisting of 5-6 denticles. Marginal denticles: 15-16 spines, gradually increasing in size distally. Natatorial setae with long distal end, setulated.

Terminal claw (fig.2f)**:** Equal in length to preanal portion. Basal spine about 1/3 of claw length, row of setules along the claw, 1 setule clearly arising in the middle part of claw.

First antenna (antennule) (fig.2c)**:** Body compact, rod-like, about twice as long as wide.

Second antenna (fig.2d)**:** antenna formula, setae 0-0-3/0-0-3, spine 0-1-1/0-0-1. All setae bisegmented. Seta arising from second segment as long as segment length. Terminal spines shorter than terminal segment of exopodite.

Trunk limb: six pairs

First trunk limb (P1) (fig.3a)**:** Outer distal lobe (ODL) with one seta slender and bearing fine setules. Rows of setules present at the base of ODL. Inner distal lobe (IDL) with three setae, seta I one hook-like, setae II as same length as seta III, both slender, second segment unilaterally armed with fine setule. Group of spines present on IDL trunk. Endite 3 (E3) with four plumose setae (1-4) subequal in length, all setae armed with short setules distally, seta 2 slightly slender than the others. Endite 2 (E2) bearing three apical setae (5-7), of which seta 6 the longest, all setulated. Endite 1 (E1) with two apical setae (8-9), both as the same length, bilaterally with fine setules. Groups of slender spinules present more radial on inner side of endite 2. Trunk with 4-5 rows of slender spines laterally. Basally two short but slender ejector hooks, of the same length, unilaterally armed with short setules. Epipodite and gnathobase not seen.

Second trunk limb (P2) (fig.3b)**:** Epipodite not seen. Exopodite (EX) rounded, small setules apically. Endopodite (EN) triangular, with eight scrapers (1-8), generally decreasing in length towards gnathobase though scraper 3 shorter than scraper 4, scrapers 1 and 2 bisegmented, similar unilaterally armed with fine setules distally; scraper 3 bisegmented, unilaterally armed with strong setules distally, one small sensillum (sn) at base of scraper 3; scrapers 4-5 more slender, unilaterally armed with file setules; scraper 6 more robust, bisegmented,

unilaterally armed with strong setules distally; scrapers 7-8 more slender, unilaterally armed with fine setules distally. Distal armature of gnathobase (GT) with three elements, the shortest naked, and the other two setulated. Gnathobasic filter comb with seven plumose setae.

Third trunk limb (P3) (fig.3c)**:** Epipodite not seen. Exopodite (EX) subquadrangular, bearing six setae (1-6): seta 1 and 2 located laterally, in typical V-formation, seta 1 longer than seta 2, seta 3 slender and longest, about 2 times of seta 4, bilaterally setulated, seta 4 shortest, armed with long setules, setae 5-6 armed with short setules.

Endopodite (EN) divided to two rows; anterior row with eight setae (1-8), setae 1 and 2 stout, as same length, both distally armed with short well-spaced spines, seta 3 more slender, bilaterally setulated distally, setae 4-7 more slender, one sensilla rod-like, naked, between setae 6 and 7; Gnathobase (GT) with three elements, element I large, curved inwards, element II and III shorter, naked, fused at the base of each other. Gnathobasic filter comb with seven setae.

Fourth trunk limb (P4) (fig.3d)**:** Endopodite (EN) or inner portion, anteriorly bearing five setae (1-5), seta 1 rounded basally and more slender distally, unilaterally armed with fine short setules, setae 2-4 'flaming-torch' setae, distally armed with long-slender setules, counting 5-6 setules each, seta 5 large hook-like.

Fifth trunk limb (P5) (fig.3e)**:** Pre-epipodite (PEP) round, radial setulated apically, elongated digitiform projection not seen. Epipodite (EP) rounded, larger than pre-epipodite. Exopodite (EX) bearing four apical setae (1-4); setae 1-3 on anterior portion as the same length, all setulated; posterior portion bearing one seta (seta 4), relatively shorter, setulaated.

Endopodite (EN) round-elongated, setulated apically, two endopodite setae setulated, one as a half-length of another.

Sixth trunk limb (P6): not studied.

Remarks:

The general shape of the headshield of *Acroperus harpae* resembles that of *Camptocercus rectirostris*. In profile however, the headshield of *A. harpae* is more curved and the posterior margin proceeds to a point as opposed to the rounded posterior margin in *C. rectirostris*. The three headpores are connected and are found in a small channel near the posterior margin. The shells have coarsely spaced diagonal striae that become curved in the anterior-ventral area of the shell and point towards the dorsal margin. Three small teeth are found at the posterior-ventral margin of the shell, though this feature is not as pronounced in each population. The postabdomen has fairly parallel edges and is shorter than that of *C. rectirostris*, with approximately 15 teeth that extend past the anal groove.

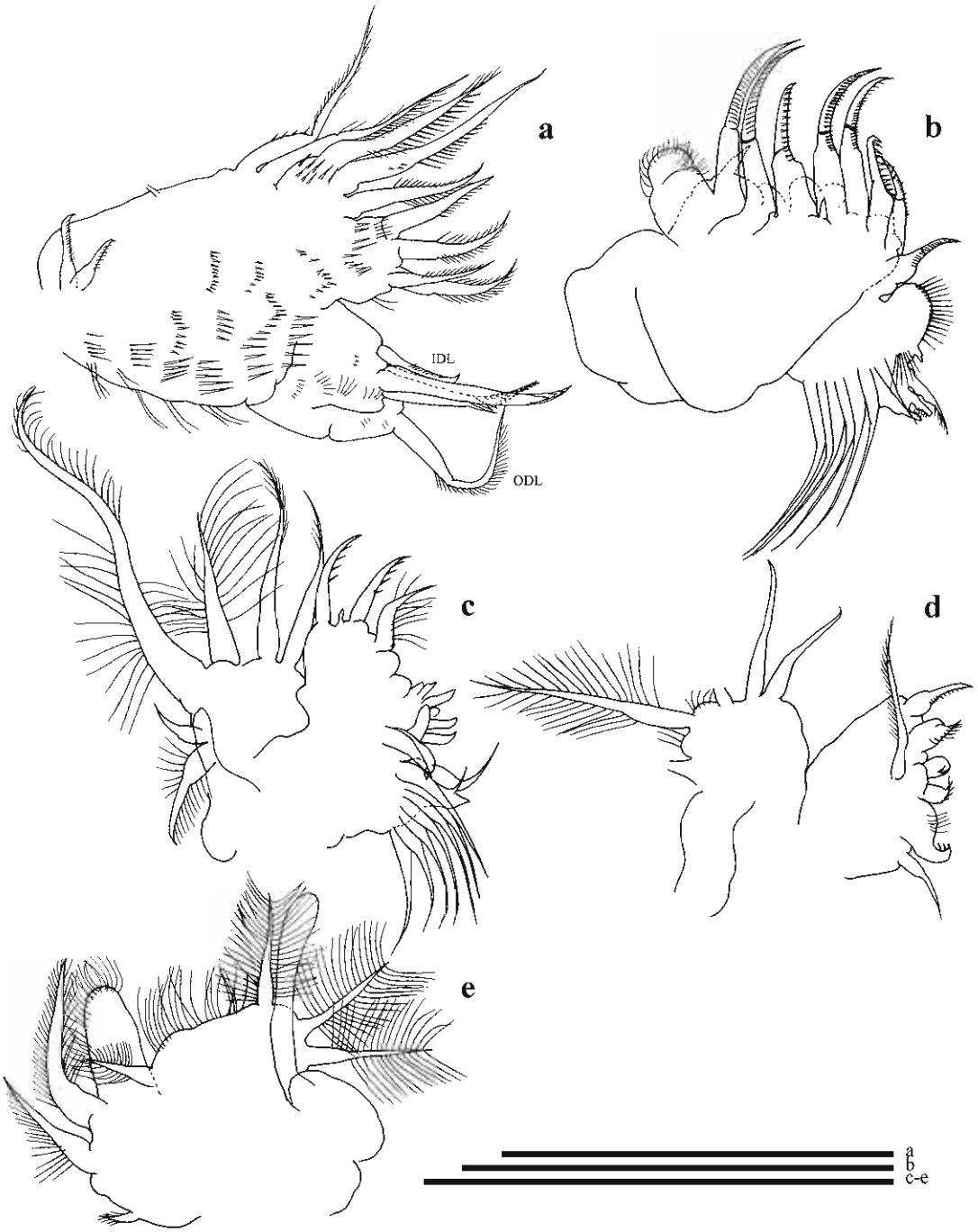
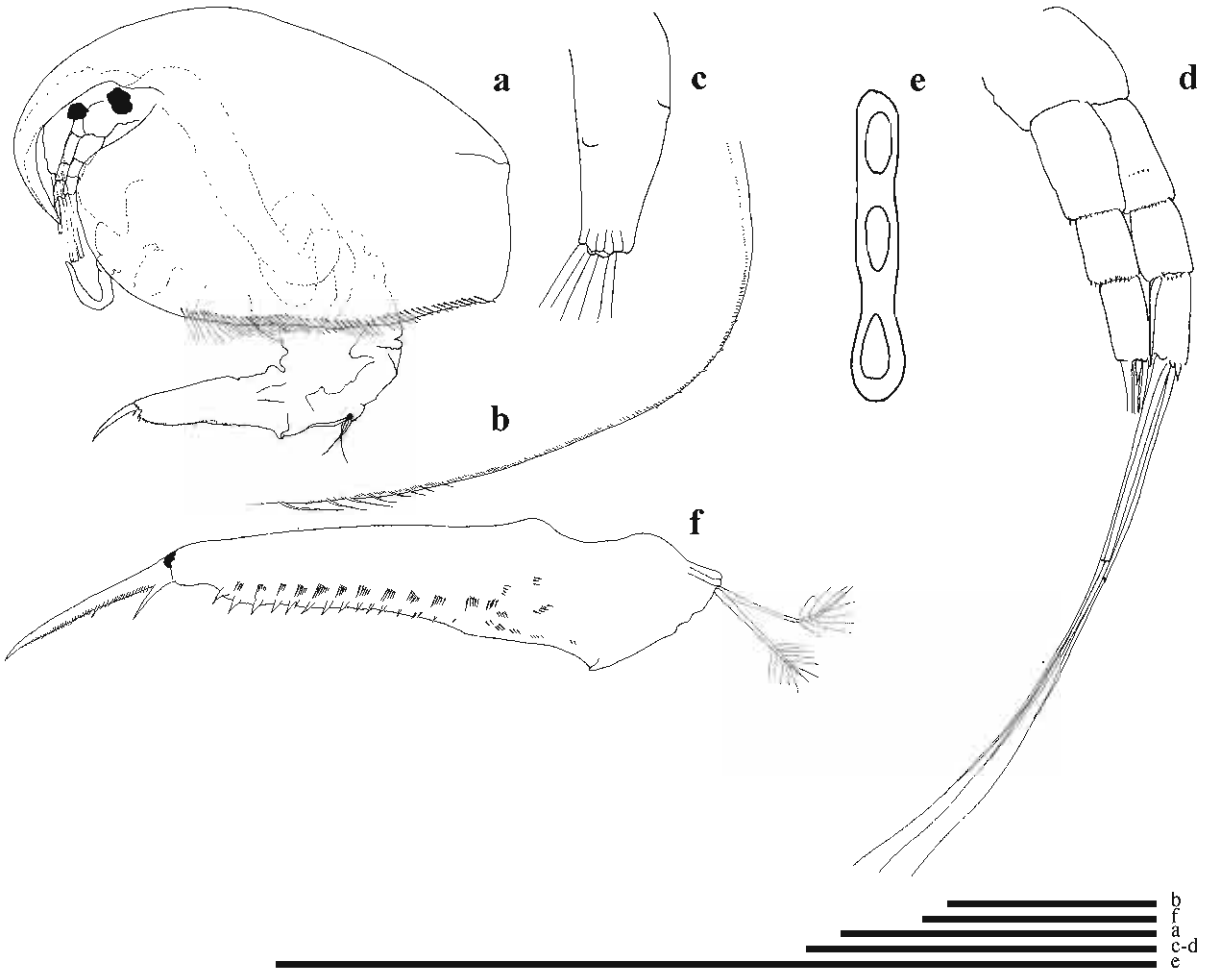


Figure 3. ***Acroperus harpae*** **(Baird,1843):** appendages of female from Kongkaew swamp (NE11), Khon Kean Province, northeastern Thailand. Figure a, trunk limb 1; Figure b, trunk-limb 2; Figure c, trunk limb 3; Figure d, trunk limb 4; Figure e, trunk limb 5. Scale bar denote 100 um.



Figures 2. ***Acroperus harpae*** **(Baird, 1843):** Figure a, male from Nhongkai marsh (NE02), Nhongkai Province, northeastern Thailand; Figures b-f, appendages of female from Kongkaew swamp (NE11), Khon Kean Province, northeastern Thailand; Figure b, postero-ventral corner of vale; Figure c, antennule; Figure d, antenna; Figure e, headpores; Figure f, postabdomen. Scale bars denote 100 um.

Genus *Alona* Baird, 1843

A total of 10 *Alona* species; *Alona affinis* (Leydig, 1860), *A. archeri* Sars, 1888, *A.* cf. *cambouei* Guerne & Richard, 1893, *A. cheni* (Chen & Peng, 1993), *A.guttata* Sars, 1862, *A. intermedia* Sars, 1862, *A. monacantha* Stingelin, 1905, *A. rectangula* Sars, 1862, *A. sarasinorum* Stingelin, 1900 and *A.verrucosa* Sars, 1901 was studied in detailed of the morphological characters.

Synonymy: Subgenus *Alona* Baird, 1843:92. *Alona* Smirnov, 1971:337-338. Genus *Biapertura* Smirnov, 1971: Smirnov and Timms, 1983: 39-50.

References: Dodson and Frey, 1991. 466-483; Smirnov and Timms, 1983: 56-64.

Key to ten *Alona* species found in Thailand

1 a. postabdomen more round, distally round, anal margin deep (s-shape)…..…..….2

b. postabdomen more elongated, distally form an angle, anal margin shallow or almost straight …….....…..5

2 a. pre-and post-anal angle of postabdomen forming angle about 90^{o} ; 3 IDL setae with one large hook-like seta; accessory seta of antennule arising from distinct tubercule.….....**1. *A. sarasinorum* Stingelin, 1900**

b. pre-and post-anal angle of postabdomen forming angle less than 90^{o} or not distinct……...….3

3 a. antenna with a row of 3-4 setules at the joint of second segment; postabdomen with long basal spine about 1/2-1/3 of terminal claw; three main head pore ……4

b. antenna with row of setules around the joint of each segment; postabdomen with short basal spine about ¼ of terminal claw; two main head pores with two 'flower-like' lateral pores.…..……....**2. *A. verrucosa* Sars, 1901**

4 a. labrum with denticle; postero-ventral corner of valve with 2-3 denticles……..…...**3. *A. monacantha* Stingelin, 1905**

b. labrum without denticle; postero-ventral corner of valve smooth…….……**4. *A. rectangula* Sars, 1862**

5 a. postabdomen quadrangular shape, anal portion as long as postanal portion…….**5. *A. intermedia* Sars, 1862**

b. postabdomen subquadrangular shape, anal portion longer than postanal portion……6

6 a. three main head pores; size relatively smaller…..……...……7

b. two main head pores; large animal, size up to 0.9 mm...**6. *A. affinis* Leydig, 1860**

7 a. three main head pores with connection; distal angle of postabdomen sharp, form 45-60^{o}……...……..8

b. three main head pores without connection; distal angle of postabdomen more blunt, form 80-90^{o} …….……**7. *A.* cf. *camboui* Guerne & Richard, 1893**

8 a. two small lateral pores; postabdomen form sharp distal end……..9

b. two semi-circular ‘sac-like’ lateral pores….....**8. *A. cheni* Chen & Peng, 1993**

9 a. labrum rounded, smooth; 3 IDL setae on trunk limb 1; distal portion of postabdomen form an angle of 50-60^{o}……...…….……..**9. *A. archeri* Sars, 1889**

b. labrum with a cluster of setules at the apex; 2 IDL setae on trunk limb 1; distal portion of postabdomen form an angle of 45^{o}.....**10. *A. guttata* Sars, 1862**

1. *Alona affinis* (Leydig, 1860)

Synonymy: Leydig, 1860 (*Lynceus affinis*): 223, Taf. 9: figs. 68-69. *Alona* (*Biapertura*) *affinis*-group; Smirnov, 1974: 574-579, figs. 582-590.

References: Alonso, 1996: 345-346, fig. 154; Sinev, 1997 (*Alona afiinis*): 47-58, figs. 1-5.

Type locality: Friedriechshafen und Langenargen, Germany

Materials examined:

Southern Thailand: ten parthenogenetic females, examined complete and thereafter dissected, from Thungtong swampn (S19), Keinsa District, Suratthani Province (8^{o} 52.66'N, 99^{o}11.83'E), southeastern Thailand, temperature 29^{o}C, pH 6.4, conductivity 0.39 and salinity 0 ppt., collected date 01-10-1999, collected by the author, SM.

: five parthenogenetic females, examined complete and thereafter dissected, from Knong-kla peat swamp (S05), Chumporn Province, (9^{o} 59.40'N, 99^{o}07.75'E), southern Thailand, collected by the author, SM

: two parthenogenetic females, examined complete and thereafter dissected, from Sri-Trang swamp, Hatyai District, Songkhla Province, southeastern Thailand, collected by the author, SM.

Northeast Thailand: two parthenogenetic females, examined complete and thereafter dissected, from Lake Kud-thing, Nong Kai Province, northeastern Thailand, collected by C. Saeng-aroon, KKU.

Malaysia: one parthenogenetic female, examined complete and thereafter dissected, from Rantang Abang Marsh, Terrenganu, western Malaysia, collected date 2003, collected by the author, SM.

The details of morphological study

Species description (see figures 4-5)

Parthenogenetic female

General shape (fig.4a)**:** sub-rectangular in lateral view, maximum height at ¾ of body. Length 0.7-0.8 mm, about 1.6-1.7 times maximal height (n=10). Dorsal margin forms slight curve. Postero-dorsal and postero-ventral angles almost round or forming a small hillock. Posterior margin slightly concave, postero-ventral corner broadly rounded. Antero-ventral corner rounded. Ventral margin almost straight, anteriormost with 18-20 marginal setae followed by 56-60 slender setae, gradually decreasing in length toward posterior end. Posteriorventral corner with 4-5 groups of 4-6 setules, lengths of setules in each group equal. Valve ornamentation consisting of ridge (figs.4a,d) but not obvious in some specimens.

Head (fig.4a)**:** Relatively small. Rostrum short, pointing downward. Compound eye present, larger than ocellus, distance between eye and ocellus shorter than distance from tip of rostrum to ocellus distinctively. Posterior margin of head shield angulated, with an angle of 70-80^{o}. Two major head pores, of same size, with a narrow connection between them (figs.4c,d), PP about 1.5 times as distance as IP. Two small lateral head pores, located slightly close to posterior, about 0.8 IP distance from midline, level before anterior median pore.

Labrum (fig.4b)**:** large, with a rounded or polygon-like anterior margin and an angulated tip (the polygon-like not obvious as in Sinev (1997)), with two clusters of setules at the posterior margin.

Postabdomen (fig.4e)**:** wide, about 2.5 times as long as high, distal part about 2.5 times longer than preanal portion. Proximal portion with almost parallel dorsal and ventral margin, gradually narrowing distally. Posterodorsal corner sharp. Anal margin relatively straight, with no distinct pre-and postanal corner and bearing 4-5 rows of small denticles, each row consisting of 2-10 denticles. Lateral fascicles: 11-13 postanal groups, each consisting of 4-6 denticles. Marginal denticles: 12-15 groups of merged spinules, gradually increasing in size distally and bearing 3-5 fused denticles on inner edge. Three groups of venterolateral denticles and groups of small setules between them. Natatorial setae with long distal end, setulated.

Terminal claw (figs.4a,e)**:** Equal in length to preanal portion. Basal spine as a half of the claw, 3-4 fine setules arising proximal to base of spine, 1 setule clearly arising in proximal part of basal spine, close to the base of claw (fig.4e).

First antenna (antennule) (figs.4a, f)**:** short, not reaching tip of rostrum. Body compact, rod-like, about twice as long as wide, three rows of small spines on inner and outer side of body. Distal end with seven aesthetascs unequal in length, two longest as long as antennular body (fig.4a), others long as a half of antennular body. All aesthetascs projecting beyond tip of rostrum (fig.4a).

Second antenna (figs.4a,g)**:** short (fig.4a), antenna formula, setae 0-0-3/1-1-3, spine 1-0-1/1-1-1. All setae bisegmented, two setae of distal segment of exopodite with a spinule at the point of articulation. Seta arising from basal segment of exopodite thin, not extending beyond tip of distal segment. Seta arising from middle segment of exopodite longer than endopodite. Spine of basal segment of exopodite as long as middle segment. Terminal spines shorter than terminal segment of exopodite.

Trunk limb: six pairs

First trunk limb (P1) (figs.5a, b)**:** Outer distal lobe (ODL) with one seta (I') slender and bearing fine setules, hardly visible. Two spines present at the base of ODL (fig.5b). Inner distal lobe (IDL) with three setae (I-III), seta I one hook-like, relatively large, a group of small setules present at 1/3 of the seta (fig.5b), setae II and III slender, the same length as ODL seta, second segment unilaterally armed with fine setules, shorter on seta III, one small sensilla (sn) located between seta I and II. Group of spines present on IDL trunk. Endite 3 (E3) with four plumose setae (1-4) subequal in length, seta 1 and 2 armed with short setules distally, seta 3 and 4 armed with longer setules distally, seta 4 slightly slender than the others, one small sensilla (sn) located close to the base of seta 2. Endite 2 (E2) bearing two apical setae (5-6), of which seta 5 the longest, both setulated. Endite 1 (E1) with three apical setae (7-9), setae 7 and 8 as the same length, bilaterally with fine setules, followed by seta 9 located laterally, as half as setae 7 and 8, armed with long setules from base to tip. Groups of slender spinules present more radial on inner side of endite 2. Trunk with

5-6 rows of slender spines laterally. Basally two long and slender ejector hooks, of the same length, unilaterally armed with short setules. Epipodite and gnathobase not seen.

Second trunk limb (P2) (fig.5c)**:** Epipodite not seen. Exopodite (EX) round-elongated, small setules apically, a setulated seta basally, bending over the exopodite. Endopodite (EN) triangular, with eight scrapers (1-8), generally decreasing in length towards gnathobase though scraper 4 shorter than scraper 3, scrapers 1 and 2 bisegmented, similar unilaterally armed with fine setules distally, one small sensillum (sn) at base of scraper 1;scrapers 3-5 bisegmented, unilaterally armed with strong setules distally, scrapers 6-8 more robust, bisegmented, unilaterally armed with strong setules distally. Distal armature of gnathobase (GT) with two elements (I-II), element I naked, element II more robust, armed with seven denticles from base to tip. Gnathobasic filter comb with seven plumose setae (1-7), setae 1 and 2 considerably shorter, setae 3-7 similar in length.

Third trunk limb (P3) (fig.5d)**:** Epipodite not seen. Exopodite (EX) globular, bearing seven setae (1-7): seta 1 and 2 located laterally, in typical V-formation, seta 1 longer than seta 2, both bilaterally setulated, seta 3 slender and longest, about 7 times of seta 4, bilaterally setulated, setae 4 and 5 shortest, both similar in length and similar armed with bilaterally setulated, seta 6 about 1/3 of seta 3, armed with three rows of more robust setules; one row longer and slender and other two strong and shorter, seta 7 more slender, bilaterally armed with short, fine setules distally.

Endopodite (EN) divided to two rows; anterior row with eight setae (1-8), setae 1 and 2 stout, seta 2 shorter than seta 1, distally armed with short well-spaced and hardly visible setules, seta 3 more slender, bilaterally setulated distally, setae 4-7 provided with short setules distally, with a wide basal part, one sensilla rod-like, naked, between setae 6 and 7; posterior row with four setae (1'-4'), similar in length and all bilaterally setulated. Gnathobase (GT) with three elements (I-III), element I large, curved inwards, unilaterally setulated, element II and III shorter, naked, fused at the base of each other. Gnathobasic filter comb with seven (?) setae.

Fourth trunk limb (P4) (fig.5e)**:** Epipodite not studied. Exopodite (EX) more round, bearing six setae (1-6) with generally gradual increasing in length anteriorly; setae 1 and 2 are of equal in length, although the first may be shorter, bilaterally setulated with long setules, setae 3 and 4 slender, bilaterally setulated with long setules, setae 5 and 6 similar in length, half as long as the first two, plumose.

Endopodite (EN) or inner portion, anteriorly bearing five setae (1-5), seta 1 rounded basally and more slender distally, unilaterally armed with fine short setules, setae 2-4 'flaming-torch' setae, distally armed with long-slender setules, counting 5-6 setules each, seta 5 rod-like receptor comparable in size to flaming-torch setae, naked; posteriorly bearing four soft setae (1'-4'), setae 1'and 2' shorter than setae 3 and 4, all bilaterally setulated. Gnathobase (GT) with three elements (I-III), element I large-slender, unilaterally setulated distally with short setules, element II and III naked fused at base to each other.

Fifth trunk limb (P5) (figs.5f-h)**:** Pre-epipodite (PEP) round, radial setulated apically, elongated digitiform projection not seen. Epipodite (EP) rounded, smaller than pre-epipodite, elongated digitiform projection presents (fig.5g). Exopodite (EX) clearly bilobed, bearing four apical setae (1-4); anterior portion smaller than posterior portion, setae 1-3 on anterior portion, seta 2 longest, setae 1 and seta 3 gradually smaller, respectively, all setulated; posterior portion larger, more round, bearing one seta (seta 4), relatively short in some specimens (fig.5f) and relatively longer in some specimens (fig.5g), two denticles basally in some specimens (fig.5f).

Endopodite (EN) larger, more ovoid, setulated apically, two endopodite setae setulated distally, one as a half-length of another. Gnathobasic comb of three seta (fig.5h).

Sixth trunk limb (P6): not studied.

Variability:

Some variability was noted in these following characters: 1) the specimens can be sub-rectangular or irregularly oval 2) the lateral head pores may be situated in front or at the same level as the first medial pore 3) the labrum can be rounded or spade

shaped, two rows of setules on the inner side, regular or irregular in number between group 4) size and curve of the hook-like seta on IDL is different between specimens, even in the same population 5) two spines at the base of inner distal lobe of P1 present or not present in some specimens and 6) presence of a long digitiform projection on epipodite of P5.

Differential diagnosis:

This species can be distinguished by its large size, which is up to 0.9 mm; it is the largest known species of *Alona* (Sars, 1901) and it has 1) two main head pores with a narrow connection between them (only *A. verrucosa* has the same number of major pores but the latter has special flower-like lateral pores); 2) a rounded or polygonal like labrum with two clusters of setules and 3) a large, wide postabdomen provided with 12-15 marginal spines with spinules at posterior margin and 11-13 broad lateral fascicles of setae. Only *A. quadrangularis* has a similarly armed postabdomen while most other species display a small number of marginal denticles, usually without spinules.

Remarks:

Sinev (1997) remarks that the body shape is variable and depends on the age of the specimen, it can be sub-rectangular or irregularly oval, with the posterodorsal corner variously produced. The lateral head-pores may be situated in front or at the level of the first main pore. Variability of the antenna seems to be unimportant; the shape of the labrum is highly variable, specimens with a rounded or polygonal margin as well as with an angulated or broadly rounded tip can be found in the same population; the shape of postabdomen varies even within a single population, the distal half can be narrowing distally or with parallel margins; the number of lateral fascicles setae and marginal denticles ranges from 12 to 16, with 1-2 proximalmost denticles.

However we found that Thai specimens mostly show the following differences (table 2); 1) antennule with only one lateral seta; 2) presence of a group of setules at the 1/3 of IDL hook-like seta and group of two spines and row of more robust spines at the base of IDL setae (fig.5b); 3) a sensillum on IDL and endite 3; 4) two stout

setae on gnathobase 2, one armed with short setules; 5) two posteriormost gnathobasic filer comb 2 times shorter than others; 6) seta 7 on exopodite 3 2/3 shorter than seta 8; 7) endopodite 4, spines of flaming torch setae long, reaching top of 1st seta; and 8) postabdomen mostly gradually narrowing distally, number of marginal denticles ranges from 12 to15 groups of 3-5 merged spinules.

Biology:

This species is mostly found among aquatic plants (Sars, 1901). In the present study it has been found in freshwater swamps, in areas dominated by *Cyperus* sp. in combination with *Nelumbo* sp. It shows higher abundance in the rainy season.

Distribution:

At present *Alona affinis* has been recorded on all continents but Antarctica. In Thailand it has been recorded in each study in many areas covering northern to southern Thailand, so it seems quite common in the country.

Table 2 Morphological differences between *A. affinis* s. str. and *A. affinis* from Thailand

characters	***A. affinis*** **(Sinev,1997)**	***A. affinis*** **Thai specimens (present data)**
Antenna 1	possesses one or two lateral setae	possesses one lateral seta
Trunk limb 1		
IDL	hook-like seta curved, naked	hook-like seta curved and very strong in some specimens, row of short setules in the middle (fig.4b)
	no seta near the base	2 seta near the base (fig. 4b)
seta 9	bilaterally armed with short setules	bilaterally armed with long setules
Sensillum (sn)	not mentioned	present on IDL and E3

Table 2 (continued.)

characters	***A. affinis*** **(Sinev,1997)**	***A. affinis*** **Thai specimens (present data)**
Trunk limb 2		
gnathobase	2 stout setae	2 stout setae, one armed with strong setules
gnathobasic filter comb	posteriormost seta 3 times shorter	2 posteriormost setae 2 times shorter
Trunk limb 3		
exopodite	seta 7 about 1/2 shorter than seta 8	seta 7 about 2/3 shorter than seta 8
Trunk limb 4		
endopodite	spines on flaming torch setae short, reach half of seta 1	spines on flaming torch setae long, reach to the top of seta 1
Trunk limb 5		
endopodite	setulated distally	setulated distally, plus one row of small setules
gnathobase	3 shorter setae	3 longer setae
Postabdomen		
Shape	parallel margins	parallel margin, mostly gradually narrowing distally
marginal denticles	with 0-5 spinules	with 3-5 spinules

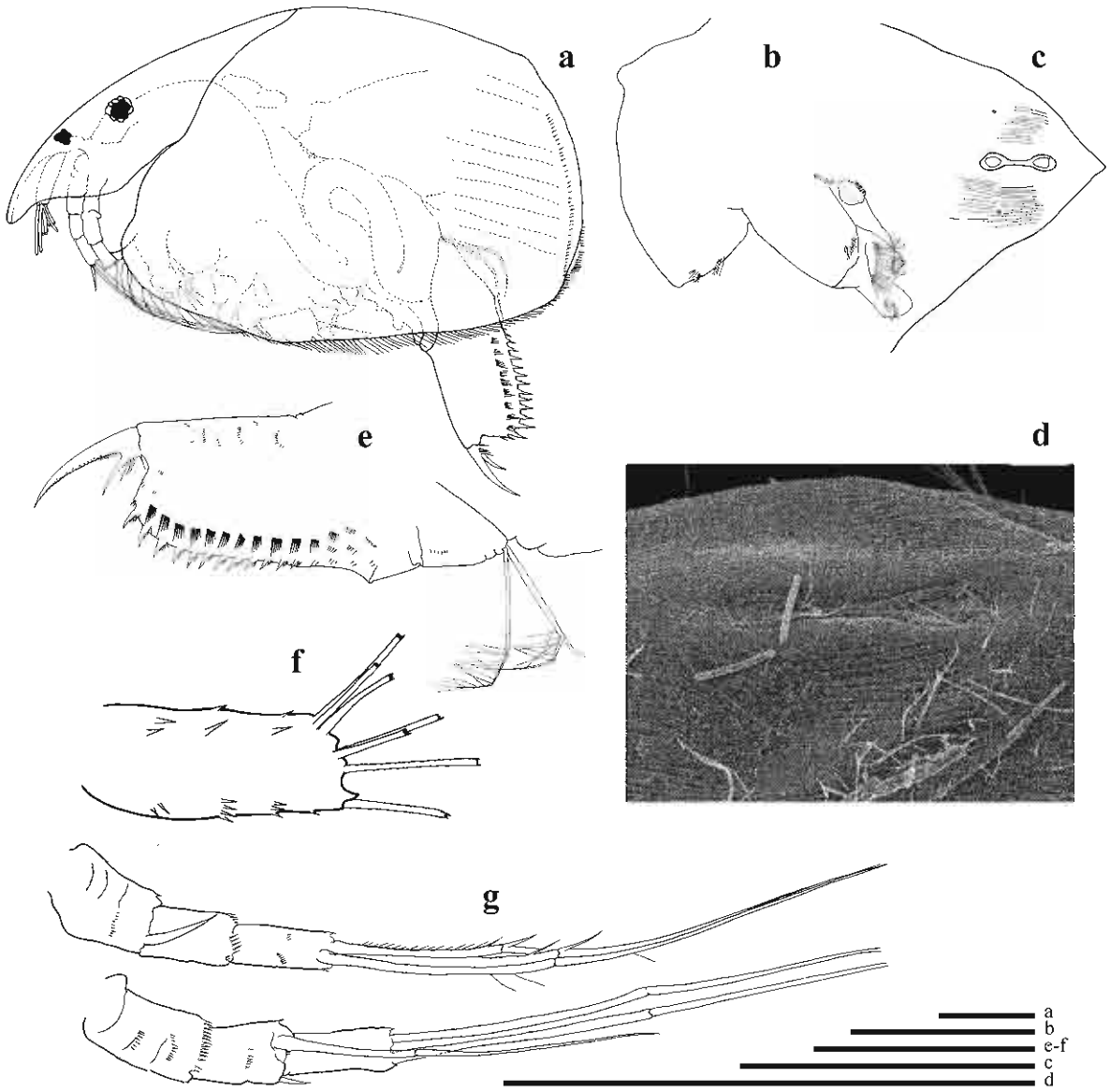


Figure 4. ***Alona affinis*** **(Leydig, 1860):** parthenogenetic female from Thungtong swamp (S19), Suratthani Province, southeastern Thailand. Figure a, adult female in lateral view; Figure b, labrum; Figure c-d, headshield and its headpores; Figure e, postabdomen; Figure f, antennule; Figure g, antenna. Scale bars denote 100 um.

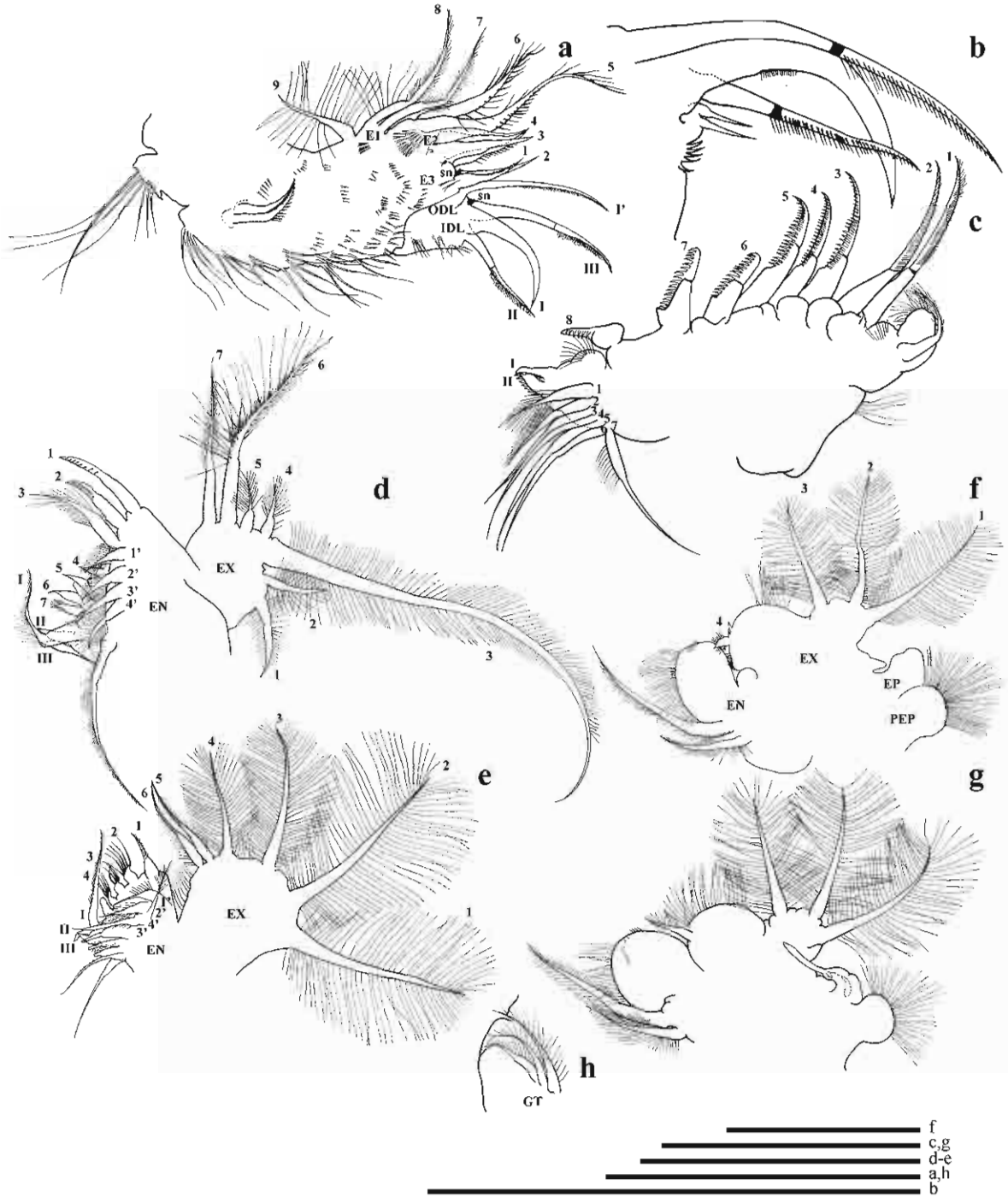


Figure 5. ***Alona affinis*** **(Leydig, 1896):** appendages of females from Thungtong swamp (S19), Suratthani Province, southeastern Thailand. Figures a-b, trunk limb 1 and its inner and outer distal lobe; Figure c, trunk limb 2; Figure d, trunk limb 3; Figure e, trunk limb 4; Figures f-h, trunk limb 5 and its gnathobasic filter comb. Scale bars denote 100 um.

2. *Alona archeri* Sars, 1889

Materials examined:

Southern Thailand: 50 parthenogenetic females, examined complete and thereafter dissected, from Kalai swamp, Phang-nga Province (S60), southwestern Thailand, collected by the author, SM.

: one parthenogenetic female, examined complete and thereafter dissected, from Pluckpraya swamp, Satun Province, (S42), southwestern Thailand, collected by the author, SM

The details of morphological study

Species description (see figures 6-8)

Parthenogenetic female

General shape (figs.6a-c)**:** oval in lateral view, maximum height at the middle or ¾ of body. Length 0.2-0.3 mm, about 1.2-1.9 times maximal height (n=50). Dorsal margin forms slight curve. Postero-dorsal and postero-ventral angles round. Posterior margin slightly concave or almost straight, postero-ventral corner rounded. Postero-ventral of valve rounded. Ventral carapace margin round, ventral setae relatively short, ending before posteroventral corner, followed by short setules posteriorly. Antero-ventral corner rounded. Ventral margin almost straight, slender ventral setae gradually decreasing in length toward posterior end. Valve ornamentation consisting of bubbles obviously, particularly in the posterior part of body (figs.6a,8a).

Head (figs.6a-b)**:** Relatively large. Rostrum short, blunt and pointing downward. Compound eye present, larger than ocellus, distance between eye and ocellus longer than distance from tip of rostrum to ocellus in some specimens (figs.6a,c) but similarly in length in some specimens (fig.6b).

Labrum (fig.6d)**:** large, with a rounded tip, anterior portion rounded and curly at the distance close to the tip.

First antenna I (antennule) (figs.6e, 8b-c): Body compact, about 1.5 as long as wide. Distal end with nine aesthetascs, two of them about 1.2-1.5 times as long as other

aesthetascs, others as haft the length of antennular body, accompanied by antennular sensory seta, implanted at about one third of apex. Three rows of 2-4 lateral setae on inner portion (fig.8c).

Second antenna (figs.6f-h, 8d): Basal segment with rows of spines. Antennal formula, spines 0-0-1/1-0-1 setae 0-1-3/0-0-3. All setae bisegmented. Spine arising from basal segment of endopodite not extending beyond tip of second segment. Terminal spines as long as its segment. Seta arising from the second segment of exopodite long, 4 times as long as the segment. Surface of segments with rows of setules. Coxa with distinct short denticle on anterior side between rami and its surface provided with clusters of longer setae on upper part, longest rows at second coxa.

Postabdomen (figs.6i-j, 8e)**:** Length about 2 times height, distal part about 1.5 times longer than preanal portion. Slightly narrow distally, distal and ventral margin almost parallel, clear angle between distal and dorsal margin, about 50 ^{o}-60^{o}. Postero-dorsal corner sharp. Anal margin relatively straight, pre-and postanal corner not distinct, bearing 7 rows of small denticles, each row bearing from 6 up to 11 denticles. Lateral fascicles: 7 postanal group, each consisting 4-8 denticles but the distalmost consist only 4 denticles, gradually increasing in length distally. Marginal denticles: 8-9 groups, each groups bearing one denticle and 2-3 spinules basally, denticles gradually increasing in size distally and largest denticle on the third group, the first very short.

Terminal claw (figs.6i-j, 8e)**:** Long and slender, as long as anal margin, bearing a short basal spine, length about 1/4 of terminal claw or little less, situlated at half its length from the base of the pecten, inner rows of small pectens from base of basal spine to tip of claw, gradually decreasing in length distally, hardly seen on the last half. Natatorial setae short.

Trunk limb: six pairs

First trunk limb (P1) (figs.6a, 8f)**:** Epipodite and gnathobase not seen. Outer distal lobe (ODL) with one long seta (I'), bisegmented, unilaterally armed with short setules distal part, hardly visible. Inner distal lobe (IDL) with three setae (I-III), seta I and

seta II the same length and similarly armed with short setules on distal segment, seta 3 hook-like chitinized seta, slender, reaching one third of seta I and II. Endite 3 (E3) with four setae (1-4), seta 1 shorter than seta 2, seta 2 as the same length as seta 3, seta 4 longest, seta 3 bilaterally armed with short setules on distal part, seta 4 unilaterally setulated with short setules on distal part. Endite 2 (E2) bearing three setae (5-7), seta 5 shortest, bilaterally armed with short setules on distal part, similarly to endite 3 setae; seta 6 longest, densely setulated from base to tip, seta 7 long and slender, long fine setules sparsely setulated on distal part, one sensillium (sn) located close to seta 7; two rows of setae, about 5-7 setae each, orientated more radial on basal of endite. Endite 1 (E1) with one seta (8), probably seta 9 is broken. Trunk with six rows of thin and slender setae on ventral surface, about 2-4 setae in each row. Basally, two long and slender ejector hooks, both of the same length, unilaterally armed with short denticles.

Second trunk limb (P2) (figs.7b-c, 8h)**:** Epipodite not seen. Exopodite (EX) bilobed, elongated; without apical or subapical seta, setulated apically. Endopodite (EN) triangular, with eight scrapers (1-8), decreasing in length towards gnathobase, though scraper 2 longest; scraper 1 and scraper 2 bisegmented, densely armed with fine setae distally, scraper 3 and so on similarly armed with fine setules, but not as fine as on scrapers 1 and 2. Number of elements on distal armature of gnathobase (GT) not clear. Small hillock between seta 8 and gnathobase, setulated apically. Seven gnathobasic filter comb.

Third trunk limb (P3) (figs.7d-e, 8i)**:** Epipodite not seen. Exopodite (EX) subquadrangular, bearing six setae (1-6), seta 1 and seta 2 located laterally, in typical V-formation, seta 2 length as a half of seta 1, bilaterally setulated, seta 4 and seta 5 as equal in length, bilaterally setulated, seta 6 more slender, length as a half of seta 5

Endopodite (EN) with anterior row of two spines and one seta on outer part (1-3), spines stout, similar in length, seta 3 more slender, unilaterally setulated distally; posterior rows with four setae (1'-4'), decreasing in length towards gnathobase, bilaterally setulated distally. Number of elements on distal armature of gnathobase (GT) and gnathobasic filter comb unclear.

Fourth trunk limb (P4) (figs.7f-g, 8j)**:** Pre-epipodite (PEP) and Epipodite (EP), pre-epipodite larger than epipodite rounded (figs.5f-g). Exopodite (EX) quadrangular, bearing six setae (1-6), setae 1-3 of the same length, bilaterally setulated, seta 4 shorter, bilaterally setulated, seta 5 length 2 times longer than seta 6, seta 6 more slender and smallest, both bilaterally setulated. Row of setules ventrally.

Endopodite (EN) inner anterior portion bearing five appendages (1-5), spine 1 slender and longest, flaming torch setae (2-4) gradually decreasing in length towards gnathobase, plus a receptor (5); posterior portion bearing comb of three setae (1'-3'), all of the same length. Distal armature of gnathobase (GT) with horse-tail seta (I) and two support setae (II-III). One last seta in gnathobasic filter comb.

Fifth trunk limb (P5) (figs.7h-I)**:** Pre-epipodite (PEP) round, radial setulated apically, elongated digitiform projection not seen. Epipodite (EP) rounded, larger than pre-epipodite (fig.7h) or eually in size in some specimens (fig.7i), elongated digitiform projection presents (fig.7h). Exopodite (EX) not clearly bilobed, bearing four apical setae (1-4); anterior portion smaller than posterior portion, setae 1-3 on anterior portion, seta 2 longest, seta 1 gradually shorter, seta 3 shortest, all setulated; posterior portion larger, more round, bearing one seta (seta 4), about ¼ of the longest, row of setules basally in some specimens (fig.7h).

Endopodite (EN) larger, more ovoid, setulated apically, two endopodite setae setulated distally, one as a half-length of another.

Sixth trunk limb (P6): not studied.

Variability:

Some variability was noted in these following characters: 1) the specimens can be oval-elongated (figs 6a,c) or oval with more concave dorsal margin (fig.6b) 2) distance between eye and ocellus longer than distance from tip of rostrum to ocellus in some specimens (figs.6a,c) but similarly in length in some specimens (fig.6b).

Differential diagnosis:

This species is very similar to *A. karelica* but it can be distinguished by 1) narrow postabdomen (figs.6i-j, 8e) 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).

Remarks

Alona archeri Sars, 1888 was originally described from Australia. After the initial description it was only 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 Thale-noi marsh (S41), 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 S60 (PK1SM001-02) and specimens recorded as *A.* aff. *karelica* from S42 (PK1SM001-01, in Maiphae 2005 and Maiphae *et al*. 2005) are all *A. archeri* (figs.6-8), on account of their narrow postabdomen (figs.6i-j,8e) 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 (table 3): 1) length 1.4-1.6 times maximum height in Sinev (2002) but about 1.4-1.8 times in Thai specimens (figs.6a-c, 8b-c); 2) antennule not reaching tip of rostrum in Sinev (2002) but reaching that tip in Thai specimens (fig.6b); 3) longest aestetasc about 0.5 length of antennule in Sinev (2002) but about 0.8 length of antennule in Thai specimens (fig.6e); 4) labral keel with re-curve rounded apex in Sinev (2002) but more round in Thai specimens (fig.6d); 5) basal spine of postabdomen 1/3 of claw length in Sinev (2002) but ¼ in the present study (figs.6i-j), and 6) 1st and 2nd scrapers of the same length in Sinev (2002) but 1st scraper shorter

than 2nd in Thai specimens (fig.7b). We here refrain from giving these taxonomic weights.

Table 3 The comparison between specimens of *Alona archeri* from Australia (Sinev, 2002) and Thai specimens from present study

Characters	Sinev, 2002	Present data
Size	Maximal length 1.4-1.6 times of maximal height	Maximal length 1.4-1.8 times of maximal height (figs.6a-c)
Antennule	Not reaching the tip of rostrum	Reaching the tip of rostrum (fig.6b)
	Longest aestetasc of about 0.5 length of antennule	Longest aestetasc of about 0.8 length of antennule (figs.6e, 8b-c)
Labrum	Labral keel with a re-curve rounded apex	Labral keel more round (fig.6d)
Postabdomen	Basal spine of postabdomen 1/3 of claw length	Basal spine of postabdomen ¼ of claw length (figs.6i-j, 8e)
Trunk limb 2	1st and 2nd scrapers are as the same length	1st scraper shorter than 2nd scraper (figs.7b, 8h)

Distribution:

At present *Alona archeri* Sars, 1888 has been recorded from Indonesia (Brehm 1933), Tadzhikistan (Mukhamediev 1986), Queensland, New South Wales and Tasmania (Smirnov & Timms 1983) Australia (Sars, 1888). In Thailand it has been recorded only from southern Thailand in Thale-noi march (S41), Pattalung Province, southern Thailand (Pholpunthin, 1997), from Pluckpraya swamp, Satun Province (S42), Kalai swamp, Phang-nga Province (S60).

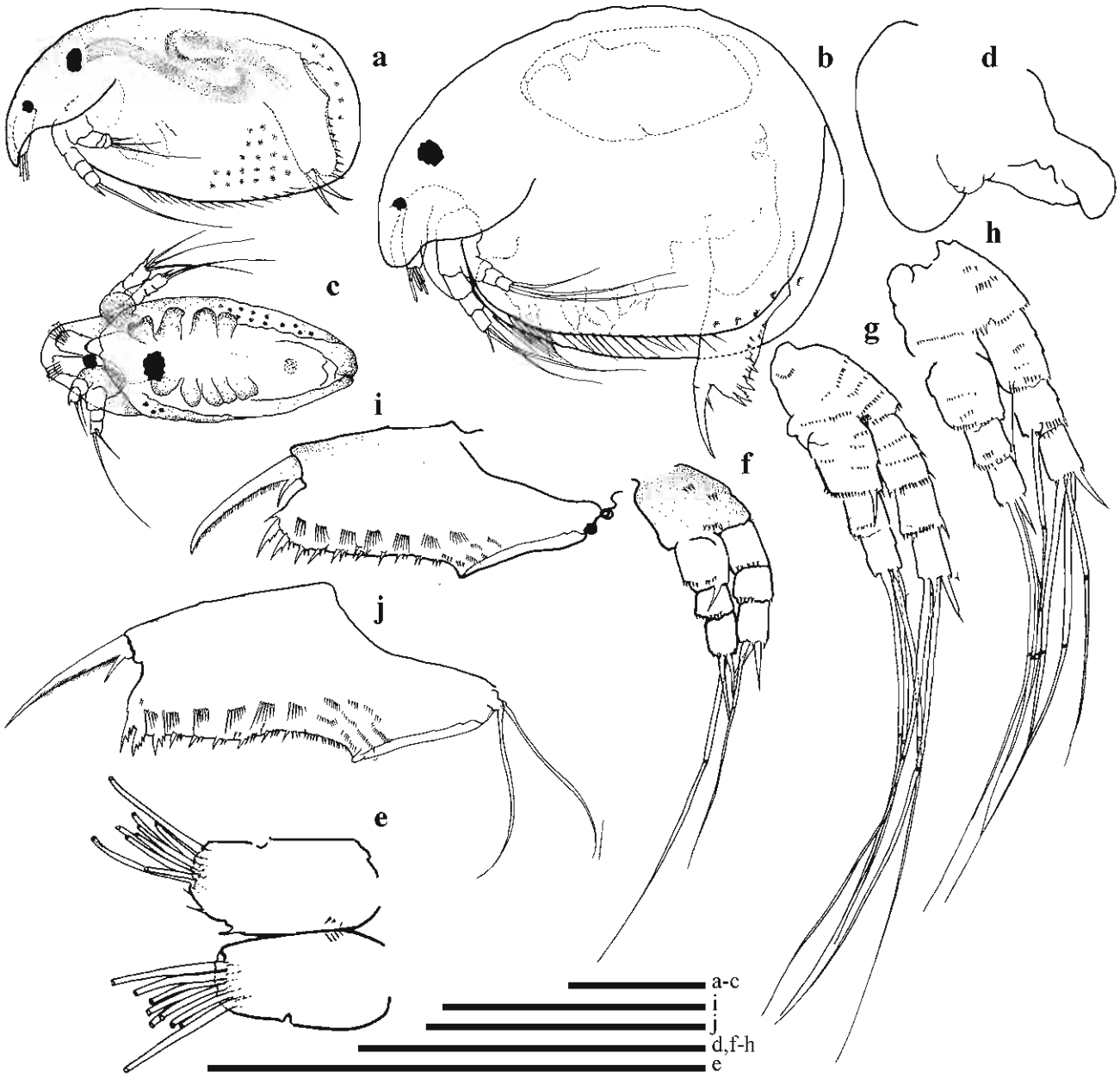


Figure 6. ***Alona archeri*** **Sars, 1888:** parthenogenetic females from Kalai swamp (S60), Phang-nga Province, southwestern Thailand. Figures a-b, adult females in lateral view; Figure c, adult female in ventral view; Figure d, labrum; Figure e, antennule; Figures f-h, antenna; Figures i-j, postabdomen. Scale bars denote 100 um.

Figure 7. ***Alona archeri*** **Sars,1888:** appendages of parthenogenetic females from Kalai swamp (S60), 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 um.

Figure 8. ***Alona archeri*** **Sars,1888:** parthenogenetic female from Pluckpraya swamp (S42), Satun Province, southwestern Thailand. Figure a, postero-ventral corner of valve; Figures b-c, antennule; Figure d, antenna; Figure e, postabdomen; Figures f-g, trunk limb 1; Figure h, trunk limb 2; Figure i, trunk limb 3; Figure j, trunk limb 4. Scale bars denote 100 um.

3. *Alona camboui* Guerne & Richard, 1893 and *A.* cf. *camboui* Guerne & Richard, 1893

Synonymy: Daday, 1910: 128-130, Taf. 6, figs. 30-35 (*pulchella*); Rey and Saint-Jean, 1968: 11, fig. 25, A-D (*pulchella*); Rajapaksa and Fernando, 1987, fig. 139 (*pulchella*); Dumont *et al.*, 1984: 166-167, fig.2, 1-2 (*pulchella*); Chen, 1993: 27, figs.1-5 (*pulchella*); Venkataraman, 1993: 382-383, figs. 34-37 (*pulchella*).

References: Guerne and Richard, 1893: 224-244, figs. 10-11; Richard, 1894: 371-374, figs. 5-8; Sinev, 2001: 5-18, figs. 34-58.

Type locality: Madagasca

Materials examined:

Southern Thailand: one parthenogenetic female, examined dissected, from Maikhao peat swamp (S28), Phuket Province, collected by the author, SM.

Malaysia : one parthenogenetic female, examined complete and thereafter dissected. Collected by C. H. Fernando, Fernando collection, Raffles Museum, NUS.

Southern Spain: one parthenogenetic female, examined complete and thereafter dissected, from Used, Zaragoza, collected by Van Damme, K., GU.

The details of morphological study

Species description (See figures 9-10)

Parthenogenetic female

General shape (figs.9a-b)***:*** Length 0.32-0.34 mm, about 1.4 times maximal height (n= 3) while Venkataraman (1991) reported its size 0.26 mm in female and 0.33 mm in male (Venkataraman, 1995). Body in lateral view oval, largest height around the middle but body seems almost parallel. Dorsal margin generally curved, depression between head and the rest of body absent. Postero-dorsal and postero-ventral margin rounded, with small setules reaching the middle of the body. Ventral margin almost straight, ventral setae relatively long, with slender 34-40 setae which slightly differ in

length, slightly decreasing towards posterior end, longer setae clearly at anterior part, end before posteroventral corner (fig.9b). Valves with longitudinal striation, some specimens rectangular-like.

Head*:* Moderate size, rostrum well developed, blunt. Compound eye present, size larger than ocellus; distance between eyes and ocellus same as between ocellus and tip of rostrum. Head shield wide, anterior margin with blunt apex (fig.9f), posterior margin with three notches, the middle notch located in the midline. Three major head pores, shape not round in Thai and Malaysian specimens (figs.9e-d), but rounded in Spain specimen (fig.9g), without connection. Central pore is the same size as the anterior and posterior one. Lateral pores small, located around the middle.

Labrum (fig.9c)***:*** Round and relatively large. Labral tip rounded or slightly angular. Posterior edge convex.

Postabdomen (figs.9h-j)***:*** gradually narrowing distally but almost straight. Anal margin almost straight (figs.9h,j) and concave in Spain specimen (fig.9i), with distinct pre-and post-anal corner, not obvious in some specimens (fig.9h), bearing about 14 small denticles. Supra-anal projection well-marked and located considerably above the middle, lower corner rectangular. Lateral fascicles about 5-7 groups, each counting 9-11 denticles. Lateral fascicles on anal margin about 9 groups, of which the denticles situated parallel to each other. Teeth-like marginal spines gradually increasing in size distally, in group of 3-4, mostly three distally, and three distal ones one each side being much larger than the others. Natatorial setae moderately, setulated distally.

Terminal claw*:* elongated, about as long as anal margin (figs.9h-j), very long in Malaysia specimen, compared with postanal margin. Basal spine slender, length almost half terminal claw, two additional setules or more in Spain specimen (fig.9i) situated at the base of basal spine. Denticles of pecten along the claw.

Trunk limb: five pairs

First trunk limb (P1) (figs.10a-d)***:*** Outer distal lobe (ODL) with one seta (I'), one slender, length as long as IDL setae, bearing short, hardly visible setules distally. Inner distal lobe (IDL) with three setae (I-III), two subequal in length (I-II), their distal end unilaterally armed with sparsely spines decreasing in length distally, seta III smaller, curved-like.

Endite 3 (E3) with four plumose setae (1-4). Endite 2 (E2) with three apical setae (5-7), seta 5 smallest, seta 6 and seta 7 unequal in length; seta 7 only half of length of seta 6 in Spain specimen (fig.10a), both slender, setulated with long setules on one side and shorter setules on other side. Endite 1 (E1) with two apical setae (8-9), setulated. Groups of slender spinules present on inner side of second endite. Trunk with 6-7 rows of slender spines laterally. Basally two long and slender ejector hooks, of the same length, unilaterally armed with short setules. Epipodite and gnathobase not seen.

Second trunk limb (P2) (fig.10e)***:*** Epipodite not seen. Exopodite (EX) round-elongated, small setules apically, a short seta basally. Endopodite (EN) triangular, with eight scrapers (1-8), generally decreasing in length towards gnathobase, all unilaterally armed with fine setules distally. Distal armature of gnathobase (GT) with three elements, element I naked, element II more robust, armed with setules from base to tip.

Third trunk limb (P3) (figs.10f-g)***:*** Epipodite (EP) not seen. Exopodite (EX) sub-rectangular, bearing six setae (1-6): setae 1 and 2 long, located laterally, in typical V-formation, both as the same length and setulated, seta 4 slender, setulated, seta 5 long and slender, bilaterally armed with long and fine setules distally, the last seta (6) small and slender, as half as seta 6, unilaterally armed with sparsely short setules distally.

Endopodite (EN) (fig.10g); distally with three setae (1-3), setae 1 and 2 stout, seta 2 shorter than seta 1, distally armed with well-spaced setules; posteriorly with four setae (1'-4'), gradually increasing in length towards gnathobase, all setulated. Gnathobase (GT) with two elements (I-II), element I large, curved inwards,

unilaterally setulated, element II shorter, naked, fused at the base of each other. Gnathobasic filter comb with seven setae, setulated.

Fourth trunk limb (P4) (figs.10h-i)***:*** Epipodite and Endopodite not seen. Exopodite (EX) round, bearing six setae (1-6); setae 1 and 2 are of equal in length, although the second may be longer, both setulated, seta 3 setulated, longest about 1.5 time of the first two, setae 4 and 5 as the same length in Thai specimen (fig.10h) and seta 5 longer in Spain specimen (fig.10i), theirs length about half that of the longest, both setulated, the last seta (6) shortest, about 1/3 of the longest (fig.10h) or as the same length of seta 4 (fig.10i). Row of setules laterally.

Endopodite (EN) or inner portion (fig.10i), anteriorly bearing five setae (1-5), seta 1 elongated, unilaterally armed with fine setules, setae 2-4 'flaming-torch' setae, distally armed with long slender setules, counting 5-6 setules each, seta 5 rod-like receptor, comparable in size of seta 4, naked; posteriorly bearing four soft setae (1'-4'). Gnathobase (GT) with two large elements (I-II), element I unilaterally setulated distally with long setules, element II naked, fused at the base of each other.

Fifth trunk limb (P5) (figs.10j-k)***:*** Pre-epipodite (PEP) small, oval, setulated apically with long setules and rows of small setules basally, no elongated digitiform projection. Epipodite (EP) bilobed, elongated, no elongated digitiform projection. Exopodite (EX) bilobed, bearing four setae (1-4); anterior portion smaller than posterior portion, setae 1-3 on anterior portion, all the same length (fig.10k) or seta 3 shorter, as half of those two obviously (fig.10j), all setulated; posterior portion larger, more oval, bearing one seta (4), relatively short, about 3 times shorter than seta 3, setulated.

Endopodite (EN) larger, more oval, setulated apically, two endopodite setae setulated distally. Gnathobasic filter comb not seen.

Differential diagnosis:

This species can be distinguished by 1) the disconnected three main head pores; 2) the postabdomen with dorsal and ventral margins parallel, and the teeth-like

marginal denticles of postabdomen occurring in groups; and 3) on trunk limb 1, ODL seta shorter than IDL setae and seta 6 about 1.5 times longer than seta 7.

Remarks:

The members of the *Alona pulchella*-group, *A. pulchella, A. cambouei*, *A. glaba* and *A. laevissima*, share characteristics such as an elongated postabdomen with parallel margins, very well developed lateral fascicles of setae and moderately developed marginal denticles. Sinev (2001) mentioned that disconnected central head pores is the main character for separating *A. cambouei* from *A. pulchella* and also uneven number of notches of posterior margin of head shield, less number of setae on ventral margin of valve (30-35 setae in *A. cambouei* and 40-45 in *A. pulchella*), preanal angle of postabdomen prominent and anal margin prominent. Thai specimens share most characters with *A. cambouei* as shown in characters 1-6 and 14-15 (table 4), and they share only three characters with *A. pulchella* (characters 9, 13 and 16). However, there are some characters different from both *A. pulchella* and *A. cambouei*, as described from Iraq, Sudan (Sinev, 2001) and southern Spain in the following characters 1) three central head pores disconnected but their shape not rounded but more elongated; 2) number of setae on ventral margin of valve range between those specified by Sinev (2001) as *A. cambouei* (30-35 setae) and *A. pulchella* (40-45 setae); 3) postanal margin as long as anal margin but in Malaysian specimen postanal margin two times longer than anal margin; 4) preanal angle prominent in Thai, Sudan and Spain specimens but not prominent in Malaysian ones; 5) anal margin of Thai and Malaysian specimens not concave; 6) long terminal claw but very long in Malaysian specimen; 7) ODL seta as long as IDL setae in Thai specimen but this seta is shorter in specimen from other places; 8) seta 6 of trunk limb 1 subequal in length of seta 7 in Thai specimen but this seta about 1.5 times longer than seta 7 in specimens from other places; 9) seta 3 of trunk limb 4 long, about 1.5 times longer than seta 2 in Thai specimen but shorter in specimens from other places and 10) setae 4-6 of trunk limb 4 show differences in length; in Thai specimen seta 4 equal in length as seta 5; and seta 6 shortest, as half of those two ; seta 6 of P4 as a half of setae 4 and 5 in Thai specimens but in Spain specimens shorter.

Biology:

Found in swamps and marshes; common among aquatic weeds (Nayar, 1971).

Distributions:

Alona cambouei is distributed in South America i.e. Chili, Patagonia (Richard, 1897; Jenkin, 1934), Africa (Harding, 1955; Sinev, 2001), tropical Asia i.e. India, Madagasca (Jenkin, 1934) and also, reported from Australia (Griggs, 2001).

Table 4 Morphological comparisons among *A. pulchella* and *A. cambouei* from Iraq and Sudan (Sinev, 2001), *A. cambouei* from southern Spain and *A*. cf. *cambouei* from western Malaysia and Thailand

Characters		***A. pulchella*** Australia (Sinev, 2001)	***A. cambouei*** Iraq / Sudan (Sinev, 2001)	***A. cambouei*** southern Spain (present data)	***A.* cf. *cambouei*** western Malaysia (present data)	***A.* cf. *cambouei*** southern Thailand (present data)
Head pores	1)	3 central pores rounded-shape interconnected	3 central pores rounded-shape disconnected	3 central pores rounded-shape disconnected	3 central pores shape not rounded, disconnected	3 central pores shape not rounded, disconnected
Head shield						
number of notches of	2)	even or greater; 10 or 12	uneven; 5 or 7	uneven; 3		
posterior margin of head shield	3)	central pair of notches located symmetrically from midline	the middle notch located in midline	the middle notch located in midline		
Number of setae on ventral margin of valve	4)	40-45 setae	30-35 setae			36-41 setae
Postabdomen	5)	postanal margin 1.5 times of anal margin	postanal margin ~ anal margin	postanal margin ~ anal margin	**postanal margin 2 times of anal margin**	postanal margin ~ anal margin

Table 4. (Continued)

Characters		***A. pulchella*** Australia (Sinev, 2001)	***A. cambouei*** Iraq / Sudan (Sinev, 2001)	***A. cambouei*** southern Spain present data	***A.* cf. *cambouei*** western Malaysia present data	***A.* cf. *cambouei*** southern Thailand present data
	6)	preanal angle not prominent	preanal angle prominent	preanal angle prominent	preanal angle not prominent	preanal angle prominent
	7)	anal margin almost straight	anal margin strongly concave	anal margin concave	anal margin almost straight	anal margin almost straight
	8)	terminal claw long compare with postanal margin	terminal claw long compare with postanal margin	terminal claw long compare with postanal margin	terminal claw **very long** compare with postanal margin	terminal claw long compare with postanal margin
Trunk limb 1						
ODL-IDL	9)	ODL seta as long as IDL setae	ODL seta shorter than IDL setae	ODL seta shorter than IDL setae		**ODL seta as long as IDL setae**
Endite 2	10)	seta 6 ~1.5 times longer than seta 7	seta 6 ~1.5 times longer than seta 7	seta 6 ~1.5 times longer than seta 7		**seta 6 subequal of seta 7**
exopodite	11)	seta 3 longest, 1.2 times longer than seta 2	seta 3 longest, 1.2 times longer than seta 2	seta 3 longest, 1.2 times longer than seta 2		seta 3 longest, 1.5 times longer than seta 2

Table 4. (Continued)

Characters		***A. pulchella*** Australia (Sinev, 2001)	***A. cambouei*** Iraq / Sudan (Sinev, 2001)	***A. cambouei*** southern Spain present data	***A.* cf. *cambouei*** western Malaysia present data	***A.* cf. *cambouei*** southern Thailand present data
Trunk limb 4						
exopodite	11)	seta 3 longest, 1.2 times longer than seta 2	seta 3 longest, 1.2 times longer than seta 2	seta 3 longest, 1.2 times longer than seta 2		seta 3 longest, 1.5 times longer than seta 2
	12)	seta 4 shorter than seta 5,	seta 4, 5, 6 as equal in length	seta 4 shorter than seta 5		seta 4 as equal as seta 5
	13)	seta 6 as a half of seta 5		seta 6 shorter than seta 5		seta 6 as a half seta 4,5
Trunk limb 5						
Epipodite	14)			bilobed		bilobed
Exopodite	15)	bilobed, but not obviously	bilobed, but not obviously	bilobed		bilobed
	16)	seta 3 almost the same length of seta 2	seta 3 almost the same length of seta 2	**seta 3 half of seta 2**		seta 3 almost the same length of seta 2

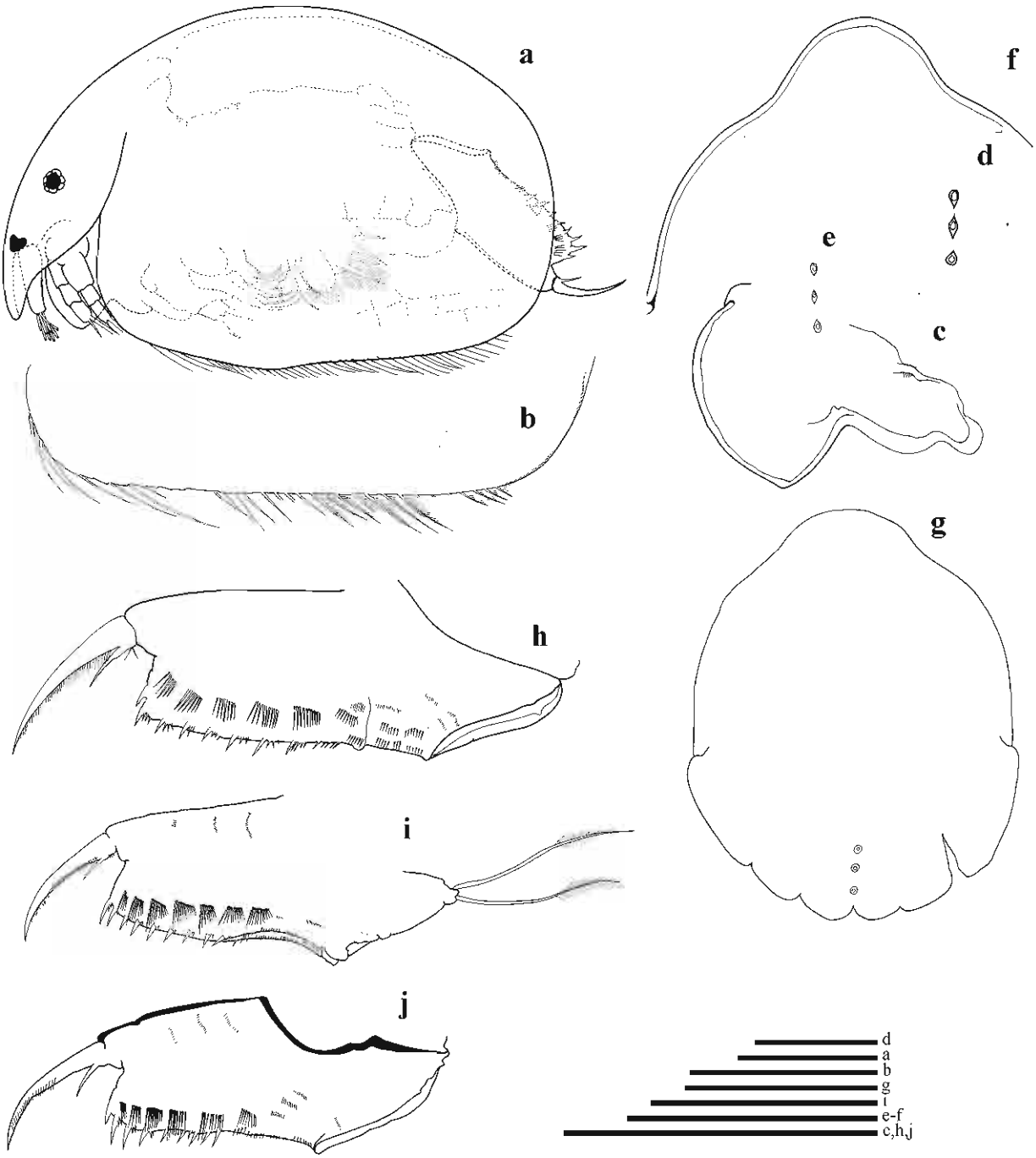


Figure 9. ***Alona*** **cf.** ***cambouei*** **Guerne & Richard, 1893:** parthenogenetic females from Maikhao peatswamp (S28), Phuket Province, southwestern Thailand (a-d,j). Rantang Abang marsh, Terrenganu, eastern Malaysia (e-f,h) and Zonragoza, Spain (g,i). Figure a, adult female in lateral view; Figure b, ventral margin of valve; Figure c, labrum; Figures d-e, headpores; Figure f, anterior margin of head shield; Figure g, head shield; Figures h-j, postabdomen. Scale bars denote 100 um.

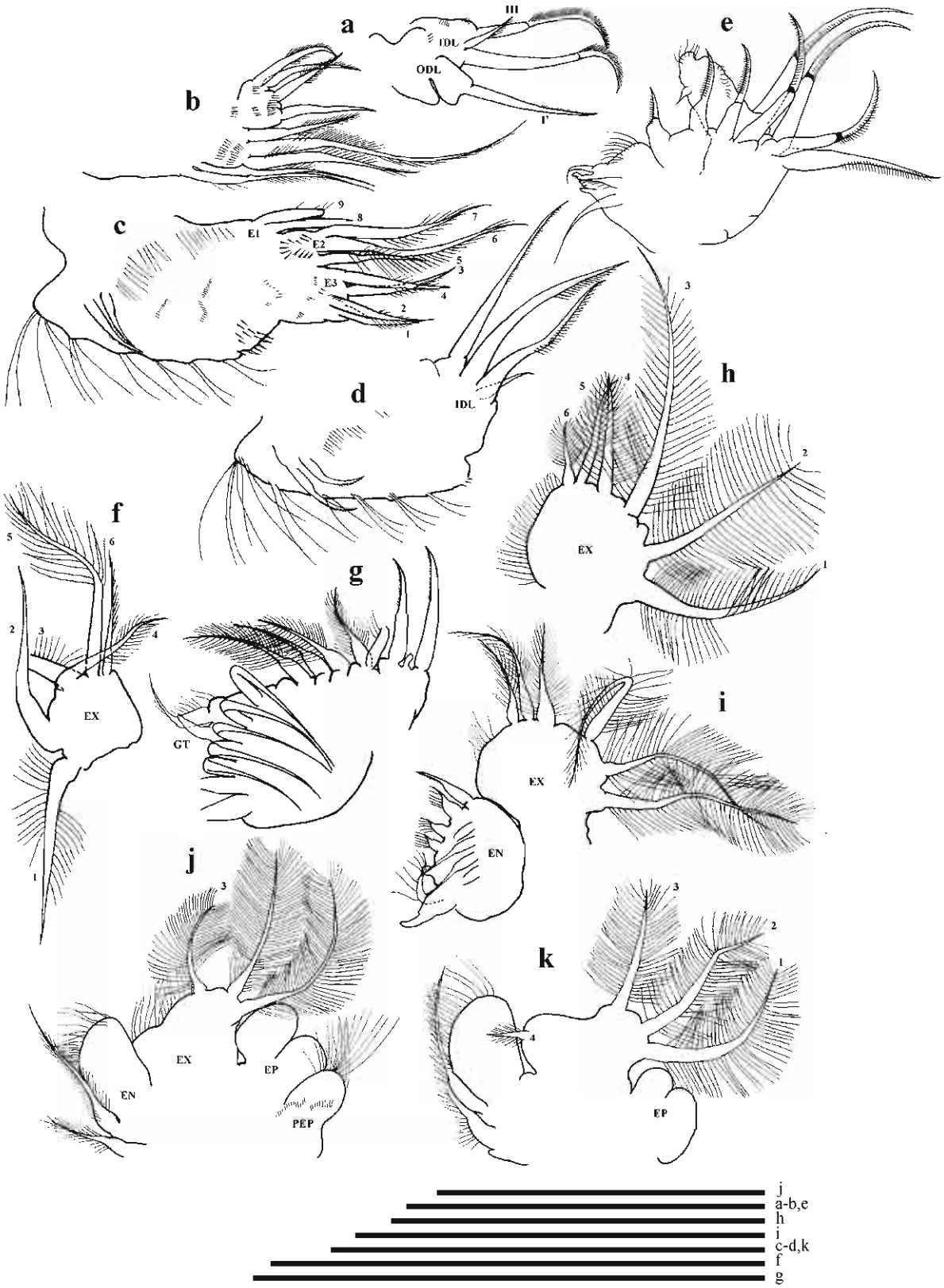


Figure 10. ***Alona*** **cf.** ***cambouei*** **Guerne & Richard, 1893:** appendages of females from Maikhao peatswamp (S28), Phuket Province, southwestern Thailand (c-d,h,i), Boak swamp (NE10), Khon Kean, northeastern Thailand (e), Zonragoza, Spain (a-b, f, g,j). Figures a-d, runk limb 1; Figure e, trunk limb 2; Figures f, exopodite of trunk limb 3; Figure g, endopodite of trunk limb 3; Figures h-i, trunk limb 4; Figures j-k, trunk limb 5. Scale bars denote 100 um.

4. *Alona cheni* (Chen & Peng, 1993)

Synonymy: *Alona setigera* Chen & Peng, 1993: 19, figs 1-5 (not *A. setigera* Brehm, 1931)

Reference: Sinev, 1999 (*A. cheni*): 142-146, figs 8-10.

Type locality: India, Ahmedabad, Aiwa Reservoir

Holotype: parthenogenetic female from India, Ahmedabad, Aiwa Reservoir, 25.III.1964, slide in Canada balsam, deposited in the collection of the Zoological Museum of Moscow State University, inventory number M1-05.

Paratype: parthenogenetic females from the same locality, mounted on slides in glycerol, sealed with Canada balsam, also deposited in the collection of the Zoological Museum of Moscow State University, inventory number M1-06 and M1-07.

Materials examined:

Southern Thailand: 20 parthenogenetic females, examined complete and thereafter dissected, from Thungtong Swamp (S19), Keinsa District, Suratthani Province (8^{o} 52.66'N, 99^{o}11.83'E), southeastern Thailand, temperature 29^{o}C, pH 6.4, conductivity 0.39 and salinity 0 ppt., collected date 01-10-1999, collected by the author, SM.

: ten parthenogenetic females, examined complete and thereafter dissected, from Mai-khao peat swamp, Phuket Province (8^{o} 07.21'N, 98^{o}17.34'E), southwestern Thailand, temperature 31.3-31.6^{o}C, pH 6.86-7.23, conductivity 0.07 and salinity 0.4 ppt. collected by the author, SM.

Northeast Thailand: two parthenogenetic females, examined complete and thereafter dissected, from Lake Kud-Thing, Bung Kan District, Nong Khai Province, collected date 28.02.1998, by C. Saeng-aroon, KKU.

Malaysia: one parthenogenetic female, examined complete and thereafter dissected, collected by Fernando, C. H., Fernando collection, NUS.

Singapore: one parthenogenetic female, examined completed and thereafter dissected, collected by Fernando, C. H., Fernando collection, NUS.

The details of morphological study

Species description (See figures 11-13)

Parthenogenetic female

General shape (figs.11a-b, 13a-c)***:*** Length 0.35-0.48 mm, about 1.5-1.6 times maximal height (n=30). Body in lateral view oval, more ovoid in some specimens (fig.13c), maximum height around the middle of body and narrowing anteriorly. Dorsal margin forms slightly curve. Postero-dorsal and postero-ventral angles round. Posterior margin slightly concave. Ventral margin almost straight, some specimens with small hillock in the middle (figs.13a-b) with 46 slender setae, slightly different in length, slightly decreasing in length posteriorly, longer setae clearly at anterior part in some specimens (fig.13b), end before posteroventral corner. Antero-ventral angle concave.

Head (figs.11a-d, 13a-c)**:** Relatively small, with short rostrum, broadly rounded, pointing downward. Compound eye present, larger than ocellus, distance between eye and ocellus slightly shorter than distance from tip of rostrum to ocellus. Head shield length about 1.2 times maximum width (fig.11c), posterior margin broadly rounded. Three major head pores connected by a channel, the connection between central and posterior pore wide, that between central and anterior pore narrower (figs.11c-d), central pore smaller than anterior and posterior one, located slightly close to posterior; two lateral pores large, transversely oriented, with characteristic irregular sac-like structure, large semi-circular pockets located behind lateral pores, depth of pockets 0.5 times length of pore. Distance between posterior head pore and posterior corner of head shield (PP) about 0.8 times distance between anterior and posterior head pores (IP). Transverse lateral pores of about 1IP length, located about 0.5IP distance from midline, at level between anterior and central pore.

Labrum (figs.11e, 13d)***:*** height about 2 times maximum width. Labral keel naked, bending, notch at anterior margin, rounded to blunt apex, forming an angle in some specimens (fig.13d), possessing one cluster of setules at posterior margin (fig.11e).

Postabdomen (figs.11h, 13e-g)***:*** Length about 2.5 maximum height, distal part about 1.5 times longer than preanal portion. Slightly narrowing distally, dorsal and ventral margin almost parallel, with clearly form an angle between distal and dorsal margins about 45^{o}-60^{o}. Posterodorsal corner sharp, with an angle of 90^{o} or little less. Posterior margin with indentation. Anal margin relatively straight, with no distinct pre-and postanal corner, hard to define, bearing 3-5 rows of small denticles, each row bearing up to 11 denticles. Lateral fascicles: 7-9 postanal groups, each consisting 5-9 denticles, gradually increasing in length distally. Marginal denticles: 8-11 groups of merged spinules, gradually increasing in size distally and bearing 3-5 fused denticles on inner edge. Three or four groups of venterolateral denticles. Natatorial setae relatively short.

Terminal claw (figs.11h,13e-g)***:*** Long and slender, as long as pre-anal margin, bearing a short and slender basal spine, length about 1/3 or ¼ terminal claw, situated at half its length from base of pecten, inner and outer rows of small pectens from base of basal spine to tip of claw, longer pecten on last half (figs.13e-g).

First antenna (antennule) (figs.11a-b, f, and 13d)***:*** short, not protruding beyond tip of rostrum but pointing downward. Body compact, about twice as long as wide. Distal end with nine aesthetascs, one distalmost aesthetasc, implanted on elongated apex, as long as antennule and about 1.5 times as long as other aesthetascs, subapical aesthetasc of same length as antennule, accompanied by antennular sensory seta, implanted at about one third of distal end. All aesthetascs projecting beyond tip of rostrum (figs.11a-b, 13d).

Second antenna (figs.11a-b, g)***:*** relatively short, reach about 1/3 of body. Basal segment with conical distal spine. Antennal formula spines with three marginally spines in formula: 0-0-1/1-0-1 and with eight setae in formula: 1-1-3/0-0-3. All setae

bisegmented, setulated distally. Seta arising from basal segment of endopodite not extending beyond tip; exopodite seta longer and setulated. Seta arising from middle segment of exopodite long, as half of three seta on distal segment. Terminal spines as long as their segment. Surface of segments with rows of setules. Coxa with distinct short denticle on anterior side between rami and its surface provided with clusters of longer setae on upper part, longest rows at second coxa.

Trunk limb: six pairs

First trunk limb (P1) (figs.12a-b)***:*** Epipodite and Exopodite not seen. Outer distal lobe (ODL) with one long seta (I'), with short distal setulation. Inner distal lobe (IDL) with three setae (I-III), seta I short and slender, chitinized hook-like, with one small sensillum (sn) near base, seta II and III bisegmented, similar in length to ODL seta, with fine setules along distal part. Endite 3 (E3) with four setae (1-4), seta 1 same as seta 2, both bilaterally setulated with short setules, seta 3 more slender and longer than seta 4, both unilaterally armed with short setules, one sensillum (sn) at base of seta 3. Endite 2 (E2) with three long setae (5-7), seta 5 more slender, bilaterally setulated, setae 6 and 7 armed with stiff setules along distal segment, two radial rows of setules at base of endite. Endite 1 (E1) with two setae (8-9), both setulated and longer than setae on other endites but not protruding beyond them. Close to endite 1, a blunt projection with radiant setules. Trunk with 5-6 rows of stiff setae on ventral surface, about 6 setae on last row. Two ejector hooks, similar in size, unilaterally spinulated distally. Rows of thin setae on the base of trunk, about 4-7 setae in rows. Gnathobase not studied.

Second trunk limb (P2) (fig.12c)***:*** Epipodite not seen. Exopodite (EX) round-elongated, setulated on slightly inflated apex, one short seta at about half its length. Endopodite (EN) triangular, with eight scrapers (1-8), decreasing in length towards gnathobase, though scraper 4 shorter than scraper 5; scrapers 1 and 2 equal in length, unilaterally armed with fine setules as on scraper 4; scrapers 3 and 5 unilaterally armed with strong setules; scrapers 6-8 unilaterally armed with strong setules but less than on scrapers 3 and 5. Distal armature of gnathobase (GT) with two elements (I-II), both hook-like, naked, one minute element on the hillock element I. Gnathobasic filter

comb with seven setae, the posteriormost considerably shortest and the rest are the same length.

Third trunk limb (P3) (fig.12d)***:*** Epipodite (EP) not seen. Exopodite (EX) subquadrangular bearing seven setae (1-7), seta 1 and seta 2 located laterally, in typical V-formation, both similar in length, seta 3 longest, densely feathered, seta 4 and seta 5 the same length, about 1/5 times as long as the longest, both plumose, seta 6 and 7 slender, seta 7 about half the longest.

Endopodite (EN) divided into two rows; anterior row with three appendages on external portion (1-3). Spines 1 and 2 stout, similar in length, both unilaterally spinulated, small sensillum (sn) located between spines 1 and 2, seta 3 more slender, bilaterally setulated distally; a posterior comb of four plumose setae (1'-4'), gradually increasing in length to gnathobase. Gnathobase (GT) with three elements (I-III), element I large, curved inwards, unilaterally setulated with long setules, element II and III shorter, naked, fused at the base. Gnathobasic filter comb with seven setae, gradually increasing in length posteriorly.

Fourth trunk limb (P4) (figs.12e-f)***:*** Epipodite not seen. Exopodite (EX) quadrangular, bearing six setae (1-6), seta 1 and 2 are of the same length, though seta 2 may be shorter, both bilaterally setulated, seta 3 plumose and longest, setae 4, 5 and 6 of the same length, about a half of the longest seta (fig.12e) or unequal in length, setae 4 and 5 bilaterally armed with short setules from base to tip; setae 5 and 6 forming a forceps; seta 6 more slender, bilaterally armed with shorter setules on distal part.

Endopodite (EN); anteriorly bearing five appendages (1-5). Spine 1 stout, rounded basally and more slender distally, unilaterally armed with short denticles, setae 2-4 'flaming torch' setae, seta 2 widened, apically with a crown of about 10 stiff setae, setae 3 and 4 more slender, all armed with slender-long setules on distal end, counting 6 and 8 setules respectively, seta 5 a rod-like receptor, naked; posterior portion bearing three setae (1'-3'), setae 1' and 2' are of the same length, but seta 3 about 1.5 times longer than setae 1 and 2. Gnathobase (GT) horse-tail seta compose of three elements (I-III), element I large-slender, unilaterally setulated, element II and III

short, naked fused at the base to each other. Gnathobasic filter combs five setae, equally in length.

Fifth trunk limb (P5) (fig.12g)***:*** Pre-epipodite (PEP) elliptical, with long setae setulated radially, elongated digitiform projection not seen. Epipodite (EP) more ovoid, smaller than pre-epipodite. Exopodite (EX) not form bilobe, bearing four apical setae (1-4), densely setulated apically; anterior portion bearing three setae (1-3), gradually decreasing in length posteriorly, though seta 1 shorter than seta 2, all bilaterally setulated, posterior portion bearing one seta (seta 4), relatively short about 1/3 of seta 3, bilaterally setulated.

Endopodite (EN) larger than pre-epipodite and epipodite, more ovoid, setulated apically, two endopodite setae setulated distally, one as a half length of another.

Sixth trunk limb (P6): ciliated lobe (Sinev, 1999).

Variability:

Some variability was noted in 1) the shape of the labrum and number of distal setules on its apex; 2) size of center pore and width of the channel connection; 3) length of setae 4-6 on exopodite of trunk limb 4.

Differential diagnosis:

The characters as the shape of the postabdomen; the structure of the head pores and trunk limbs of *A. cheni* appears to share with other member of *costata*-group, *A. costata*, *A. rustica*, *A. setigera*, *A. hudeci*, *A. bicolor*, *A. fabricii* and *A. muelleri*, make these species easily distinguished from the majority of other *Alona.*

A. cheni can be separated from *A. costata* by several clear-cut differences in head pore structure and trunk limbs: middle pore smaller than other two, wide connection between middle and posterior head pore, longer lateral pores, and semi-circular, not rounded, lateral pore pockets with depth only 0.5 length of pore proper; scrapers 1-3 on trunk limb 1 of *A. costata* longer than other scrapers obviously but in *A. cheni* all scrapers seem to be more gradually increasing in length distally; seta 4 on

exopodite of trunk limb 3 same length as seta 5 but it shorter in *A. pulchella*; in addition seta 5 shorter than seta 6 but they are the same length in *A. costata*. The differences between the species and some differences in the present specimens are summarized in table 3.

Remarks:

At present we can recognize eight species of *Alona* as belonging to the *costata*-group: *A. costata*, *A. cheni, A. setigera, A. rustica, A. hudeci, A. bicolor, A. fabricii* and *A. muelleri.* This group is defined as follows (Sinev, 1999): 1) transverse lateral head pores with large to very shallow pockets behind. This character is unique in *Alona* and in the subfamily Aloninae as a whole and 2) male postabdomen with sperm ducts opening at end of a process protruding above base of postabdominal claws (Sinev, 1999). There are no other species of *Alona* with such a male postabdomen, similar to *Leydigia* Kurz, 1875.

During last two decades, the name '*Alona costata*' has been recorded in each study in Thailand. As usual, we followed the key from Malaysia (Idris, 1983) which shows sac-like lateral head pores as the main characteristic of this species. Without checking the difference of pores shape and/or depth of the pockets and other details, especially trunk limbs, we name any *Alona* with such a character *Alona costata*. However, after checking specimens from southern and northeast Thailand, Malaysia and Singapore, the records of *A. costata* all seem to belong to *A. cheni* as these specimens present semi-circular pockets of lateral pores and those characteristics of trunk limbs as mentioned in differential diagnosis.

However, there are some differences in general characters and trunk limbs between *A. cheni* described from type locality, India, and Thai specimens, not mentioned in the original paper, as following (table 5) 1) in Thai specimens, anterior margin and tip of labrum rounded, height about 2 times maximum width and two clusters of more dense setules on posterior margin, close to each other, but more it more obtusangular tip and height ~3 times maximum width in type specimen; 2) all scrapers on trunk limb 2 gradually increasing in length distally but in Thai specimens, seta 6-8 about 0.3-0.5 times shorter than seta 5 obviously; 3) spines on flaming torch seta on exopodite 4 about 1.5-2 times seta body in Thai specimens but

only 1-1.2 times in type specimen; 4) exopodite of trunk limb 5 not clearly forming lobe; and 5) one short seta on posterior portion of trunk limb 5 as a quarter of seta 2 on anterior portion in Thai specimens but this seta about half of seta 2 in type specimen.

Biology:

This species has been found mostly in freshwater swamps and marshes with dominance of *Cyperus* sp. It shows a higher abundance in the rainy season.

Distribution:

A. costata inhabits Europe and North Asia, reaching East Siberia and central Mongolia in the east as well as the Caucasus and northern Kazakhstan in the southeast. While A. *cheni* is currently known from three localities only, one in India, the other in China, and from Thailand, it can be presumed a common species at least in these countries, likely to have repeatedly been confused with the European A. *costata* (Sars, 1903; Chiang and Du, 1979; Sharma and Michel, 1987). The great distance between these three documented occurrences of *A. cheni* shows that its distribution is quite vast, possibly covering South and Southeast Asia.

Table 5 Morphological comparison among *Alona costata*, *A. cheni* and *A. cheni* from Thailand

Characters		***A.costata*** Sinev, 1999	***A. cheni*** India Sinev, 1999	***A. cheni*** Thailand Present data
Head pores				
main head pores	1)	3 interconnected median head pores	3 interconnected median head pores	3 interconnected median head pores
PP/IP	2)	0.5-0.8	0.7-0.9	0.9

Table 5. (Continued.)

Characters		***A.costata*** Sinev, 1999	***A. cheni*** India Sinev, 1999	***A. cheni*** Thailand Present data
lateral head pores	3)	2 lateral head pores transverse, length ~ 0.75IP	2 lateral head pores transverse, length ~ 0.9-1IP	2 lateral head pores transverse, length 1IP
location of lateral head pores	4)	0.5IP from midline	0.7IP from midline	~0.7IP from midline
pockets of lateral head pores	5)	large rounded depth ~2 times length of pore	**semi-circular depth ~0.5 times length of pore**	**semi-circular, depth ~0.5 times length of pore**
Labrum				
labral plate	6)	rounded anterior & rounded tip,	**not rounded tip but obtusangular**	rounded anterior & rounded tip,
	7)	height ~2 times maximum width	height ~3 times maximum width	**height ~2 times maximum width**
	8)	2 clusters of setules	2 clusters of setules	**2 clusters of more densely setules, closer to each other**
Trunk limb 2				
scrapers	10)	gradually increasing in length distally **but scrapers 1-3 longer than others obviously**	gradually increasing in length distally	gradually increasing in length distally **scrapers 6-8 ~0.3-0.5 times of scrapers 1-5**
Trunk limb 3				
Exopodite	11)	**seta 4 shorter than seta 5**	seta 4 as same length as seta 5	seta 4 as same length as seta 5
Trunk limb 4				

Table 5. (Continued.)

Characters		***A.costata*** Sinev, 1999	***A. cheni*** India Sinev, 1999	***A. cheni*** Thailand Present data
exopodite	12)	**seta 5 as same length as seta 6**	seta 5 shorter than seta 6	seta 5 shorter than seta 6
endopodite	13)	spines on flaming torch seta 1 time as long as body	spines on flaming torch seta 1-1.2 times as long as body	**spines on flaming torch seta 1.5-2 times as long as body**
	14)	seta 3 on posterior portion as long as setae 1 and 2	?	**seta 3 on posterior portion 2 times longer than setae 1 and 2**
Trunk limb 5				
exopodite	15)	2 lobes, anterior portion larger	2 lobes, anterior portion larger	**not clearly forming lobe**
	16)	one long seta on posterior portion, as 0.5 of the longest on anterior portion	one long seta on posterior portion, as half of the longest (seta 2) on anterior portion	**one short seta on posterior portion, as a quarter of the longest (seta 2) on anterior portion**

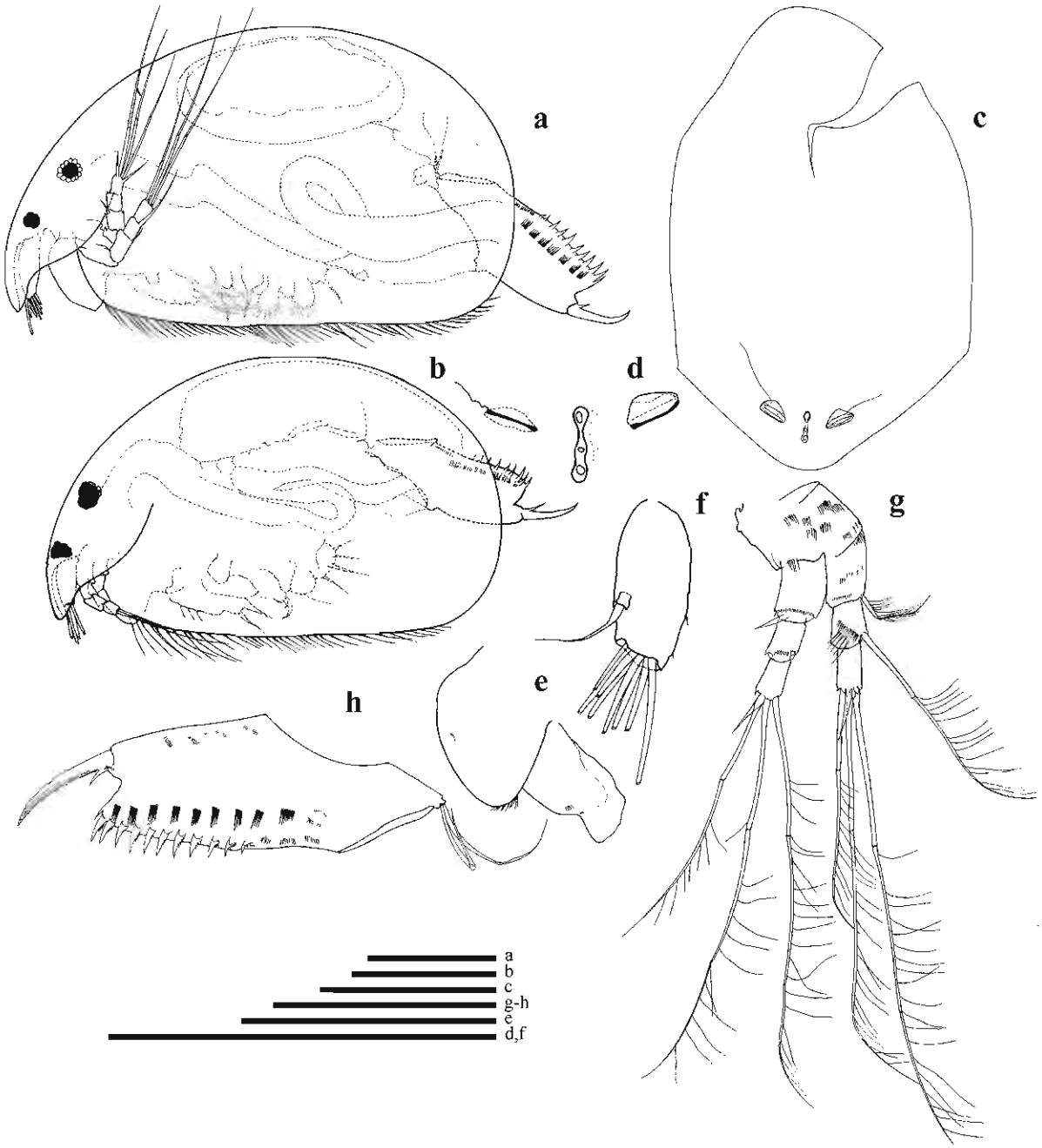


Figure 11. ***Alona cheni*** **(Chen & Peng,1993):** parthenogenetic females from Thungtong swamp (S19), Suratthani Province, (a,c-h) and from Pak Panang Bay, Nakhon Si Thammarat Province (b), southeastern Thailand. Figures a-b, adult female in lateral view; Figures c-d, head shield and its head pores; Figure e, labrum; Figure f, antennule; Figure g, antenna; Figure h, post-abdomen. Scale bars denote 100 um.

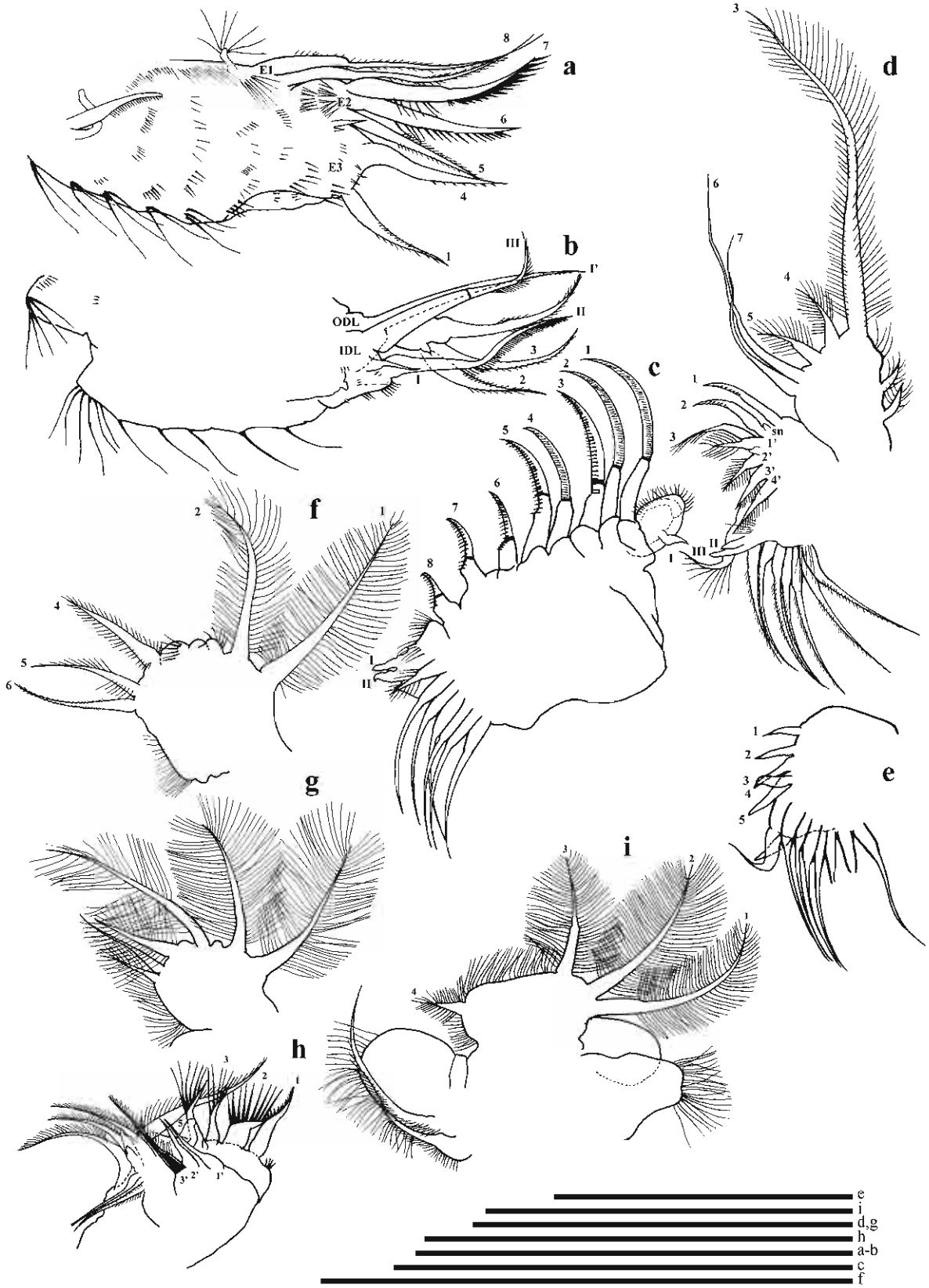


Figure 12. ***Alona cheni*** **(Chen & Peng, 1993):** appendages of females from Thungtong swamp (S19), Suratthani Province, southeastern Thailand. Figures a-b, trunk limb 1; Figure c, trunk limb 2; Figures d-e, trunk limb 3 and its inner portion; Figures f-h, trunk limb 4 and its inner portion; Figure i, trunk limb 5. Scale bars denote 100 um.

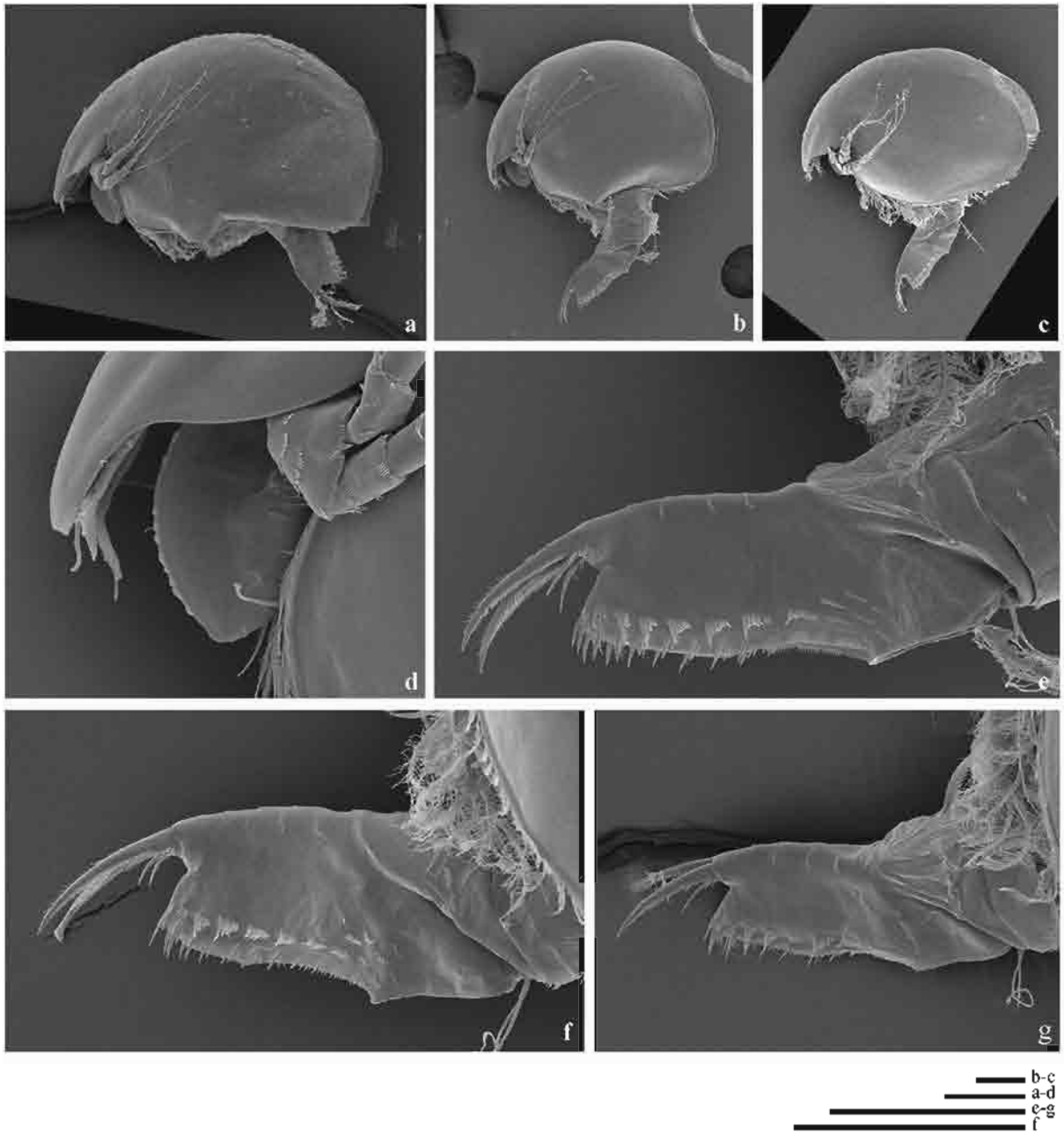


Figure 13. ***Alona cheni*** **(Chen & Peng, 1993):** parthenogenetic females from Thungtong swamp (S19), Suratthani Province, southeastern Thailand. Figures a-c, adult females in lateral view; Figure d, laburm; Figures e-g, postabdomen. Scale bars denote 100 um.

5. *Alona guttata* Sars, 1862

References: Sars, 1862: 287-289; Daday, 1902: Des.264, 264, no figs; Sabater, 1987: Des. 54, no fig.; Alonso, 1996: Des. 329, 331, fig. 146.

Type locality: Lake Ostensjovand, Norway

Materials examined:

Southern Thailand: two parthenogenetic females, examined complete and thereafter dissected, from Yai swamp (S04), Chumporn Province, southern Thailand. Collected by the author, SM.

Northeast Thailand: one parthenogenetic female, completed and dissected, from Lake Gud-Thing, Nong Khai Province, collected by C. Saeng-aroon, KKU.

The details of morphological study

We found only a few specimens of this species so it was difficult to make a complete description. However, the partial description of general characters including first and second trunk limbs can be proposed here.

Partial species description (See figure 14)

Parthenogenetic female

General shape: Body oval to ovoid in lateral view (fig.14a), maximum height around middle of body. Length 0.38-0.42 mm, about 1.6-1.7 times maximal height (n=3) (size 0.25-0.27 mm; Daday, 1902). Dorsal margin form slightly curved. Postero-dorsal and postero-ventral angles round. Posterior margin slightly concave. Antero-ventral corner almost rounded. Ventral margin almost straight, ventral setae relatively short, ending before posteroventral corner, followed by short setules posteriorly (fig.14b). Longitudinal valve striation best visible in posteroventral quarter of valve.

Head: relatively small (fig.14a). Rostrum pointing downwards. Compound eyes present, larger than ocellus, distance between eyes and ocellus same as distance from ocellus to tip of rostrum, sometime shorter. Head shield not studied. Three major head

pores (fig.14c), anterior and posterior one of the same size, central head pore smaller, all connected by a narrow channel. Two small lateral pores located slightly close to posterior.

Labrum: large (fig.14a), with rounded anterior margin or slightly wavy laterally and blunt at apex, with row of spinules apically (fig.14d).

Postabdomen: width about 1.5 times maximum height (fig.14f). Dorsal margin narrow distally, forming triangular-like distal end, with an angle of 45-50 ^{o}. Posterodorsal corner sharp, with an angle of 60^{o} or little less. Posterior margin with indentation. Anal margin relatively straight, with no distinct pre-and postanal corner, bearing 2-3 rows of setules, each row consisting of 5-10 setules. Lateral fascicles: 8-9 postanal groups, each consisting of 4-8 denticles. Marginal denticles: 10-11 groups of merged spinules, gradually increasing in size distally and bearing 3-5 fused denticles on inner edge. One group of venterolateral denticles. Natatorial setae with long distal end.

Terminal claw: long and slender, about as long as anal margin. Basal spine, relatively moderate and slender, length a third of terminal claw or little less, situated at the base of the pecten with row of denticles on first half, three setules arising in proximal part of basal spine, close to base of claw.

First antenna (antennule): reaching, protruding almost reach the tip of rostrum (fig.14a). Body elongated, about twice as long as wide. Distalmost aesthetasc, implanted on elongated apex, about 1.2 times as long as other aesthetascs. Subapical aesthetasc haft the length of antennule. All aesthetascs projecting beyond tip of rostrum.

Second antenna: reach about half of body, antennal formula setae 0-1-3/0-0-3, spines 0-0-1/1-0-1 (fig.14e). All setae bisegmented. Spine arising from basal segment of endopodite not extending beyond the tip of second segment. Rows of 7-8 setules on second segment of exopodite, located at the base of long seta. Surface of segments

with rows of setules. Coxa with distinct short denticle on anterior side between rami and its surface provided with clusters of longer setae on upper part, longest rows at second coxa. The spine on first exopod segment as long as the second.

Trunk limb: five pairs

First trunk limb (P1) (figs.14g-h): relatively small. Outer distal lobe (ODL) with one seta (I') (fig.14h), slender and bearing short, fine setules distally, hardly visible. Inner distal lobe (IDL) with two slender setae (I-II), of the same length, and the same length as ODL seta, both unilaterally setulated distally. Groups of spinules at the base of IDL trunk. Endite 3 (E3) with four plumose setae (1-4), setae 1-3 of the same length, seta 4 longer and base wider, all armed with short setules distally. Endite 2 (E2) bearing three setae (5-7), seta 5 as long as seta 4 and similarly armed, setae 6-7 as same length, seta 6 unilaterally armed with fine setules distally and seta 7 unilaterally armed with sparsely setules distally. Endite 1 (E1) with two apical setae (8-9), seta 8 more slender, unilaterally armed with short and fine setules. One accessory seta located laterally (arrow). Rows of small spinules on trunk and two rows of slender spinules present more radial on inner side of endite 2. Trunk with 4-6 rows of thin setae on ventral surface, 5-7 setae each. Basally two long and slender ejector hooks, one smaller, unilaterally armed with short setules. Epipodite and gnathobase not seen.

Second trunk limb (P2) (fig.14i)***:*** Epipodite and Exopodite not seen. Endopodite (EN) triangular, with eight scrapers (1-8), generally decreasing in length towards gnathobase though scraper 1 shorter than scraper 2, all bi-segmented, scrapers 1 and 2, similarly armed with fine setules distally, scrapers 3-4 unilaterally armed with strong setules distally, scrapers 5-6 unilaterally armed with finer setules distally but not fine as the first two, scrapers 7-8 base wider, unilaterally armed with strong setules distally. Small hillock before distal armature of gnathobase (GT), with four elements (I-III), one minute (I), element II hook-like, element IV small, all fused at the base. Gnathobasic filter comb present but number of setae unclear.

Variability:

Variability can be found in the characters of 1) postabdomen, dorsal margin narrowing distally and form triangular-like distal end but varied in the angle; and 2) labrum: the presence of a row of a number of setules distally or only few.

Differential diagnosis:

This species can be distinguished by 1) labrum: the presence of a row of setules on its tip; 2) postabdomen: dorsal margin narrow distally, triangular-like distal end, forming an angle about 45-50^{o}, ventero-dorsal margin prominent; 3) second antenna: row of 6-7 long setules at the base of seta arising from middle segment of exopodite and 4) trunk limb 1: setae 6 and 7 equal in length, seta 7 armed with strong denticles.

Biology:

Mostly found in freshwater swamps and marshes, more abundance in shallow-stagnant habitats, with dominance of *Cyperus* sp. and *Nymphea* sp. It also can be found in the littoral of lakes and reservoirs (Armengol, 1978), it is distributed over small water bodies of the humid area (Alonso, 1985) and it was also found in the interstitial habitats Sabater (1987).

Distribution:

This species appears to distribute worldwide: Europe; Spain (Alonso, 1996); Africa; Cameroon (Chiambeng, 2004); Australia (Griggs, 2001), Asia; Malaysia (Idris and Fernando, 1984), Thailand (Sanoamuang, 1998).

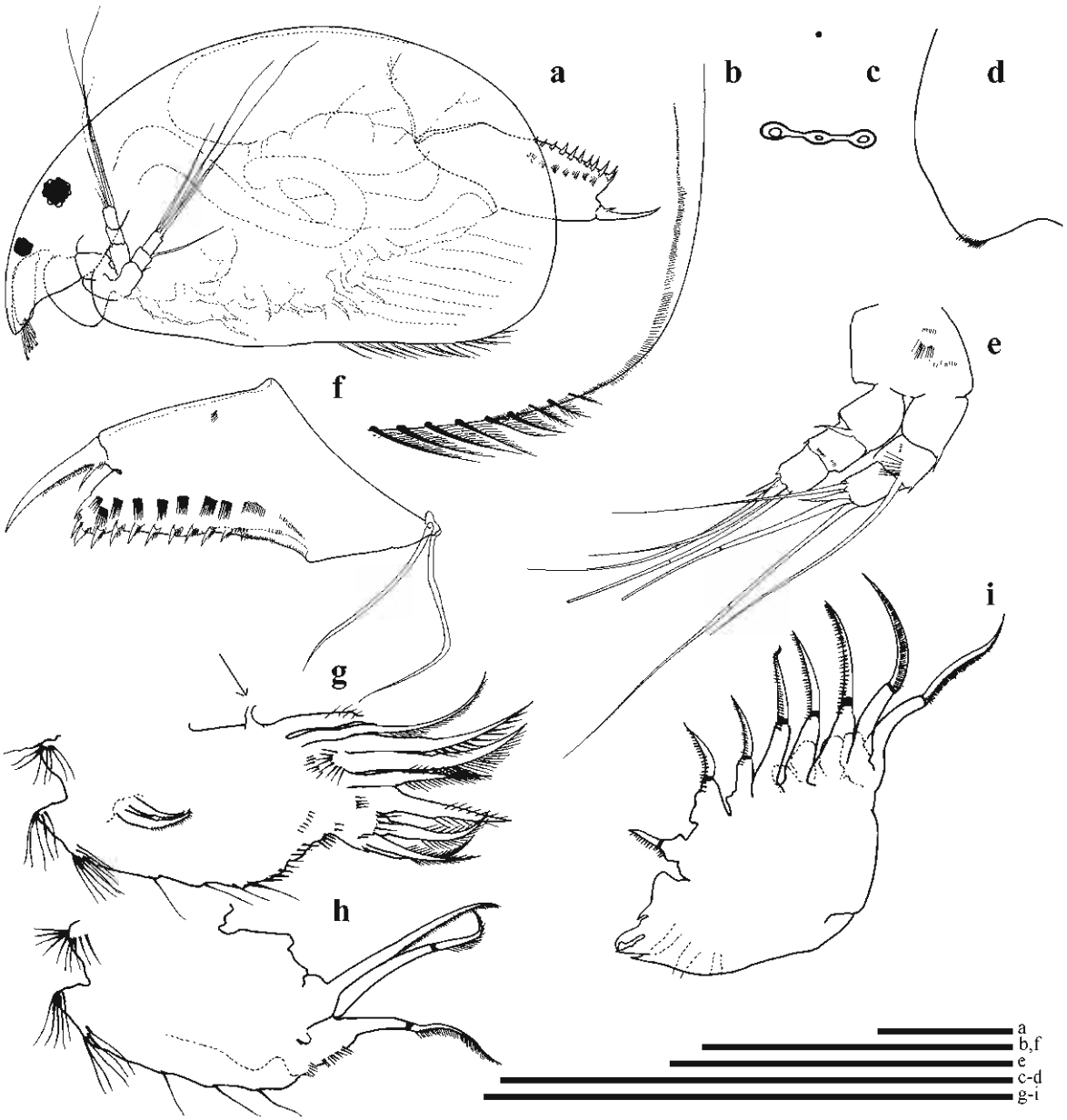


Figure 14. ***Alona guttata*** **Sars, 1863:** parthenogenetic female from Lake Kud-thing, north-eastern Thailand (a), appendages of female from Yai swamp (S04), Chumporn Province, southern Thailand (b-i). Figure a, adult female in lateral view; Figure b, postero-ventral corner of valve; Figure c, head pores; Figure d, labrum; Figure e, antennule; Figure f, postabdomen; Figures g-h, trunk limb 1; Figure i, trunk limb 2. Scale bars denote 100 um.

6. *Alona intermedia* Sars, 1862

Materials examined:

Southern Thailand: two parthenogenetic females, examined complete and thereafter dissected, from swamp in Pratong Island, Phang-nga Province, southwestern Thailand, collected by PM.

The details of morphological study

Species description (See figure 15)

Appendages of parthenogenetic female

Postabdomen (fig.15f)***:*** Quadrangular shape, length about 2 times maximum height, distal and preanal portion not clearly distinct. Slightly more broad distally, dorsal and ventral margin almost parallel. Anal margin relatively straight, with no distinct pre- and postanal corner, hard to define, bearing 3-5 rows of small denticles, each row bearing up to 12 small denticles. Lateral fascicles: 8-9 postanal groups, each consisting 4-10 denticles, gradually increasing in length distally. Marginal denticles: 9-10 groups of separated spinules, gradually increasing in size distally. Two groups of venterolateral denticles.

Terminal claw (fig.15f)***:*** Long and slender, as long as anal margin, bearing long and slender basal spine, length about 1/2 terminal claw, situated at half its length from base of pecten, inner row of small pectens from base of basal spine to tip of claw.

Trunk limb: six pairs

First trunk limb (P1) (figs.15a-b)***:*** Epipodite and Exopodite not seen. Outer distal lobe (ODL) with one long seta (I'). Inner distal lobe (IDL) with three setae (I-III), seta I short and slender, about 1/3 of the longest seta III, seta II and III bisegmented with fine setules along distal part, seta II slightly shorter than seta III (fig.15a). Endite 3 (E3) with two setae (1-2), both with the same length and bilaterally setulated with short setules. Endite 2 (E2) with three stout setae (3-5), seta 4 more slender, and longest, unilaterally armed with stiff setules along distal segment, two radial rows of setules at base of endite. Endite 1 (E1) with four setae (6-9), all setulated and shorter than setae on other endites. Two ejector hooks, similar in size, unilaterally spinulated

distally. Rows of thin setae on the base of trunk, about 4-7 setae in rows. Gnathobase not studied.

Second trunk limb (P2) (fig.15c)***:*** Epipodite not seen. Exopodite (EX) round-elongated, setulated on slightly inflated apex, one short seta apically at about half its length. Endopodite (EN) triangular, with eight scrapers (1-8), decreasing in length towards gnathobase, though scraper 4 longer than scraper 3; scrapers 1 and 2 unilaterally armed with fine setules; scrapers 3-5 unilaterally armed with stronger setules; scrapers 6-8 unilaterally armed with strong setules but less than on scrapers 3-5. Distal armature of gnathobase (GT) with two elements (I-II), both hook-like, naked, one minute element on the hillock element I. Gnathobasic filter comb with seven setae, the posteriormost considerably shortest, about 1/3 of the others and the rest are the same length.

Third trunk limb (P3) (fig.15d)***:*** Epipodite (EP) not seen. Exopodite (EX) subquadrangular bearing seven setae (1-7), seta 1 and seta 2 located laterally, in typical V-formation, both similar in length, about 1/5 times as long as the longest, seta 3 longest, densely feathered, seta 4 and seta 5 the same length, about 1/6 times as long as the longest, both plumose, seta 6 and 7 slender, seta 6 about 2/3 of the longest and seta 7 about 1/3 of seta 6.

Endopodite (EN) divided into two rows; anterior row with three appendages on external portion (1-3). Spines 1 and 2 stout, decreasing in length posteriorly, both unilaterally spinulated, seta 3 more slender, bilaterally setulated distally; posterior row not clear. Gnathobase (GT) with three elements (I-III), element I large, curved inwards, unilaterally setulated with long setules, element II and III shorter, naked, fused at the base. Gnathobasic filter comb with seven setae, gradually increasing in length posteriorly.

Fourth trunk limb (P4) (figs.15)***:*** Epipodite not seen. Exopodite (EX) quadrangular, bearing six setae (1-6), seta 2 longest, setae 1 and 3 slightly shorter, all bilaterally setulated, seta 4 plumose and shortest, about half of seta 3, setae 5 and 6 more slender,

both of the same length, about a half of the longest seta, both bilaterally armed with short setules from base to tip.

Endopodite (EN); anteriorly bearing five appendages (1-5). Spine 1 stout, rounded basally and more slender distally, unilaterally armed with short denticles, setae 2-3 ‘flaming torch’ setae, widened basally, apically with a crown of about 6 stiff setae, setae 4-5 a rod-like receptor, naked; posterior portion bearing three setae (1’-3’), setae 1’ and 2’ are of the same length, but seta 3 about 1.5 times longer than setae 1 and 2. Gnathobase (GT) compose of three elements (I-III), element I large-slender, unilaterally setulated, element II and III short, naked fused at the base to each other. Gnathobasic filter combs fore setae, equally in length.

Variability:

Number of material examined was too small to study its variation.

Differential diagnosis:

A. intermedia can be separated from other *Alona* mainly by the characters of postabdomen.

Figure 15. ***Alona intermedia*** **Sars,1862:** appendages of parthenogenetic females from Pratong Island. Figures a-b, trunk limb 1; Figure c, trunk limb 2; Figure d, trunk limb 3; Figure e, trunk limb 4; Figure f, postabdomen. Scale bars denote 100 um.

7. *Alona monacantha* Sars, 1901

References: Sars, 1901: 54-55, pl. 9: figs 5, 5a, 5b; Idris and Fernando, 1981: Des. 250, figs.67-71.

Type locality: "mud, partly from the neigh-boarhound of São Paulo, partly from Ipiranga", Brazil, South America

Type material: material from type-locality: tube GOS-F12332 & F12333

Materials examined:

Southern Thailand: two parthenogenetic females, examined complete and thereafter dissected, from Paumi marsh (S53), Yala Province, southeastern Thailand. Collected by the author, SM.

Northeast Thailand: one parthenogenetic female, examined complete, from Lake Kudthing, Nhongkai Province. Collected by C. Seang-aroon, KKU.

The details of morphological study

Species description (See figures 16-17)

Parthenogenetic female:

General shape (fig.16a)***:*** Body in lateral view oval, more quadrangular, maximum height around the middle of body. Length 0.25-0.31 mm, about 1.2-1.3 times maximum height in adults (n=3). Dorsal margin generally curved, depression between head and rest of body not seen. Antero-dorsal angle rounded. Postero-dorsal angle prominent. Postero-ventral margin rounded, bearing 2-3 denticles; sharp in some specimens (fig.16a) but some more leaf-like (fig.16b), followed by small setules along posterior margin reach to the middle of the body. Ventral margin almost straight. Ventral setae relatively short, with 26-30 setae, decreasing in length posteriorly, the posteriormost setae more robust. Ornamentation of valve stripe-like or rectangular in some specimens.

Head*:* moderate size, rostrum well developed, pointing downwards. Compound eye present, size larger than ocellus; distance between eyes and ocellus same as between ocellus and tip of rostrum. Three major head pores, central pore the same size of anterior and posterior one, or smaller in some specimens (fig.16d) and larger in some specimens (fig.16c), located at the middle, all connected with narrow channel.

Labrum (figs.16a,e-f)***:*** large, with a broadly rounded anterior margin, labral tip rounded (fig.16e) or slightly form angle (fig.16f). Posterior edge convex. Single minute denticle laterally, hardly visible (fig.16a).

Postabdomen (fig.16i)***:*** width about 2 times height, widest at postanal corner. Dorsal margin gradually narrowing distally from postanal corner on, but almost parallel to ventral margin. Postanal margin longer than anal margin. Anal margin concave, with distinct pre-and postanal corner and bearing row of small denticles. Postanal margin slightly concave distally. Lateral fascicles: about 4 postanal groups, each consisting of 8-9 denticles; about 6 groups on anal portion, each consisting of 3-7 denticles, situated parallel to each other, row of 8-9 smaller denticles on anal margin. Marginal denticles: 6-7 groups of 2-3 spinules in group, gradually increasing in size distally, distalmost largest.

Terminal claw (fig.16a)***:*** about as long as postanal margin, evenly curved to tip, row of pecten from base to tip, gradually decreasing in length towards tip of claw. Basal spine slender, length about half of terminal claw, unilaterally armed with small setules along spine, 3 fine setules arising proximal to base of basal spine, length about one third of basal spine.

First antenna (antennule) (figs.16a, g)***:*** short, not reaching tip of rostrum. Body compact, rod-like, about twice as long as wide, three slender stules laterally. Distal end with nine aesthetascs unequal in length, one longest, as long as antennular body, length of the rest ranges from 1/2- 2/3 of antennular body. All aesthetascs projecting beyond tip of rostrum.

Second antenna (figs.16a, h)***:*** reaching about half way of body (fig.16a). Antenna formula: setae 0-0-3/0-1-3, spine 0-1-1/0-0-1. Basal segment of exopodite and endopodite thicker and longer than other segments, about 2 times middle segment, middle segment shortest, terminal segment thinnest. Row of small spinules at distal edge of each segment. All setae bi-segmented, seta arising from middle segment of exopodite thin, row of three slender setules arising from base of this seta. All spines longer than their segments.

Trunk limb: five pairs

First trunk limb (P1) (figs.17a-d)***:*** Outer distal lobe (ODL) with one seta (I') slender, as long as seta II on inner distal lobe (fig.17b) or little less (fig.17a), bearing short, hardly visible setules distally. Inner distal lobe (IDL) bearing two setae (I-II), subequal in length, their distal end unilaterally armed with long setules, counting about 5, decreasing in length distally, two basalmost obviously larger. Row of setules at base of the lobe. Endite 3 (E3) with four plumose setae (1-4), gradually increasing in length towards gnathobase though seta 2 smaller than seta 1, all plumose. Endite 2 (E2) bearing three setae (5-7), seta 5 as long as endite 3 setae, plumose, seta 6 slender and longest (fig.17d), seta 7 shorter, both unilaterally setulated with long setules distally and unilaterally armed with short and stronger setules basally, counting about 7-9 setae, two rows of small setules situated radially on inner side of endite. Endite 1 (E1) with two setae (8-9), seta 8 longer, unilaterally densely armed with fine setules distally, seta 9 shorter, unilaterally armed with shorter setules distally. Trunk with 5-6 rows of slender spines laterally, counting 4-5 spines each group, increasing in length basally. Basally two slender ejector hooks, similar in size, unilaterally armed with short setules distally. Epipodite and gnathobase not seen.

Second trunk limb (P2) (fig.17e)***:*** Epipodite not seen. Exopodite (EX) elongate with naked digitiform projection. Endopodite (EN) triangular, with eight scrapers (1-8), generally decreasing in length towards gnathobase though scraper 3 shorter than scraper 4, all scrapers bi-segmented; scrapers 1 and 2 unilaterally densely armed with fine setules, scrapers 3-5 unilaterally armed with strong setules but not as strong as on scrapers 6-8, scrapers 6-8 more robust, unilaterally armed with strong denticles

distally, counting 6-7 denticles. A rounded hillock between scraper 8 and gnathobase, apically setulated, followed by a minute denticle (fig.17e, arrow). Distal armature of gnathobase (GT) with three elements (I-III), element I and II of same size, rod-like, thin, naked, element III smaller, naked, located close to the base of element II, follow by a minute denticle at the base of element III. Gnathobasic filter comb present but number of setae unclear.

Fourth trunk limb (P4) (fig.17f)***:*** Epipodite not seen. Exopodite (EX) more round than oval, bearing six setae (1-6), seta 3 slender, plumose, a hillock between seta 2 and seta 3 (arrow), apically setulated; conical-like seta 4 shorter, about half of seta 3, seta 5 longer than seta 6, both more slender, followed by row of long setules on body of exopodite.

Endopodite (EN) or inner portion anteriorly bearing five setae (1-5). Seta 1 stout, naked, unilaterally setulated with short setules distally, hardly visible; setae 2-4 'flaming-torch' setae, gradually decreasing in size towards gnathobase, distally armed with long slender setules, counting 4-5 setules each, followed by seta 5 round-elliptical like receptor, comparable in size to seta 4, naked; posteriorly bearing three setae (1'-3'), generally increasing in length towards gnathobase, all setulated. Gnathobase (GT) with two elements (I-II), element I large, unilaterally setulated distally, element II smaller, naked, fused at the base of each other.

Fifth trunk limb (P5) (fig.17g)***:*** Pre-epipodite (PEP) rounded, apically with long setules, elongated digitiform projection not seen. Epipodite (EP) rounded, similar in size of pre-epipodite, with elongated digitiform projection. Exopodite (EX) bilobed, bearing four apical setae (1-4); anterior portion bearing setae 1-3, setae 1 and 2 subequal in length, seta 3 shorter, all setae setulated; posterior portion bearing one seta (seta 4), relatively short, setulated. Row of long setules on posterior portion.

Endopodite (EN) larger, more oval, apically setulated, two endopodite setae.

Variability:

Some variability was noted in the following characters: 1) number of denticles at postero-ventral angle of valve which can be 2 or 3; 2) center pores vary in size, they

may be smaller or larger comparatively with anterior and posterior pores; 3) labrum; tip rounded or form angle; 4) ornamental of valve striation or quadrangular; 5) ODL seta as the same length of IDL seta II or shorter; 6) basalmost spine on IDL setae large or smaller and 7) setae 6-7 on endite 2 of trunk limb 1 slender and long or shorter.

Differential diagnosis:

This species can be distinguished by 1) the presence of 2-3 denticles at posterior-ventral angle of valve and shape of denticles sharpen or leaf-like; 2) body shape more oval, quadrangular; 3) shape of labrum, a minute denticle at anterior margin, tip rounded or form angle; 4) row of three setules at the base of seta on middle segment of exopodite second antenna; 5) terminal claw with long basal spine; 6) ODL seta same length as IDL setae or little less and 7) IDL setae armed with long setules, basalmost setule large.

Remarks:

Sars (1901) described this species from Brazilian specimens with only one denticle on the postero-ventral corner of the valve. Denticle numbers later became one of the important characters for separating this species into subspecies. In 1905, Stingelin described *Alona acusticostata* var. *tridentata* from Thailand which has three denticles on each valve. In 1974 Smirnov described this species named *Alona monacantha tridentata* and it has been remarked that this subspecies, unique in the present of three denticles, was found only from Thailand. However, the number of denticles turned out to be variable since the specimens found later on show mixed numbers of denticles, even at a single locality (present data). In the Asian region, this species also show high variation: Sri Lanka specimens have only one denticle, in contrast, Malaysian specimens have a number of denticles ranging from 1-3 denticles, in different combination of both valves (Idris and Fernando, 1981), and the specimens from present study show both two and three denticles.

Biology:

This species can be found in swamps and marshes. In present study it also can be found in open area habitats; however it reaches a high abundance in vegetated habitats.

Distributions:

Alona monacantha Sars, 1901 is distributed in Africa; Cameroon (Chiambeng, 2004), Australia (Griggs, 2001), and Asia; Malaysia (Idris and Fernando, 1981), Thailand (Stingelin, 1905; Sanoamuang, 1998; Sa-ardrit, 2001; Sa-adrit and Beamish, 2004)**.**

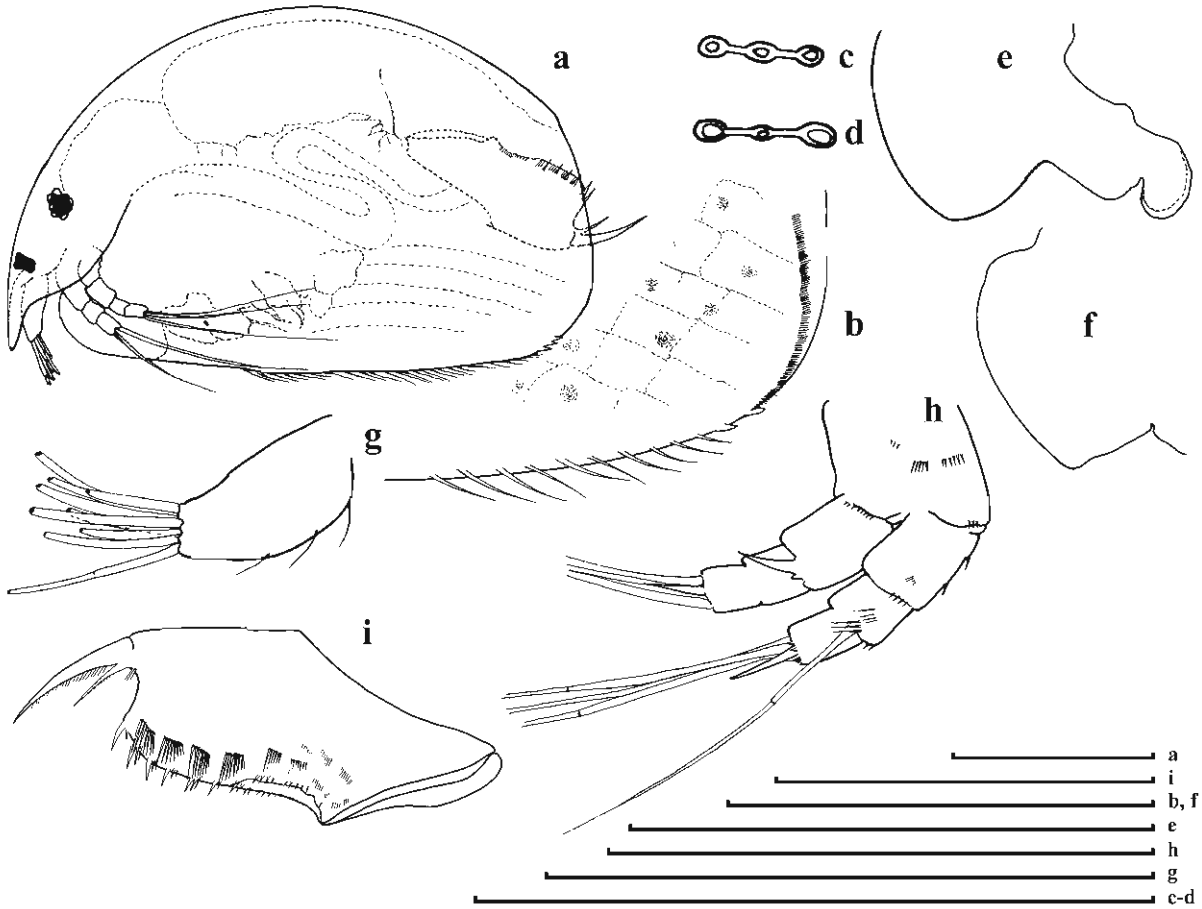


Figure 16. ***Alona monacantha*** **Sars, 1901:** parthenogenetic females from Paumi marsh (S53), Yala Province, southeastern Thailand. Figure a, adult female in lateral view; Figure b, postero-ventral of valve; Figures c-d, head pores; Figures e-f, labrum; Figure g, antennule; Figure h, antenna; Figure i, postabdomen. Scale bars denote 100 um.

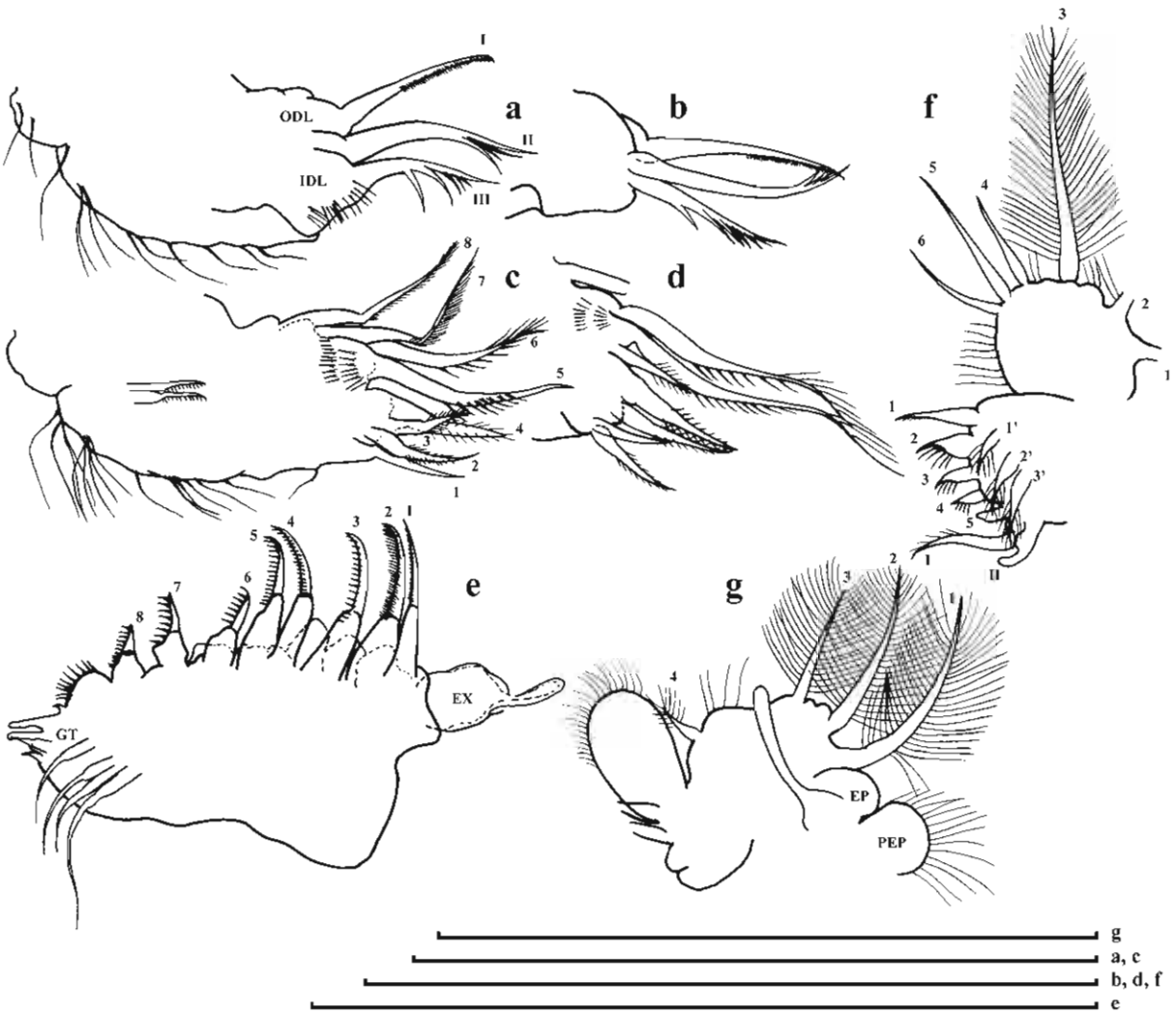


Figure 17. ***Alona monacantha*** **Sars,1901:** appendages of female from Paumi marsh (S53), Yala Province, southeastern Thailand. Figures a-d, trunk limb 1; Figure e, trunk limb 2; Figure f, trunk limb 4; Figure g, trunk limb 5. Scale bars denote 100 um.

8. *Alona rectangula* Sars, 1862

Synonymy: *Coronatella rectangula* in Dubowski & Grochowski, 1894: 381

Type locality: Dam paa Egeberg

Materials examined:

Southern Thailand: two parthenogenetic females, examined complete and thereafter dissected, from Yao swamp (S03), Chumporn Province (10^{o} 42.89N, 99^{o} 20.15E), southern Thailand. Collected by the author, SM.

: one parthenogenetic female, examined complete, from Kubaekata marsh, Narathivas Province (5^{o} 51.31N, 101^{o} 55.62E), southeastern Thailand. Collected by the author, SM.

Northeast Thailand: one parthenogenetic female, examined complete and thereafter dissected, from Lake Gudthing, Nhong Kai Province, collected by C. Saeng-aroon, KKU.

The details of morphological study

Species description (See figures 18-19)

Parthenogenetic female

General shape (figs.18a-b): Body in lateral view oval to rectangular (fig.18a), maximum height at middle of body. Length 0.28-0.30 mm, about 1.5 times maximum height in adults (n=3), height 0.18-0.20 mm. Dorsal margin form curved, depression between head and rest of body not seen. Antero-ventral angle rounded. Postero-dorsal and postero-ventral angles rounded. Posterior margin convex. A row of small setules along posterior margin up to postero-dorsal margin, not organized in groups. Ventral margin slightly concave, with 29 setae of different length, shorter posterior end, series of 3-7 setules with equal length posteriad between them. Valve with longitudinal striation.

Head (figs.18a,d-e)***:*** relatively small. In lateral view, rostrum well developed, protruding downwards (fig.18a). Compound eyes present. Three major head pores connected by a narrow channel (fig.18d). Central pore the same size as anterior and posterior one, or little smaller (fig.18e), located at middle. Two lateral head pores located at level of middle central pore, about 1 IP distance from midline.

Labrum (figs.18a,c)***:*** large, with broadly rounded anterior margin and rounded tip. Labral keel rounded. Distal labral plate without setulation.

Postabdomen (figs.18a, h)***:*** wide about 2 times as long as high, widest at postanal corner. Dorsal margin gradually narrowing distally from postanal corner on. Preanal margin longer than anal and postanal margin. Anal margin concave, almost the same length as postanal margin, with distinct pre-and postanal corner and bearing 2 small denticles. Postanal margin slightly concave distally. Lateral fascicles: about 7-8 postanal groups, each consisting of 5-9 denticles; about 6 groups on anal margin, each consisting of 5-9 smaller denticles, situated more radial than parallel to each other. Marginal denticles: 7-9 groups of 2-3 spinules in group, gradually increasing in size distally. Natatorial setae short.

Terminal claw (figs.18a,h)***:*** about as long as postanal margin, evenly curved to tip. Basal spine slender, length about a third of terminal claw, 3 fine setules ariring proximal to base of basal spine, length about half of basal spine.

First antenna (antennule) (figs.18a,f)***:*** short, not reaching tip of rostrum. Body compact, rod-like, about twice as long as wide. Distal end with seven aesthetascs unequal in length, length about half of antennular body, aesthetascs seem to consist of two parts, - a thicker basal part and a thinner, more flexible distal part. All aesthetascs projecting beyond tip of rostrum. Accessory seta arising about 2/3 of antennular body, length as long as other aesthetascs.

Second antenna (figs.18a, g)***:*** short (fig.18a), reaching about 1/3 of body. Antenna formula: setae 0-0-3/0-1-3, spine 1-0-1/0-0-1. Basal segment of exopodite and

endopodite longer than other segment, about 2 times middle segment, terminal segment thinner. Row of small spinules at distal edge of each segments. Seta ariring from middle segment of exopodite thin. All spines longer than theirs segment. Basal spine of endopodite as long as terminal spine of exopodite.

Trunk limb: five pairs

First trunk limb (P1) (fig.19a)***:*** Outer distal lobe (ODL) with one seta (I'), thin and slender, length as IDL seta I, unilaterally armed with fine setules. Inner distal lobe (IDL) with two setae (I-II), seta II larger, both hook-like setae, bi-segmented, unilaterally armed with row of setae distal end, largest posteriormost seta (stout setule), three rows of small setules at base of lobe. Endite 3 (E3) with four plumose setae (1-4), similar in length, row of small setules at base of endite. Endite 2 (E2) bearing three setae (5-7), seta 5 as long as endite 3 setae, plumose, setae 6-7 slender, seta 6 longest, both unilaterally setulated with long setules distally and unilaterally armed with short and strong spines basally, counting about 6-9 setae, two rows of small setules situated radially on inner side of endite. Endite 1 (E1) with two setae (8-9), seta 8 slender, as same length as seta 7, unilaterally armed with short fine setules from base to tip, basalmost two small denticles, seta 9 not shown in figure. Trunk with 4 rows of slender spines laterally, counting 4-7 spines each group, increasing in length basally. Basally two slender ejector hooks, one longer, unilaterally armed with short setules. Epipodite and gnathobase not seen.

Second trunk limb (P2) (figs.19b-c)***:*** Epipodite not seen. Exopodite (EX) round-elongated, small setules apically. Endopodite (EN) triangular, with eight scrapers (1-8), generally decreasing in length towards gnathobase though scraper 3 shorter than scraper 4 in some specimen (fig.19c), scraper 4 shorter than scraper 5 in some specimen (fig.19b) and scraper 6 shorter than scraper 7 in some specimen (fig.19b), all scrapers bisegmented; scraper 1 unilaterally densely armed with fine setules, scrapers 2-4 unilaterally armed with fine setules but not fine as scraper 1, scraper 5 unilaterally armed with strong setules distally, scrapers 6-8 more robust, unilaterally armed with strong setules distally. A rounded hillock between scraper 8 and gnathobase, apically setulated, followed by minute denticle (fig.19c, arrow). Distal

armature of gnathobase (GT) with three elements (I-III), element I rod-like, thin, apically setulated, element II more robust, unilaterally armed with four strong short setules from base to tip, element III minute, naked, located close to base of element II. Gnathobasic filter comb with four slender setae, all similar in length.

Third trunk limb (P3) (fig.19d)***:*** Epipodite not seen. Exopodite (EX) small, globular, bearing six setae (1-6) but first two not shown in the figure (fig.19d): seta 3 slender and longest, about 2 times of seta 4, unilaterally setulated, seta 4 setulated with long setules, setae 5 and 6 of the same length, setulated.

Endopodite (EN) divided into two rows; anterior row with eight setae (1-7), setae 1 and 2 stout, seta 2 shorter than seta 1, distally armed with 5-6 short well-spaced strong setules, one sensilla (sn) located between these setae; seta 3 more slender, setulated distally; setae 4-7 gradually increasing in length towards gnathobase, one rod-like sensilla (sn) between setae 6 and 7; posterior row with four setae (1'-4'), gradually increasing in length towards gnathobase, all setulated. Gnathobase (GT) with two elements (I-II), element I large, curved inwards, setulated, element II thin, shorter, naked, row of setules at base of this element.

Fifth trunk limb (P5) (figs.19e-f)***:*** Pre-epipodite (PEP) rounded, apically setulated with two rows of long setules, elongated digitiform projection not seen. Epipodite (EP) rounded, similar in size of pre-epipodite, elongated digitiform projection not seen. Exopodite (EX) bilobed but nor clear (arrow), bearing four apical setae (1-4); anterior portion bearing setae 1-3, seta 3 shortest in some specimen (fig.19e) but as the same length of seta 2 in some specimen (fig.19f), all setae setulated; posterior portion bearing one seta (seta 4), relatively short, widen basally (fig.19f), setulated.

Endopodite (EN) larger, more oval, apically setulated, two endopodite setae setulated distally, one as a half length of another.

Variability:

It was noted several times that this species shows high variability in 1) body size vary from 0.23-0.5 mm: in the original description, Sars (1901) gives the length as 0.25 mm. Lilljeborg (1901) gives the length of reproductive females as 0.36-0.50

mm, 0.25 mm height (Daday, 1903), 0.35 mm (Nayar, 1971) and 0.23-0.43 mm (Alonso, 1996), 0.4-0.43 mm width; 2) body shape; posterior margin usually sloping forward dorsally but sometimes almost vertical; 3) longitudinal striation on valve present or absent.

However, specimens from southern Thailand show more variability in details of trunk limbs: 1) length of scrapers 3-6 of trunk limb 2, scraper 3 shorter or longer than scraper 4, scraper 4 shorter or longer than scraper 5 and scraper 6 shorter or longer than scraper 7 and 2) length of seta 3 on exopodite of trunk limb 5 shortest or as equal as seta 2.

Differential diagnosis:

This species can be distinguished by 1) its general body shape; oval or almost quadrangular; 2) characters of postabdomen, postanal margin rounded, distal angle rounded, marginal denticles with group of spinules, basal spine reach half of terminal claw; 3) trunk limb 1 with one large ODL seta, unilaterally armed distally, basalmost setule large; three IDL setae, one of them large and armed as ODL seta and 4) one rod-like receptor between seta 6 and 7 on anterior row of endopodite trunk limb 3.

Biology:

This species was found to occur in vegetation and in high abundance in macrophyte places (Sars, 1901; Alonso, 1996). It is also found in interstitial habitat (Sabater, 1987) and some specimens were found in river mouth sediment (Sabater, 1986). However it has rarely been mentioned in groundwater habitats.

In our study it was found only from two localities, only in rainy season (September-October) but with a few specimens. These habitats are vegetated places, densely covered with *Nymphea* spp., *Cyprus* spp. and algae.

Distribution:

Alona rectangula is distributed in Africa; Cameroon (Chiambeng, 2004), Europe; Spain (Sabater, 1987; Alonso, 1996), Australia (Griggs, 2001) and South East Asia (Idris and Fernando, 1981; Sanoamuang, 1998; Sa-ardrit, 2001; Sa-adrit and Beamish, 2004).

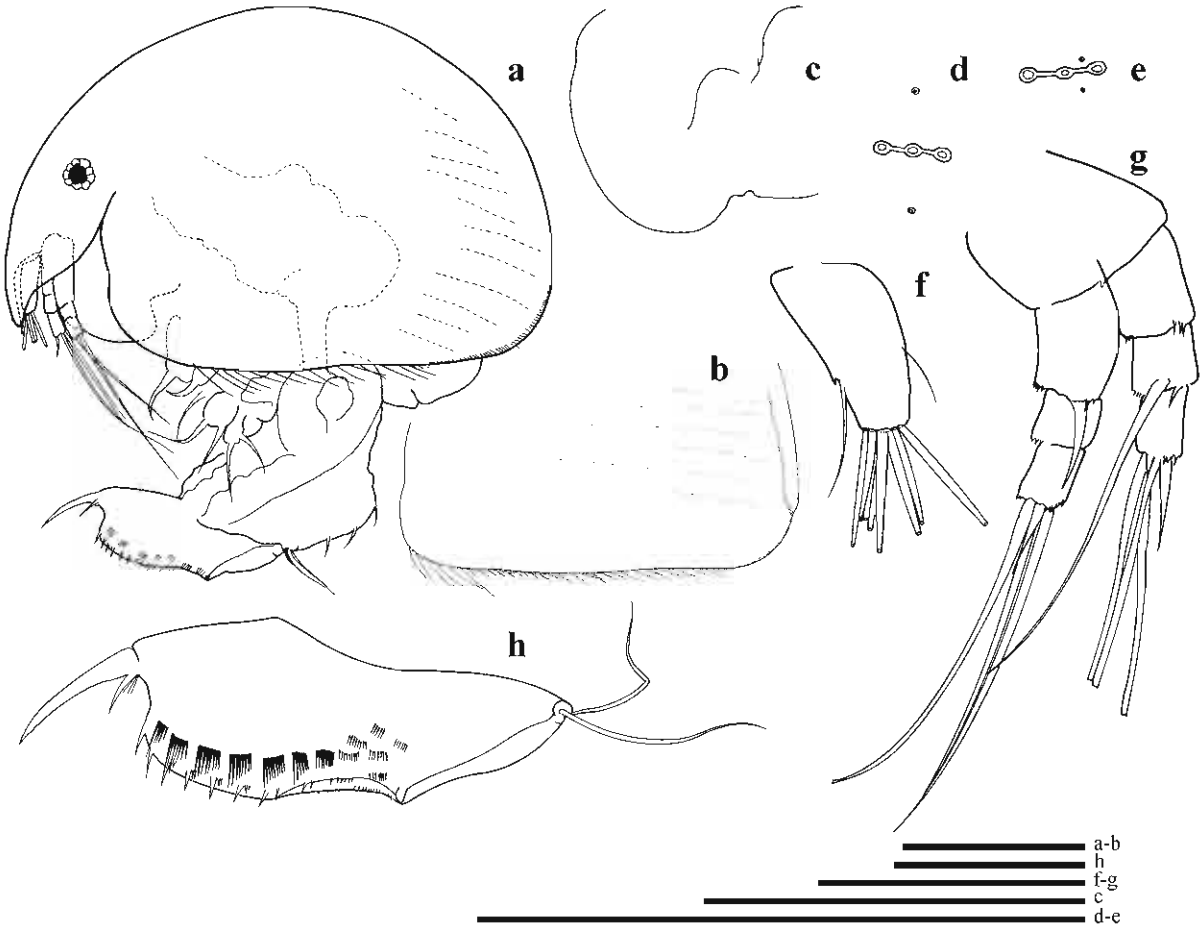


Figure 18. ***Alona rectangula*** **Sars,1862:** parthenogenetic females from Yao swamp (S03), Chumporn Province, southern Thailand. Figure a, adult female in lateral view; Figure b, ventral of valve; Figure c, labrum; Figures d-e, head pores; Figure f, antennule; Figure g, antenna; Figure h, postabdomen. Scale bars denote 100 um.

Figure 19. ***Alona rectangula*** **Sars,1862:** appendages of female from Yao swamp (S03), Chumporn Province, southern Thailand. Figure a, trunk limb 1; Figures b-c, trunk limb 2; Figure d, trunk limb 3; Figures e-f, trunk limb 5. Scale bars denote 100 um.

9. *Alona sarasinorum* Stingelin, 1900

References: Stingelin, 1900: 197-198, Pl.14 figs. 4-5; Brehm, 1933: 78-79, fig.1; Smirnov, 1971, 1974: 422, fig. 388; Idris and Fernando, 1981: 247-249, figs. 57-62 and Frenzel, 1987: 498, figs. 3B-3C.

Type locality: Celebes (Sulawesi), Indonesia

Holotype: Stingelin's collection No. III/6

Materials examined:

Type specimen: one specimen on slide, Celebes, 1900

Southern Thailand: Twenty parthenogenetic females, examined complete and thereafter dissected, from Maikhao Peat Swamp (S28), Phuket Province, southwestern Thailand (8°07.21′ N 98°17.34′E), pH 6.89 DO 6.9, conductivity 7.28 and salinity 0.3-0.5 ppt, collected date 27-10-01 and 07-04-02 by the author, SM.

: five parthenogenetic females, examined complete and thereafter dissected, from Pattani Bay, Yaring, Pattani Province, southeastern Thailand, pH 7-8, salinity 6-8 ppt. collected by S. Mulmek, SM.

: four parthenogenetic completed females, from Pak Panang Bay, Nakornsrithamaras Province, southeastern Thailand, collected by S. Sangkaew, SM.

The details of morphological study

Partial description of type specimen (see figure 26)

Body in lateral view rounded, gradually form curved anterior and posteriorly, maximum height around middle of body, about 1.5 time of width (fig.26a). Postero-dorsal and postero-ventral angles rounded. Ventral margin slightly concave. Head relatively small. Three major head pores of same size connected with narrow channel, central pore located at middle between anterior and posterior ones (fig.26c). Lateral head pores located at level of middle central pore. Labrum moderate size (figs.26a-b). Labral keel round with blunt apex. Distal labral plate without setulation. Anterior margin with one curl, posterior margin without any clusters of setules. Second

antenna relatively short, reaching less than half of body (fig.26a). Basal segment of both exopodite and endopodite 1.5 times longer than middle and apical segments, all segments cylindrical (fig.26d). Postabdomen relatively broad since postanal angle, widest in postanal corner, around middle (figs.26a, f), with distinct pre-and postanal corner and bearing 2-3 groups of small denticles. Posterior to anal margin, 5 groups of lateral fascicles, distally decreasing in number from postanal corner on, each group counting ranges from 5-8 fascicles, not beyond to distal margin. Marginal spines in groups of 2-4, mostly 3, largest in the middle of postanal past, mostly curved and pointing in different directions. Terminal claw long and slender (fig.26e), evenly curved to tip, with a narrow row of setae along concave edge. Basal spine slender, length about half of terminal claw, two short setules arising proximal to almost the base of basal spine. Row of pectens reaching tip of claw, gradually decreasing in length distally. Inner distal lobe (IDL) of trunk limb 1 bearing three setae (fig.26g), one large, strong hook-curved like, one seta slender, unilaterally setulated basally (hardly visible), another seta thin, smallest, weakly sclerotised, curved, resembling a second hook, length about half of slender one.

Species description of specimens from southern Thailand (see figures 20-25)

Parthenogenetic female

General shape (figs.20a-b, 22a-b)***:*** Body in lateral view round (figs.20a, 22a), body in dorsal view wide anteriorly and elongated posteriorly (fig.22b), relatively high, maximum height at middle of body. Length 0.34-0.44 mm, about 1.3 times maximum height in adults (n=20), height 0.24-0.32 mm. Dorsal margin form curved, forming dorsal keel, depression between head and rest of body not seen. Postero-dorsal and postero-ventral angles broadly rounded. Posterior margin convex. A row of about 140 setules along posterior margin at some distance from one on inner side of carapace, these setules not organized into groups. Ventral margin slightly concave, with 86-90 setae, anterior and posterior setae equally in length, row of small setules among these setae. Antero-ventral angle rounded. Reticulation, pentagon shaped on whole valve.

Intestine: with up to three convolutions

Head (figs.20a,c; 22c-d)***:*** relatively small. In lateral view, rostrum well developed, protruding forwards (fig.20a). Compound eyes present, size larger than ocellus; distance between eyes and ocellus greater than that between ocellus to the tip of rostrum. Three major head pores of same size connected with narrow channel, central pore located at the middle between anterior and posterior ones (figs.20c, 22c-d). Two lateral head pores located at level of middle central pore, about 1 IP distance from midline.

Labrum: moderate size (figs.20a, 22e). Labral keel round with blunt apex. Distal part of labral keel as a sub-triangular, distal labral plate without setulation. Anterior margin form into one or two curls (fig.20e), posterior margin without any clusters of setules. No lateral projections on labrum and no folds surrounding its base.

Postabdomen (figs.20f-g, 22g-h)***:*** relatively broad since postanal angle, length about 2 or 2.5 times width (figs.20f and 20g, respectively), widest in postanal corner, around the middle. Dorsal margin gradually narrowing distally from postanal corner on. Anal margin almost straight, relatively same length as terminal claw, parallel to dorsal margin, with distinct pre-and postanal corner and bearing 3-4 groups of small denticles. Posterior to the anal margin, 5-7 groups of lateral fascicles, distally decreasing in number from postanal corner on, each group counting ranges from 9-5 fascicles, not beyond distal margin. Lateral fascicles on anal margin about 7 groups, of which the denticles (minimal 3, maximal 9) situated more radial than parallel to each other. Marginal spines 8-9 groups, 2-4 spines in group, mostly 3, largest in the middle of postanal past, mostly curved and pointing in different directions. Two-three groups of venterolateral denticles (hardly visible). Natatorial setae short.

Terminal claw (figs.20f-g, 22g-h)***:*** long and slender, about as long as preanal portion, evenly curved to tip, with a narrow row of setae along concave edge. Basal spine slender, length about a third of terminal claw (fig.20f) or almost a half (figs.20g, 22g-h), three short setules arising proximal to almost the base of basal spine. Row of pectens almost reaching tip of claw, gradually decreasing in length distally.

First antenna (antennule) (figs.20a,d)***:*** relatively short (fig.20a), tube-like, almost reaching tip of rostrum. Body compact, about 2 times as long as wide, two rows of very short setules transversely on anterior face (fig.20d). Antennular sensory seta slender, almost as long as antennule, arising at ¾ distances from the base. Distal end with eight aesthetascs subequal in length, three longest as long as antennular body. All aesthetasces projecting beyond tip of rostrum.

Second antenna (figs.20a,e; 22f)***:*** relatively short, reaching less than half of body (fig.20a). Antennal formula: setae 0-0-3/1-1-3, spine 1-0-1/0-0-1. Basal segment of both exopodite and endopodite 1.5 times longer than middle and apical segments, all segments cylindrical. All setae bisegmented. Seta arising from basal segment of exopodite thin and five times shorter than apical setae, and seta arising from middle of exopodite slender, length about one third of apical setae. Basal spine of endopodite (fig.20f) and apical spines of both exopodite and endopodite short.

Trunk limbs: five pairs

First trunk limb (P1*)* (figs.21a-b, 23a-h)***:*** Relatively large. Outer distal lobe (ODL) with one long seta (I'), bi-segmented, basally naked, setulation distally with short setules, hardly visible. Inner distal lobe (IDL) bearing three setae (I-III), seta I large, strong hook-curved like, row of 10-13 short setules along the middle portion of seta, gradually increasing in length distally; seta II slender, bi-segmented, unilaterally setulated; seta III thin, small, weakly sclerotised, curved, resembling a second hook, length half of seta II, distally armed with short setules (fig.21e). Endite 3 (E3) bearing three (?) setae (1-3), seta 1 more robust, setulated distally with long setules, seta 2 slender, setulated distally with fine short setules, seta 3 bilaterally armed with well-spaced strong short setules. Endite 2 (E2) bearing three setae (4-6), of which seta 5 longest, seta 4 one third of seta 5, bilaterally armed with shorter setules, seta 5 feathering, seta 6 more robust, unilaterally setulated; two small sensilla near the base of setae 5 and 6 (fig.21h), two rows of slender setules at base of endite. Endite 1 (E1) bearing two slender setae (7-8), both of same length, bi-segmented, seta 7 setulated distally with short setules, seta 8 setulated distal and basally. Six rows of thick setules on ventral face of limb, groups of thin setules parallel with. On anterior face, 6-8 rows

of short setules radially (figs.22a; 23b). Basally, two ejector hooks, one smaller, unilaterally armed with strong setules (fig.23g).

Second trunk limb (P2) (figs.21c; 24a-b)***:*** Epipodite not seen. Exopodite (EX) elliptical, bearing small setules on apex. Endopodite (EN) triangular, with eight scrapers (1-8), generally decreasing in length towards gnathobase, though their length set in groups (figs.21c, 24a); first group consist of scrapers 1 and 2, the second includes scrapers 3-5 and the last one include scrapers 6-8, which shorter in order respectively. Scrapers 1 and 2 of the same length, unilaterally densely armed with fine denticles distally; scrapers 3 and 4 unilaterally armed with small denticles distally, not as densely as in previous two; scraper 5 similar in length with scraper 4, unilaterally armed with stronger denticles but not as strong as scrapers 6-8; scrapers 6-8 more robust, similar in length, about half of scrapers 3-5, unilaterally armed with about 14-17 strong denticles. Distal armature of gnathobase (GT) with two elements (I-II) (figs.21c; 24b), hillock between scraper 8 and gnathobase, apically setulated, followed by a minute denticle (figs.21c; 24b, arrow). Element I slender, element II hook-like at apex, fused at the base. Gnathobasic filter comb with seven setae, the first three setulated, of the same length, though the third may be longer, these setae considerably shorter than the others, seta 4-7 unilaterally setulated.

Third trunk limb (P3) (figs.21d-g; 24c-g)***:*** Epipodite not seen. Exopodite (EX) small, sub-rectangular, bearing six setae (1-6) (fig.21d): setae 1-2 located laterally in typical V-formation, seta 2 shortest, about half of seta 1, both setulated; seta 3 slender and longest, about 7 times of seta 2, setulated; seta 4 slender, subequal in length to seta 3, setulated, more dense basally; seta 5 slender, as half of seta 3, setulated distally; seta 6 small, slender, setulated basally.

Endopodite (EN) divided into two rows; anterior row bearing seven setae (1-7), setae 1 and 2 stout (fig.21g), both the same length, distally armed with 2 rows of well-space strong denticles (fig.24c), counting 6-8 denticles, seta 3 more slender, setulated with long setules, one sensillum (sn) between setae 1 and 2 and another one between setae 2 and 3 (figs.21g; 24f), setae 4-6 slender, gradually increasing in length towards gnathobase (fig.21e), all unilaterally armed with short setules, seta 7 rod-like

receptor, naked; posterior row bearing four setae (1'-4') alternating with one regressed seta and three small bumps (fig.24g), gradually increasing in length towards gnathobase, all setulated. Distal armature of gnathobase (GT) with three elements (I-III) (figs.21f; 24d), element I large, elongated, unilaterally setulated distally with long setules, elements II and III similar in length, setulated distally (fig.24d), fused at base of each other. Gnathobasic filter comb with seven setae, subequal in length, all setulated from base to tip.

Fourth trunk limb (P4) (figs.21h-j; 25a-c)***:*** Epipodite (EP) globular, bilobe with small hillock between lobes, apically setulated with long setules, one short setules setulated. Exopodite (EX) round bearing six setae (1-6), setae 1 and 2 of the same length though seta 2 may be shorter, both setulated with long setules; seta 3 longest, about 1.5 times seta 2, plumose; a hillock between seta 3 and 4 (fig.21h, arrow) setae 4 and 5 subequal in length, seta 4 setulated with long setules; seta 5 more slender bilaterally armed with well-space short setules; seta 6 shortest, about half of seta 5, bilaterally armed with short setules. Followed by row of long setules on the body of exopodite.

Endopodite (EN) or inner portion; anteriorly bearing five setae (1-5), setae 1-4 of the same length, widened basally, seta 1 naked, with bunch of long setules at base of seta; setae 2-4 setulated distally, followed by seta 5 rod-like receptor, small, naked; posteriorly bearing three setae (1'-3'), generally increasing in length towards gnathobase, all setulated. Gnathobase (GT) with four elements (I-IV), element I large, longest, distally setulated, elements II, IV small, element III smallest, element II and III fused at base, element IV more slender, these three elements naked. Gnathobasic filter comb with five setae, similar in length, all unilaterally setulated.

Fifth trunk limb (P5) (figs.21k; 25d)***:*** Pre-epipodite and epipodite not seen. Exopodite (EX) oval, subdivided into two lobes but not clear (fig.21j, arrow) bearing four setae (1-4); setae 1-3 on anterior portion gradually decreasing in length posteriorly, all setulated, small hillock between setae 2 and 3; seta 4 on posterior portion shortest, length ¼ of seta 3, unilaterally setulated. Row of long setules between two lobes.

Endopodite (EN) rounded, relatively large, setulated apically, rows of small spinules basally (fig.25d), bearing two endopodite setae, the first one shorter, the second large, widen at base, both unilaterally setulated. Gnathobasic filter comb with two setae, one rod-like seta, setulated apically, another more slender, setulated.

Variability:

Body size; in the original description the body ranged from 0.36-0.38 mm height and 0.46-0.52 mm width. Some variability was noted in the following characters: 1) proportion of anal margin and postanal margin of postabdomen and 2) curve of large hook-like seta on inner distal lobe.

Differential diagnosis:

This species can be distinguished by 1) the presence of a dorsal keel; 2) anterior margin of labrum forming one or two curls; 3) eight aesthetasc setae of first antenna, antennular seta as long as the longest aesthetasc seta and arising from a distinct tubercle; 4) the general characters of postabdomen: broad with postanal margin longer than anal and preanal portion, tapering distally, pre- and postanal angle distinct obviously, postanal angle form an angle of 45-50^{o} degree; 5) ventral rim of valve, row of strong setules reach to postero-angle of valve, series of smaller setules among them, and continue with small setules to postero-dorsal angle; 6) three IDL setae, one large curved-hook like seta (unique character of the taxa); 7) length of eight scrapers of trunk limb 2 forming three groups; 8) the first three gnathobasic filter comb of trunk limb 2 considerably shorter than others; 9) two small sensilla (sn) between seta 1 and 2 and between seta 2 and 3 on exopodite of trunk limb 3; 10) seta 3 on exopodite of trunk limb 4 longest and 11) one seta of gnathobasic filter comb of trunk limb 5 rod-like.

Remarks:

Alona sarasinorum Stingelin, 1900 was originally described from brackish water in Celebes Island Indonesia, separated from known ‘lynceids’ based on shape and armature of the postabdomen, and has been recorded from athalassic saline waters throughout Asia (Brehm, 1933; Idris and Fernando, 1981 and Venkataraman, 1999).

There were few specimens found in each study and no sufficient description and good illustrations available. However, previous researches show a number of unique characters: body shape, shape of the labral plate, arrangement of setules on the posterior-ventral margin of the valves, head shield, structure of the postabdomen and terminal claw and large hook-like IDL seta of trunk limb 1.

In 1977 Shirgur and Naik described *Alona taraporevalae* on specimens hatched from ephippia originating from Back Bay (India). This taxon is undoubtedly similar to *A. sarasinorum*. However their taxonomic identity has never been proven. Only once, *A. taraporevalae* was used to compare with *Celsinotum*, new genus described by Frey (1991), because of theirs similarity in gross view of characters. However, at that time the comparison stated that they are not closely related.

The results of insufficient detailed morphology as well as illustrations, their rare and narrow distribution make the taxonomical status of these two species has never been discussed. However number of specimens of *A. sarasinorum* from southern Thailand is available to write a complete description of parthenogenetic female and we also can discuss the similarity with *A. taraporevalae* and make a note on their generic status by morphological comparison with *Alona affinis*, closet species of *Alona* type species and *Celsinotum*, the genus which show high similarity in morphology.

Details of morphological study on *Alona taraporevalae* Shirgue & Naik, 1977

References: *Alona taraporevalae* Shirgur & Naik, 1977: 48-52, figs.1-3; Sharma and Michael, 1984: 35-38, figs.1a-f; Michael and Sharma, 1988: 186-188, figs.64a-f; Frey, 1991, figs.93-101.

Materials examined:

Paratypes: three specimens of *Alona taraporevalae* Shirgue & Naik, 1977 on slide mounted by D. G. Frey.

Partial description of type specimen *Alona taraporevalae* (see figure 27)

Parthenogenetic females

General body: in lateral view rounded (fig.27a). Maximum height at middle of body. Length 0.40-0.44 mm, about 1.4 times maximum height in adults (n=3), height 0.27-0.32 mm. Postero-dorsal and postero-ventral angles rounded. Ventral margin slightly concave, with 46-50 setae, anterior and posterior setae equally in length, row of small setules among these setae (fig.27b).

Head: relatively small.

Labrum: moderate size (figs.27a,c). Labral keel round with blunt apex. Distal labral plate without setulation. Anterior margin form into one curl, posterior margin without any clusters of setules.

Postabdomen: relatively broad since postanal angle, length about 2 times width (fig.27d), widest in postanal corner, around the middle. Dorsal margin gradually narrowing distally from postanal corner on. Anal margin almost parallel to dorsal margin, with distinct pre-and postanal corner and 3-4 groups of small denticles. Posterior to the anal margin, 5 groups of lateral fascicles, each group from 5-10 fascicles, not extending beyond to distal margin. Lateral fascicles on anal margin about 4 groups, of which the denticles (minimal 6, maximal 9) more radial than parallel to each other. Marginal spines about 9 groups, 2-4 spines in group, mostly 3, largest in the middle of postanal past, mostly curved and pointing in different directions. Natatorial setae short.

Terminal claw: long and slender (figs.27e-f), evenly curved to tip, with narrow row of setae along concave edge. Basal spine slender, length about half of terminal claw or little less, having a single seta along anterior margin about 1/3 from base, where there is a distinct break in contour, two short setules arising proximal to almost base of basal spine (fig.27e). Row of pectens reaching tip of claw, gradually decreasing in length distally.

Trunk limbs: five pairs

First trunk limb (P1): Outer distal lobe (ODL) of trunk limb 1 with one slender seta, longest (fig.27g). Inner distal lobe (IDL) bearing three setae, one large, strong hook-curved like; one seta slender, bi-segmented, setulated distally; another seta thin, smallest, weakly sclerotised, curved, resembling a second hook, length about half that of the slender one.

Third trunk limb (P3): Anterior row of endopodite of trunk limb 3 with two stout distal setae (fig.27h), both of the same length, distally armed with 2 rows of well-space strong denticles, counting 4-6 denticles.

Fourth trunk limb (P4): Exopodite of trunk limb 4 round, bearing six setae (fig.27i; seta 6 difficult to draw from specimen in slide), setae 1 and 2 are of the same length, seta 1 unilaterally setulated, seta 2 setulated with long setules; seta 3 shorter, setulated; setae 4 and 5 subequal in length.

The relationship between *A. sarasinorum* Stingelin, 1900 and *A. taraporevalae* Shirgue & Naik, 1977

The original description and figures of *Alona taraporevalae* is inadequate (Shirgue and Naik, 1977) although they provided both description of parthenogenetic female and male. Sharma and Michael (1984) attempted to redescribe this taxon but did not contribute new details to overall description. Frey (1991) also gave only a partial redescription from few specimens obtained from Shirgur. Here we tried to provide more details of this species but unfortunately we have only three paratypes on mounted slide to study and no male. It was difficult to see the complete setation on the trunk limbs and some other details, so that a complete description could not be attempted. Nevertheless, some more details on some parts (as above) together with the combination of previous descriptions, a morphological comparison with *A. sarasinorum* can be provided (table 5) so that the relationship between these species can be discussed.

The 29 morphological characters of *A. sarasinorum* and *A. taraporevalae* were used to compare (table 6) and state their status. They apparently showed high

similarity between these two species as they have the same characteristic of 27 gross and fine characters in range of size, body shape, labrum, first and second antenna, postabdomen and details of trunk limbs 1, 3, 4 and 5 and also biological and ecological range. There are only characters of setae on exopodite of trunk limb 4 (characters 24-25) that show a difference, but only in micro-details. Unfortunately, we have no male of *A. sarasinorum* to compare with male of *A. taraporevalae* which show unique character among other Aloninae as they having lateral aesthetascs on the antennule and in having a narrow distally of postabdomen (Shirgur and Naik, 1977; Frey, 1991). However, from female characteristics we can conclude that *Alona taraporevalae* is highly likely a junior synonym of *Alona sarasinorum*.

Noted on generic status of *Alona sarasinorum* Stingelin, 1900

A. sarasinorum shows considerable differences from *Celsinotum*, a possibly related genus, in many characters of parthenogenetic females (table 6): 1) smaller size; 2) apex of labrum not strongly expand as *Celsinotum* and anterior margin not smooth but forming curls; 3) small setae present between long slender setae at postero-ventral corner of valve; 4) basal and middle setae on endopodite of second antenna; 5) postabdomen different in the relative length of three zones, with postanal zone longest; 6) three IDL setae instead of only two in *Celsinotum*; and 7) length of setae on trunk limbs 3-5. Thus, in spite of having similar general shape and postabdomen, and the taxon occurs in saline water, *A. sarasinorum* is not related to *Celsinotum.*

Moreover, it differs from the other taxa obviously by having a large and very strong hook IDL seta on trunk limb1 and characteristics of the postabdomen which are unique among the Aloninae. The completed description of parthenogenetic females raises to a higer level its information but can not lead to final conclusion. Additional details description of the ephippial females and males is indeed needed for determining its relationships to other species and its generic status.

Biology:

A. sarasinorum is found in the littoral zone of Maikhao peat swamp closed to Maikhao beach in Phuket Island, southwestern Thailand. The characteristics of the

habitat are a typical peat swamp such as brownish water and cover with algae and vegetation. It appears to be more common in summer, pH ranges from 4-6, and salinity has not clearly changed during sampling year (0-4 ppt).

It also found in athalassic water in slow-running open area in southeastern Thailand, both upper and lower parts (Mulmek, S. and Sangkaew, S. pers.com.). However it has been found only in rainy season when pH ranges from 6-8 and salinity decrease to 7-8 ppt.

Distribution:

Until now *A. sarasinorum* has become known only from South East Asia. It is noticeably distributed along the coastal areas. As previous records, it has been found in Celebes Island, Indonesia (Stingelin, 1900 and Brehm, 1933), Rantang Abang Marsh, the place close to the western coast in Terengganu, Malaysia (Idris and Fernando, 1987) and southern Tamil Nadu, Madurai, southeastern India (Venkataraman, 1999). In the present study it also has been found only the place close to coastal area along both side of southern Thailand.

Table 6 Morphological comparison among *A. affinis*, closet species of type species of *Alona*, *A. sarasinorum* & *A. taraporevalve* and *Celsinotum*.

Characters		***A. affinis*** Thai specimens (Sinev, 1999 and present data)	***Celsinotum*** (Frey, 1991)	***A. sarasinorum*** Type specimen & Thai specimens (present data)	***A. taraporevalae*** Paratypes (Shirgur & Naik, 1977; Frey, 1991 & present data)
Size	1)	0.55-0.90 mm	0.55-0.90 mm	length 0.34-0.44; height 0.24-0.32 mm	Length 0.40-0.44; Height o.27-0.32 mm
L/H	2)	1.7-1.9 times	>1.25 times	1.3-1.4 times	1.4 times
Dorsal keel	3)	Absent	present	present	present
PvCv	4)	small setae between long-slender setae	no small setae between slender setae	shorter setae between long slender setae	shorter setae between long slender setae
Labrum	5)	large, rounded or polygon-like	rounded, apex blunt and expand strongly anteriorly	rounded, blunt apex but not expand,	rounded, blunt apex but not expand,
	6)	anterior margin angulated tip	anterior margin rounded	anterior margin form into 1-2 curls	anterior margin form into 1 curl
	7)	posterior margin with two clusters of setules	no setules	no setules	no setules
First antenna					
lateral seta	8)	>1	1 or many	1	1
Aesthetascs	9)	9	9	9	9
accessory seta	10)	1 or more	1	1, arises from a well developed & rounded tubercle projecting from its side	1, arises from a well developed & rounded tubercle projecting from its side
Second antenna	11)	spines at articulation points of antennal setae	absent	absent	absent

Table 6 (Continued)

Characters		***A. affinis*** Thai specimens (Sinev, 1999 and present data)	***Celsinotum*** (Frey, 1991)	***A. sarasinorum*** Type specimen & Thai specimens (present data)	***A. taraporevalae*** Paratypes (Shirgur & Naik, 1977; Frey, 1991 & present data)
	12)		basal & middle setae on endopodite longer	basal & middle setae on endopodite shorter than in *Celsinotum*	basal & middle setae on endopodite shorter than in *Celsinotum*
	13)		basal & terminal spines short but longer than in *A. sarasinorum* & *A. taraporevalae*	basal & terminal spines short, not visible	basal & terminal spines short, not visible
Postabdomen	14)			different in the relative length of the three zones obviously, postanal longest	different in the relative length of the three zones obviously, postanal longest
	15)	marginal denticles with merged spinules	8-12 groups of marginal spines, these spines not strong as in *A. sarasinorum* & *A. taraporevalve*	8-9 groups of marginal spines, 2-4 spines in group, these spines strong	9 groups of marginal spines, 2-4 spines in group, these spines strong
	16)	pre-postanal not distinct obviously	pre-postanal distinct but not obvious as *A. sarasinorum* & *A. taraporevalve*	pre-postanal distinct obviously	pre-postanal distinct obviously
	17)	with parallel dorsal and ventral margin	dorsal margin strongly curve	dorsal margin slightly curve	dorsal margin slightly curve

Table 6 (Continued)

Characters		***A. affinis*** Thai specimens (Sinev, 1999 and present data)	***Celsinotum*** (Frey, 1991)	***A. sarasinorum*** Type specimen & Thai specimens (present data)	***A. taraporevalae*** Paratypes (Shirgur & Naik, 1977; Frey, 1991 & present data)
Terminal claw	18)	several short setules	2-3 setules but very short & thin	2-3 setules on base of basal spine	2-3 setules on base of basal spine
Trunk limb 1					
Outer distal lobe (ODL)	19)	1 seta	1 seta	1 seta	1 seta
Inner distal lobe (IDL)	20)	3 setae, one curved; more curved in some specimens	2 slender setae	3 setae, one curved-hook like seta	3 setae, one curved-hook like seta
Trunk limb 3					
Exopodite	21)	7 setae	6 setae	6 setae	6 setae
	22)	seta 1=seta 2	seta 1=seta 2	seta 1=3 times seta 2	seta 1=3 times seta 2
	23)	seta 3 longest, about 6 times of seta 4	seta 3~2 times seta 4	seta 3~seta 4	seta 3~seta 4
Trunk limb 4					
Exopodite	24)	setae 1-3 gradually decreasing in length towards gnathobase	seta 3 longest, 2 times of seta 2	seta 3 longest, 1.5 times of seta 2	setae 1-3 gradually decreasing in length towards gnathobase
	25)	seta 5~seta 6	seta 5 longer than seta 6	seta 5~2 times of seta 6	seta 5~seta 6
Endopodite	26)	finger-like setae, unilateral setulated		finger-like setae but more slender, bilateral setulated distally	
Trunk limb 5	27)	bi-lobed	bi-lobed	bi-lobed	bi-lobed
	28)	1 minute seta	1 minute seta	1 minute seta, shorter	1 minute seta, shorter
saline (≥ 8%)	29)	no	yes	yes	yes

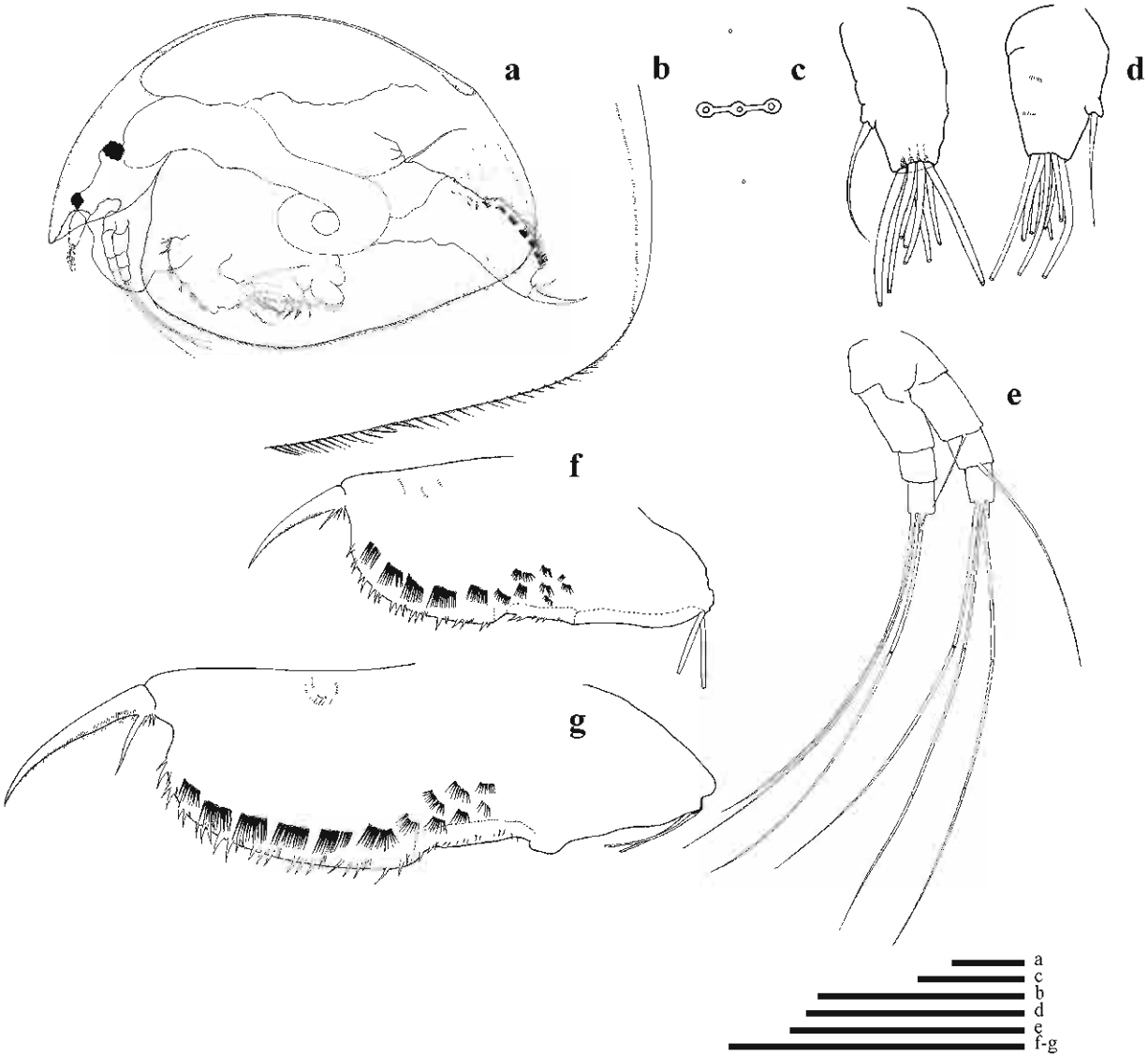


Figure 20. ***Alona sarasinorum*** **Stingelin,1900:** parthenogenetic females from Maikhao swamp (S28), Phuket Province, southwestern Thailand. Figure a, adult female in lateral view; Figure b, postero-ventral margin of valve; Figure c, head pores; Figure d, antennule; Figure e, antenna; Figures f-g, postabdomen. Scale bars denote 100 um.

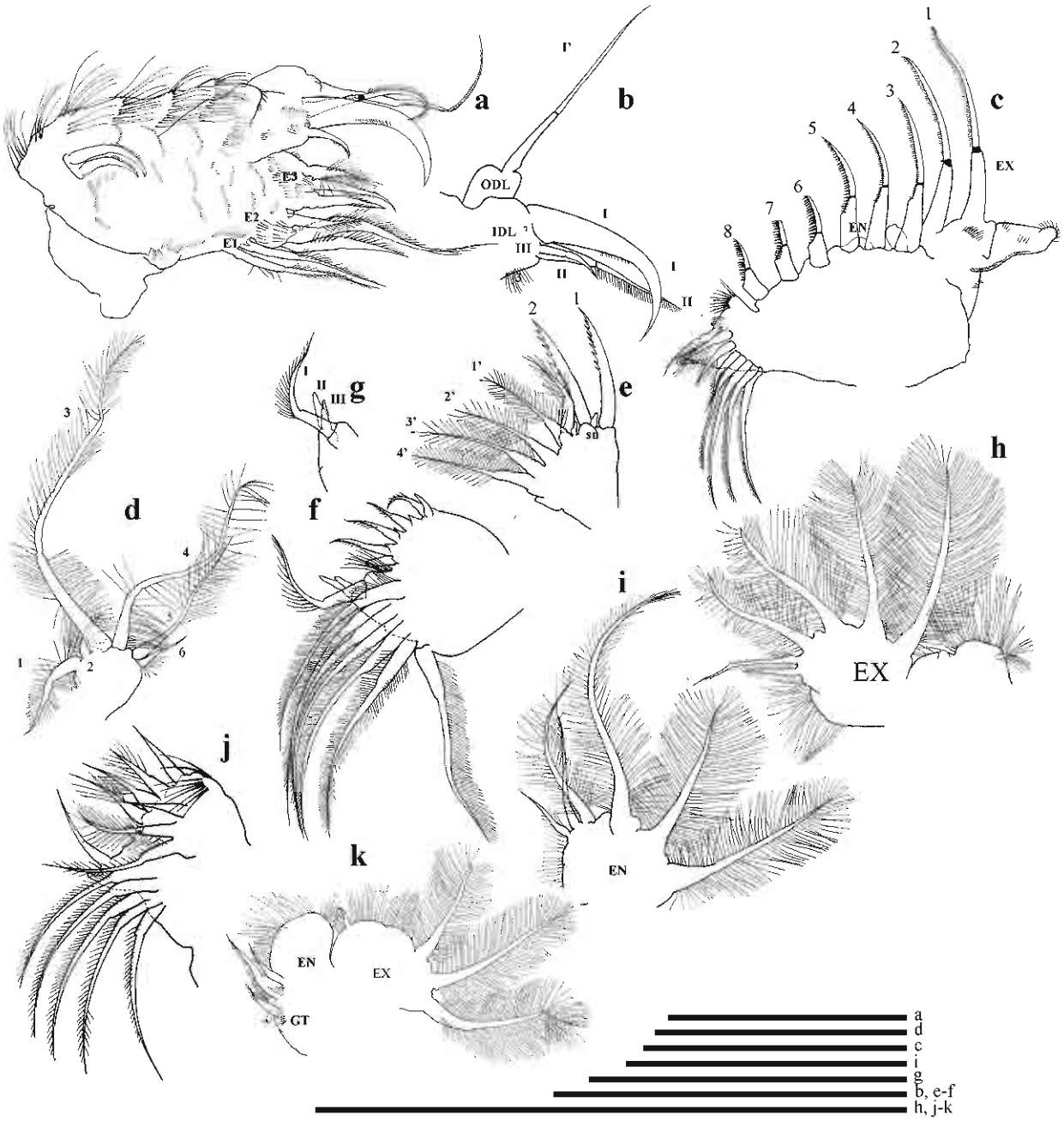


Figure 21. ***Alona sarasinorum*** **Stingelin,1900:** appendages of females from Maikhao peatswamp (S28), Phuket Province, southwestern Thailand. Figures a-b, trunk limb 1 and its inner and outer distal lobe; Figure c, trunk limb 2; Figure d, exopodite of trunk limb 3; Figures e-f, anterior and posterior row of endopodite of trunk limb 3; Figure g, its gnathobase; Figures h-i exopodite of trunk limb 4; Figure j, endopodite of trunk limb 4; Figure k, trunk limb 5. Scale bars denote 100 um.

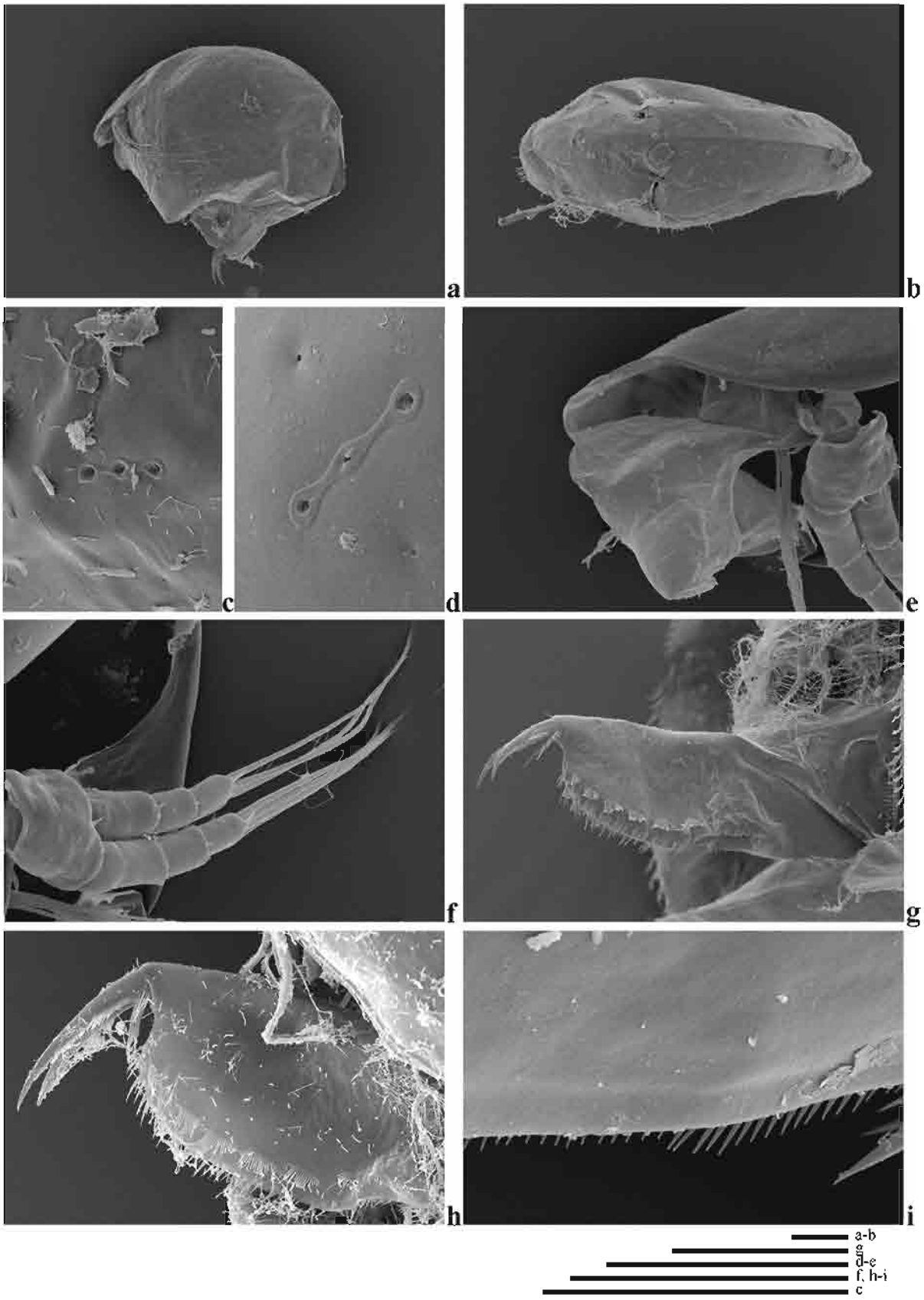


Figure 22. ***Alona sarasinorum*** **Stingelin,1900:** parthenogenetic females from Maikhao peatswamp (S28), Phuket Province, southwesterm Thailand. Figure a, adult female in lateral view; Figure b, adult female in dorsal view; Figures c-d, head pores; Figure e, labrum; Figure f, antenna; Figures g-h, postabdomen; Figure i, ventral of valve. Scale bars denote 100 um.

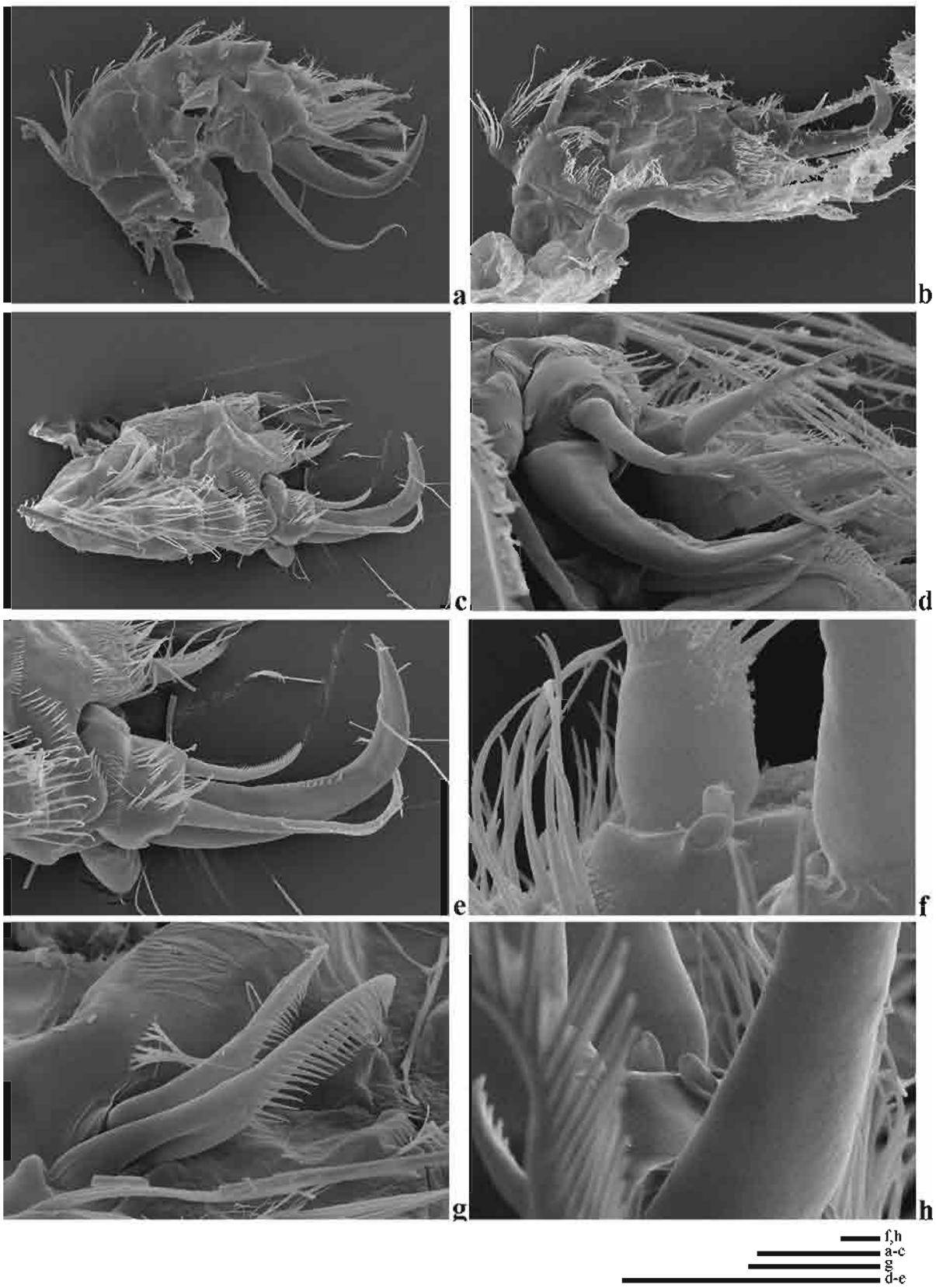


Figure 23. ***Alona sarasinorum*** **Stingelin,1900:** trunk limb 1 of parthenogenetic females from Maikhao peatswamp (S28), Phuket Province, southwestern Thailand. Figures a-c, trunk; Figures d-e, inner and outer distal lobe; Figures f,h, sensilla; Figure g, ejector hooks. Scale bars denote 100 um.

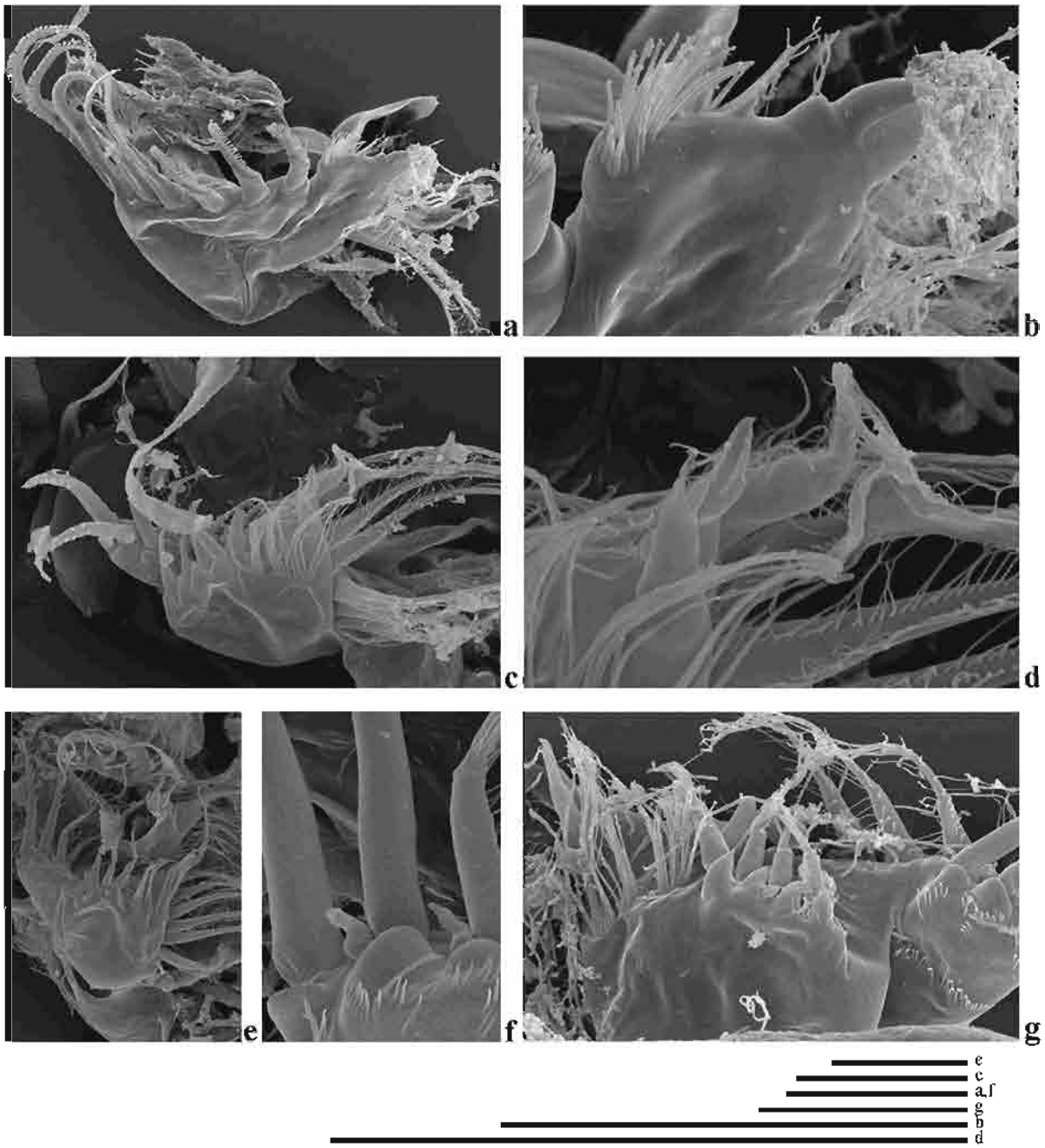


Figure 24. ***Alona sarasinorum*** **Stingelin,1900:** appendages of females from Maikhao peat-swamp (S28), Phuket Province, southwestern Thailand. Figures a-b, trunk limb 2 and its gnathobase; Figures c-g, trunk limb 3, its gnathobase, exopodite, endopodite and sensilla on exopodite. Scale bars denote 100 um.

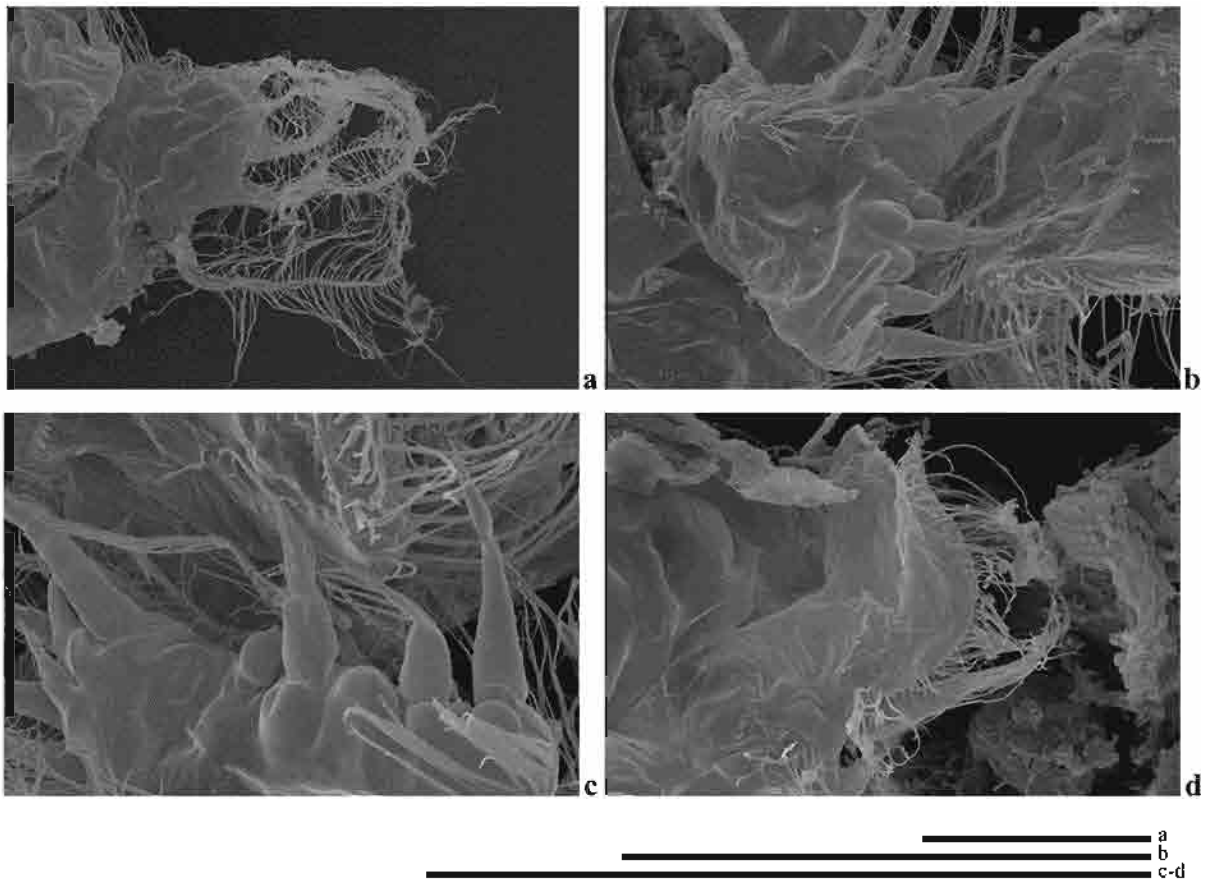


Figure 25. ***Alona sarasinorum*** **Stingelin,1900:** appendages of parthenogenetic females from Maikhao peatswamp (S28), Phuket Province, southwestern Thailand. Figure a, exopodite of trunk limb 4; Figures b-c, endopodite of trunk limb 4; Figure d, endopodite of trunk limb 5; Scale bars denote 50 um.

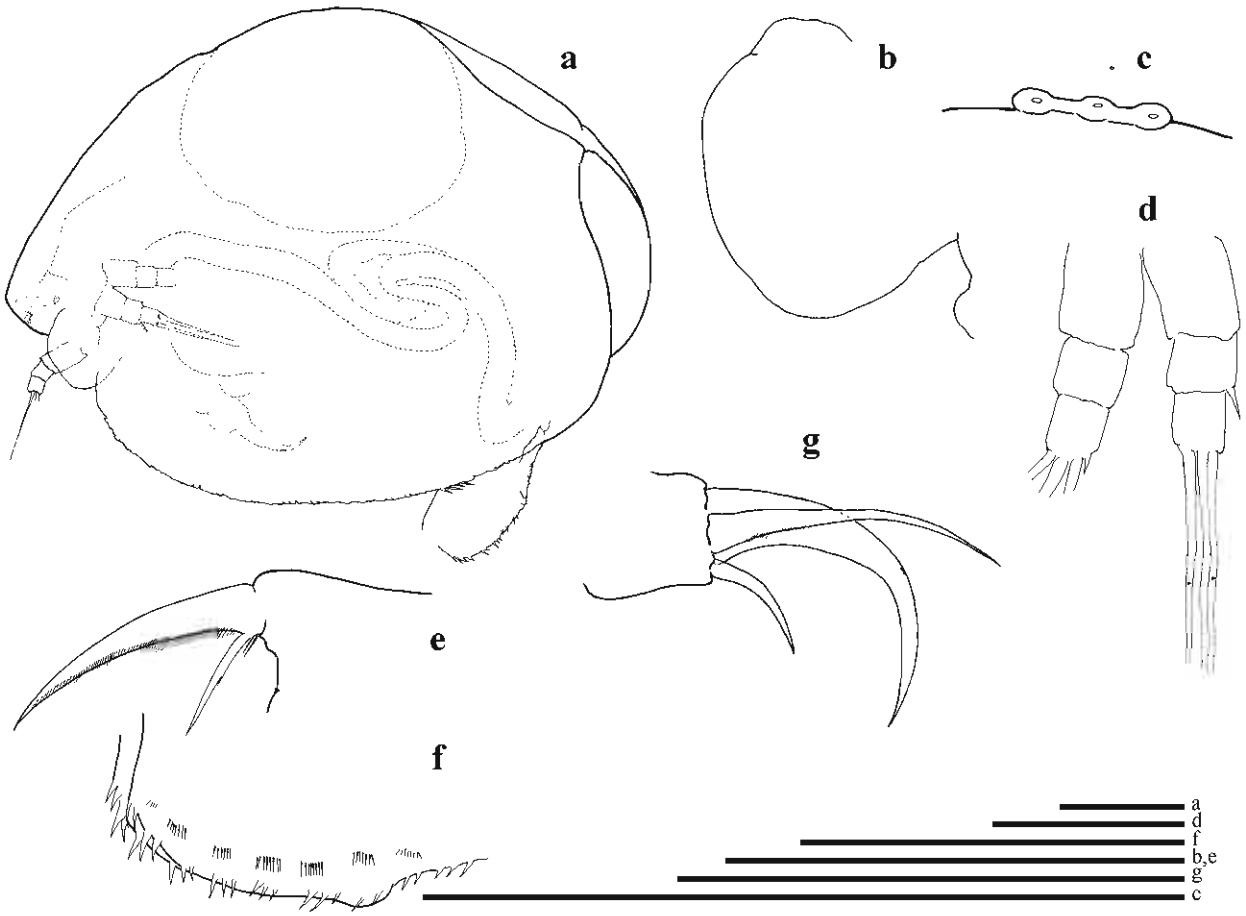


Figure 26. ***Alona sarasinorum*** **Stingelin,1900:** type specimen, parthenogeentic female from Celebes, Indonesia. Figure a, adult female in lateral view; Figure b, labrum; Figure c, head pores Figure d, antenna; Figure e, terminal claw; Figure f, postabdomen; Figure g, trunk limb 1. Scale bars denote 100 um.

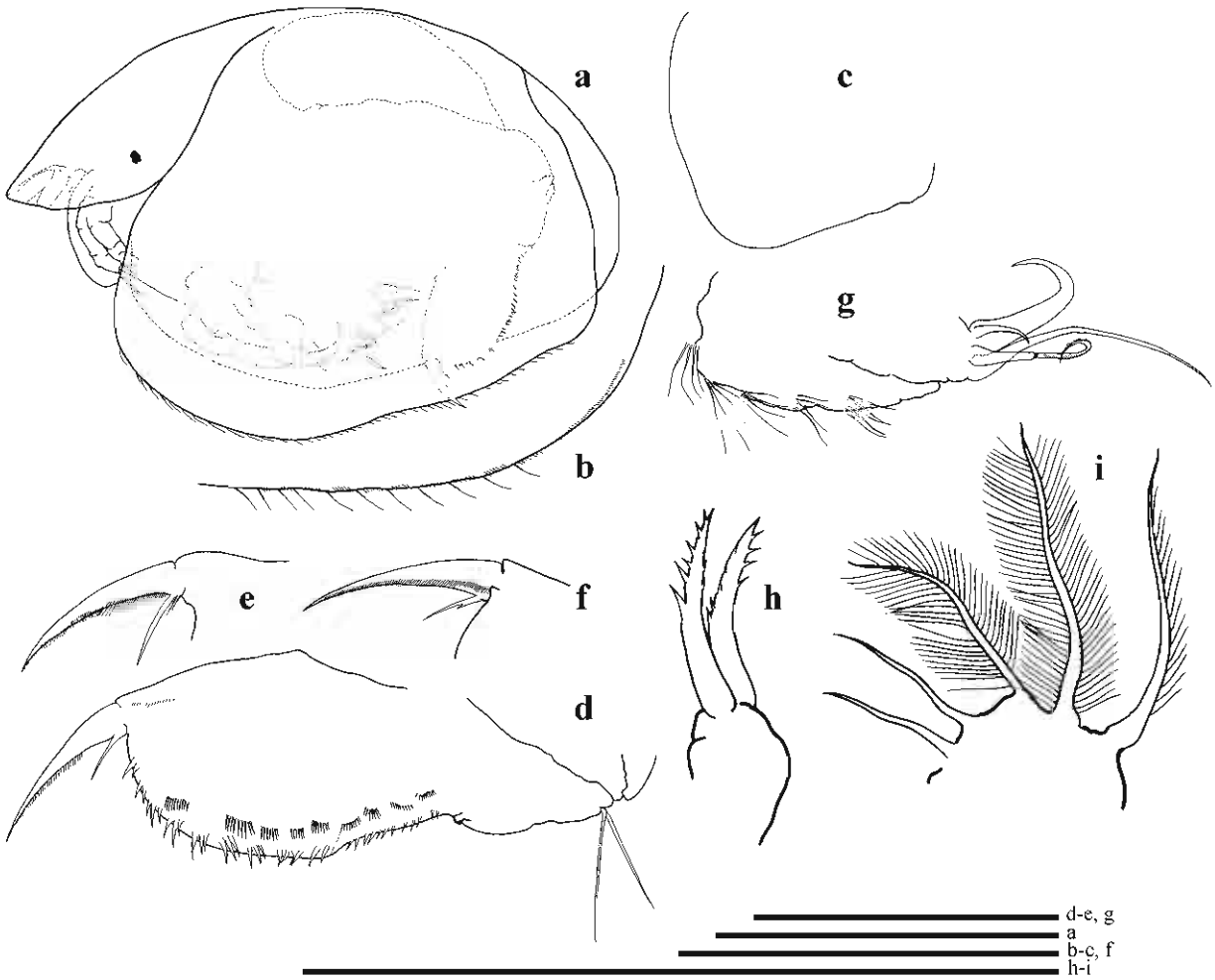


Figure 27. ***Alona taraporevalae*** **Shirgue & Naik, 1977:** paratype, parthenogenetic females from Back Bay, Bombay, India. Figure a, adult female in lateral view; Figure b, postero-ventral corner of valve; Figure c, labrum; Figure d, postabdomen; Figures e-f, terminal claws; Figure g trunk limb 1; Figure h, distal spines on exopodite of trunk limb 3; Figure i, exopodite of trunk-limb 4. Scale bars denote 100 um.

10. *Alona verrucosa* Sars, 1901

Synonymy: (*Biapertura verrucosa*); Smirnov, 1989:140.

References: Sar, 1901: Des. 56-57, Pl.9, figs. 7, 7a; Jenkin, 1934: Des. 292-295, figs. 18, 18a, 18b; Brehm, 1938: Des. 100-101, Abb. 6-7; Johnson, 1956: Des. 85-88, figs. 5-6; Rey and Saint-Jean, 1968: 111-112; Nayar, 1971: p.514, figs. 24-25; Paggi, 1975: Des. 139-144, Lam, figs. 1-22, Lam II, figs. 23-27; Smirnov, 1984: Des. P. 157, fig. 7; Venkataraman, 1995: 383, figs 41-42; Alonso, 1996 Des. 317-318, fig.141.

Type locality: "Gutenburg und Bleinbachmoos bei Langenhal"

Lectotype and paralectotypes: tubes GOS-F12338A-B, tube with paralectotypes F12337

Materials examined:

Southern Thailand: ten parthenogenetic females, examined complete and thereafter dissected, from Thungtong swamp (S19), Suratthani Province, southeastern Thailand. Collected by the author, SM.

: five parthenogenetic females, examined complete and thereafter dissected, from Buabakong swamp (S54), Narathiwas Province, southeastern Thailand. Collected by the author, SM.

: one parthenogenetic female, examined complete, from Yon peat swamp, Trang Province, southeastern Thailand. Collected by P. Sa-ardrit, SM.

: five parthenogenetic females, examined three complete and two dissected, from Pak Panang Bay, Nakornsrithammaras Province, Southeastern Thailand, collected by S. Sangkaew, SM.

*Northeast Thailand**:*** two parthenogenetic females, examined complete and thereafter dissected, from Lake Kudthing, Province, collected by C. Saeng-aroon, KKU.

Brazil: one parthenogenetic female, examine complete, from Brazil, South America, collected by Van Damme, K., GU.

The details of morphological study

Species description (See figures 28-30)

Parthenogenetic female

General shape (figs.28a-d)***:*** oval to ovoid in lateral view (figs.28a-c), largest height around the middle, or posteriormost in some specimens, length 0.26-0.32 mm. 1.4-1.7 times maximal height (n=20), height 0.17- 0.21 mm. Note that in the spotted ones, the body shows larger size and is more rounded (fig.28b), length 0.30-0.32 mm, height 0.18-0.19 mm. Dorsal margin generally curved, depression between head and rest of body absent. Postero-dorsal angle rounded, not prominent. Posteroventral corner broadly rounded. Ventral margin slightly concave, ventral embayment before the middle. Ventral setae relatively short (fig.28d), in some specimens very short (fig.28a), in some specimens short and also, densely setulated (fig.28a) or relatively longer posteriorly (fig.28b), anteriormost with 8-10 marginal setae followed by 18-20 slender setae, gradually increasing in length towards posterior end. Rows of small setules from posterior ventral corner up to the middle of body. Valve with (figs.28b, 30a) or without spots (figs.28a, c).

Head (figs.28a-c, e)***:*** moderately size, rostrum typically long, pointing downward or ventrally (figs.28a-c). Compound eye present, larger than ocellus, distance between eyes and ocellus same as distance from ocellus to tip of rostrum. Head shield elongated (fig.28e), posteriorly 4-5 curls symmetrically. Two major head pores, same size, with a narrow connection between them (figs.28f-g). Two lateral head pores, each surrounded by internal 'flower-like' structure, located closed to anterior, about 1IP from midline, level before anterior median pore.

Labrum*:* moderately, rounded or more ovoid (figs.28a-c). Anterior margin rounded, bearing a minute denticle, labral keel naked. A semi-circular ridge along anterior rim of keel (fig.30c).

Postabdomen (figs.28j-k)***:*** width about 2 times height. Relatively broad distally, distal margin round though not obvious in some specimen (fig.28b). Dorsal margin curve. Anal margin concave bearing 19 small denticles. Postanal margin shorter than

anal margin (fig.28j) but as the same length in some specimens (fig.28k), postanal corner distinct, bearing 2 groups of small denticles. Posterior to anal margin, lateral fascicles: about 10-11 postanal groups, consisting of 4-10 denticles, distally decreasing in number from postanal corner on, in contrast of theirs size, spinules of four most distal groups reaching beyond dorsal margin of postabdomen. Marginal denticles in groups: 8-10 groups, on distal margin, each group consisting of 3-5 denticles, of which middle groups slightly larger than anterior and posteriormost. Rows of venterolateral denticles (fig.28j). Natatorial setae short.

Terminal claw (figs.28j-k, 30d)***:*** Long and slender, about as long as anal margin. Basal spine slender, short, length about 1/4 of terminal claw, bearing 2-3 spinules arising proximal to base of basal spine (figs.28j-k, 30d), length of these spinules as long as basal spine in some specimens (fig.28k). Denticles of pectin relatively short, both inner and outer sides (figs.28j, 30d) gradually decreasing distally, reaching tip of claw in some specimens (figs.28j, 30d).

First antenna (antennule) (figs.28a-c, h)***:*** Body compact, about twice as long as wide (figs.28a, h), but about 3 times as long as wide in some specimen (figs.28b-c). Tip pointing downwards, some reaching beyond tip of rostrum (fig.28b) but most specimens not protruding beyond tip of rostrum (figs.28a,c). Four rows of small spines on inner and outer side of antennular body. Distal end with nine aesthetascs, unequal in length, implanted on elongated apex, length about 2/3 of the antennular body or shorter (fig.28b). Subapical aesthetasc of same length of normal aesthetascs, accompanied by antennular sensory seta, implanted at about one third of distal end. All aesthetascs projecting beyond tip of rostrum.

Second antenna (figs.28a-c, i, 30b)***:*** relatively short (figs.28a-c). Antennal formula, setae 0-1-3/0-0-3 spines 0-1-1/1-0-1 (fig.28i). All setae bisegmented. Basal segment with conical distal spine, all segments cylindrical, basal segment longest and shorter distal end. Row of long and slender spines at joint of each segment (figs.28i,30b). Spine arising from first segment of endopodite reaching beyond the second segment.

Terminal spines longer than terminal segment. Additional lateral spines on exopodite on first and second segments.

Trunk limbs: five pairs

First trunk limb (P1) (figs.29a-e)***:*** Outer distal lobe (ODL) with one apical seta (I'), bi-segmented, unilaterally armed with small setules distally. Inner distal lobe (IDL) bearing two setae, seta II length as long as ODL seta, seta I shorter than seta II, both unilaterally armed with large setules (fig.29a) and larger in some specimens (figs.29b,d), these setules decreasing in length distal end. One small receptor located between these IDL setae. Groups of small serrated knobs (fig.29a) or row of slender setules at the base of the endite (figs.29b, d). Endite 3 (E3) with four plumose setae (1-4), subequal in length, setae 1 and 3 more slender and setae 2 and 4 more robust, all armed with short setules distally, row of small spinules at the base of endite. Endite 2 (E2) with three setae (5-7), seta 2 plumose, smallest, as long as seta 3, seta 6 longest (figs.29a, e) or seta 7 longest in some specimens (fig.29c), both unilaterally densely armed with long fine setules, shorter basally (figs.30a, e). Endite 1 (E1) with two setae (8-9), similar in length and similarly armed with short setules distally (figs.29a, e). Rows of small spinules on trunk, two rows of slender spinules present more radial on inner side of endite 2. Trunk with 5-6 rows of slender spines laterally. Basally two long and slender ejector hooks, one shorter, both unilaterally armed with short setules. Epipodite with long digitiform projection (fig.29d). Gnathobase not seen.

Second trunk limb (P2) (figs.29f-g)***:*** Epipodite not seen. Exopodite (EX) oblong, small setules apically. Endopodite (EN) triangular, with eight scrapers (1-8), mostly decreasing in length towards gnathobase but scraper 3 shorter than scraper 4 and scraper 4 shorter than scraper 5 in some specimens (fig.29f); all bi-segmented, scrapers 1, 2 and 4 similar unilaterally armed with fine setules distally, scrapers 3 and 6 more robust, unilaterally armed with large denticles, about 6-7 denticles each, scrapers 5, 7 and 8 unilaterally armed with stronger setules distally. Distal armature of gnathobase (GT) with three elements (I-III), elements I and II hook-like tip, both fused at the base, element III smaller located at the base of the first two. Small hillock between scraper 1 and gnathobase, a minute denticle close to first element.

Gnathobasic filter comb with seven setae, first seta considerably shorter, other setae generally increasing in length posteriorly.

Third trunk limb (P3) (figs.29h)***:*** Epipodite not seen. Exopodite (EX) flat, sub-rectangular, relatively small, bearing six setae (1-7): setae 1 and 2 located laterally, in typical V-formation, seta 1 setulated, longer than seta 2, seta 3 longest, about 2 times longer than seta 4, setuleated, setae 4 and 5 subequal in length, seta 4 unilaterally armed with long setules from base to tip, seta 5 setulated distally, seta 6 slender and shorter than seta 5, setulated.

Endopodite (EN) divided into two rows; anterior row with three distal setae (1-3), setae 1 and 2 stout, seta 2 shorter than seta 1, distally armed with short well-spaced setules, seta 3 more slender, setulated distally; posterior row with four setae (1'-4'), generally gradually increasing in length towards gnathobase, setulated distally. Gnathobasic filter comb with five setae.

Fourth trunk limb (P4) (fig.29i)***:*** Epipodite not seen. Exopodite (EX) rounded, bearing six setae (1-6), with generally decreasing in length, but seta 3 longest; setae 1 and 2 of the same length, setulated with long setules, seta 3 longest about 2 times longer than seta 4, setulated, seta 4 more robust, setulated, setae 5 and 6 more slender, similar in length, setulated with short setules.

Endopodite (EN) or inner portion, anteriorly bearing five setae (1-5), generally decreasing in length towards gnathobase; seta 1 long and slender, setae 2-4 'flaming torch' setae, seta 2 more robust, unilaterally armed with long and strong setules, setae 3 and 4 bilaterally armed with short setules distally, seta 5 rod-like receptor, relatively larger than seta 4, naked; posteriorly bearing four setae (1'-4'), generally increasing in length towards gnathobase. Gnathobase (GT) with two slender elements (I-II) both naked, fused at base of each other. Gnathobasic filter comb not seen.

Fifth trunk limb (P5) (fig.29j)***:*** Pre-epipodite (PEP) small, without elongated digitiform projection. Epipodite (EP) larger than pre-epipodite, more rounded, elongated digitiform projection present. Exopodite (EX) bearing four apical setulated setae (1-4); anterior portion smaller than posterior portion, bearing three setae (1-3),

seta 2 longest, setae 1 and 3 gradually smaller, respectively, all setulated; posterior portion bearing one seta (4), relatively short about a half of seta 3. Row of long setules between anterior and posterior portion.

Endopodite (EN) larger, more ovoid, setulated apically, two endopodite setae, setulated one shorter than the other, both not bending over the endite. Gnathobase (GT) relatively small, rounded.

Variability:

This species show high variability, noted in the following characters: 1) body shape, more ovoid (fig.28a) or highly arched in middle of body (fig.28b); 2) presence of spots on valves (fig.28b) or absent (fig.28a); 3) different range of body size between specimens with and without spots; 4) labrum more elongated (fig.28a) or more rounded (fig.28b); 5) first antenna compact (fig.28a) or more elongated (fig.28b); 6) the proportion of anal and postanal portion, postanal longest (fig.28j) or equal as other zones (fig.28k); 7) IDL setae armed with long setules distally, posterior setule large (fig.29a), very large in some specimens (figs.29b, d); 8) elongated digitiform present or absent in trunk limb 1; and 9) two ejector hooks of the same size (fig.29c) or one shorter (figs.29a, d).

Differential diagnosis:

The species can be distinguished from other species by the presence of 1) two major head pores connected with narrow connection, with two flower-like lateral pores; 2) labrum, anterior margin with a minute denticle; 3) distal margin of postabdomen round and broadly widen distally; 4) row of long setules around the joint of each segment on exopodite of second antenna; 5) IDL setae of trunk limb 1 distally armed with long setules, larger posteriorly and posteriormost largest; 6) scrapers 3 and 6 of trunk limb 2 more robust and armed with strong 5-7 denticles; and 7) a sensilla (sn) located between setae 4 and 5 of exopodite 3 and two sensillae (sn) between setae 1 and 2 of endopodite 3.

Remarks:

Although all specimens shared a peculiar character of 'flower-like' lateral head pores but the species shows differences between specimens both intra-and inter habitats in several characteristics as shown above. Here is apparently more than one species in this group in southern Thailand which can be roughly separated from the combination of some characters: 1) high proportion of specimens show more ovoid in shape, ventral setae relatively short, antennule compact and postanal margin of postabdomen longer than anal margin (fig.28a); and 2) few specimens show more rounded, ventral setae relatively longer posteriorly, antennule elongated and postanal margin of postabdomen as long as anal margin (fig.28b).

Biology:

A. verrucosa is the most diverse species in the present sampling sites, covering Southern Thailand. It can be found in every kind of habitat, however different in number. It is high abundance in vegetated area, especially dominant of *Nuphar lutea* (Alonso, 1996).

Distribution:

It is distributed widly in tropical zone i.e. in South America (Sao Paulo) (Jenkin, 1934); India (Nayar, 1971); Malaysia (Idris and Fernando, 1981); Thailand (Sanoamuang, 1998; Sa-adrit, 2001; Sa-adrit and Beamish, 2004).

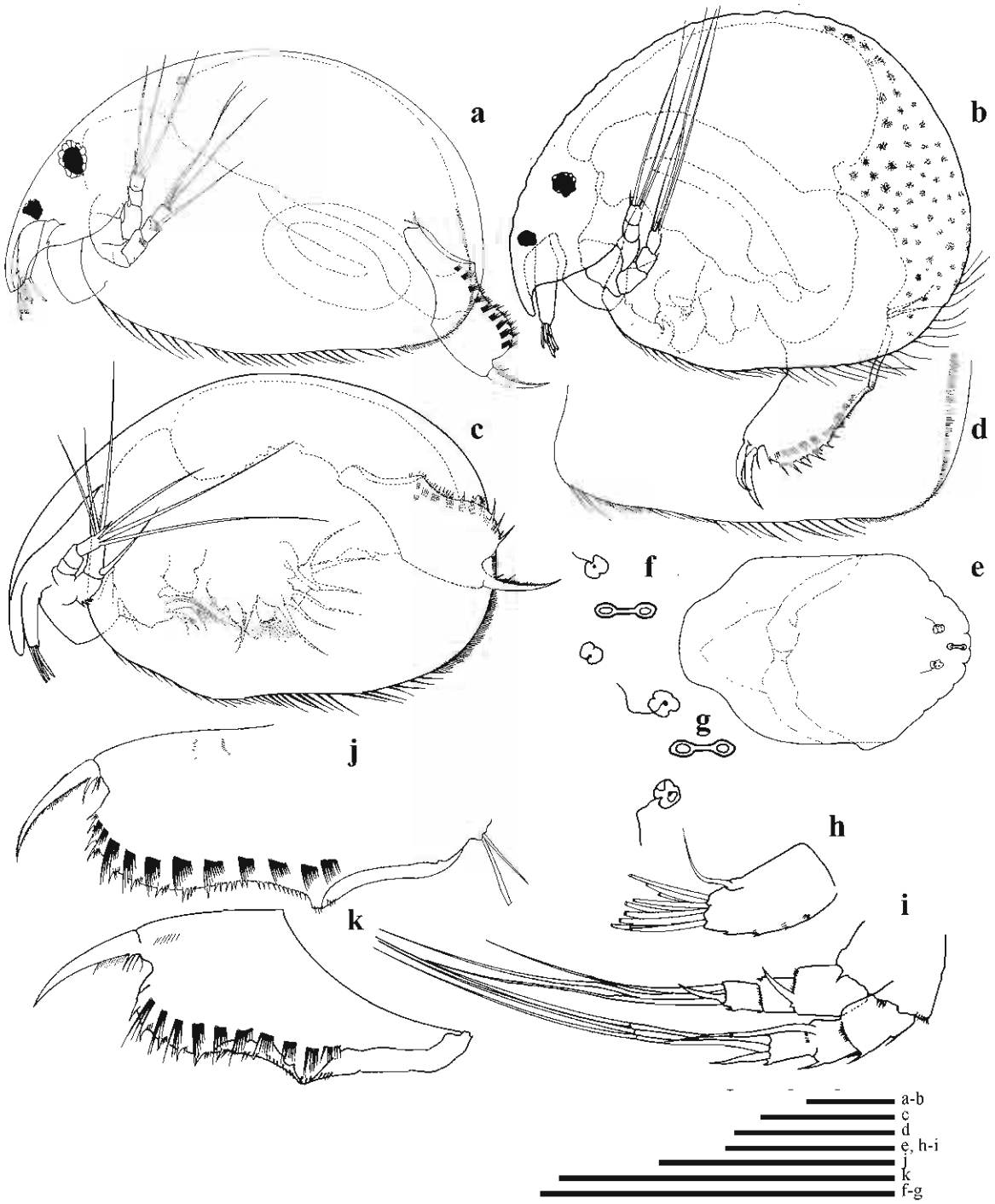


Figure 28. ***Alona verrucosa*** **Sars,1901:** parthenogenetic females from Thungtong swamp (S19), Suratthani Province, southeastern Thailand (a,d-j), Lake Kud-thing, northeastern Thailand (k), and Brazil (c). Figures a-c, adult females in lateral view; Figure d, ventral of valve; Figure e, head shield; Figures f-g, head pores; Figure h, antennule; Figure i, antenna; Figures j-k, post-abdomen. Scale bars denote 100 um.

Figure 29. ***Alona verrucosa*** **Sars,1901:** appendages of females from Thungtong swamp (S19), Suratthani Province, southeastern Thailand (a-c,f, h-j) and Lake Kud-thing, northeastern Thailand (d-e,g). Figures a-e, trunk limb 1; Figures f-g, trunk limb 2; Figure h, trunk limb 3; Figure i, trunk limb 4; Figure j, trunk limb 5. Scale bars denote 100 um.

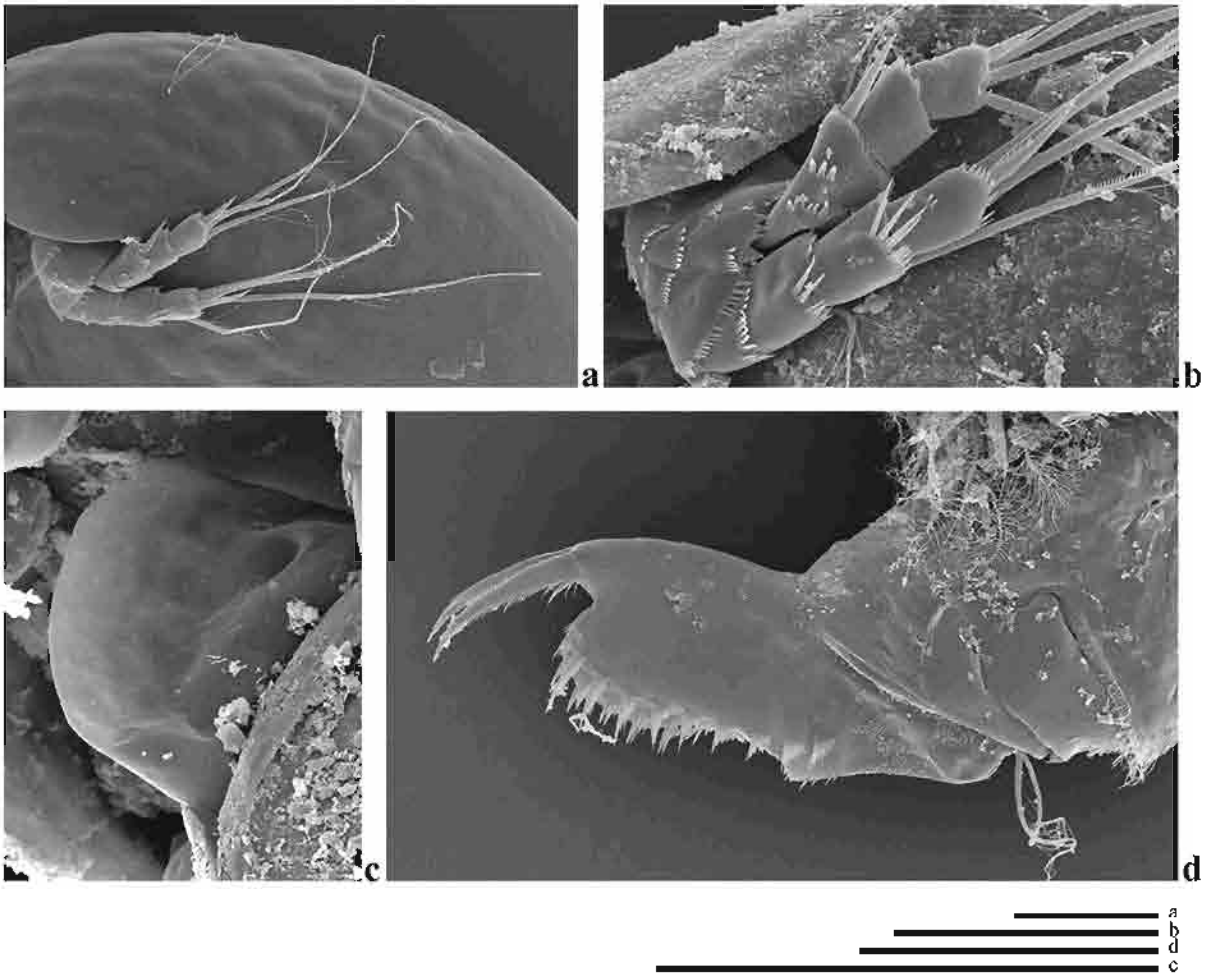


Figure 30. ***Alona verrucosa*** **Sars,1900:** parthenogenetic females from Thungtong swamp (S19), Suratthani Province, southwestern Thailand. Figure a, valve; Figure b, antenna; Figure c, labrum; Figure d, postabdomen. Scale bars denote 50 um.

Genus *Alonella* Sars,1862

Short description of the genus (Smirnov, 1996)

Leteral body outline short, oval. All ventral setae of valves inserted on its edge. Major head pores two, separated, situated at less than IP distance from posterior margin of head shield. Height of posterior margin of valve comparatively large in comparison with maximum body height, in contrast to *Pleuroxus*.

This genus was established by Sars (1862) for *Alonella pygmaea* Sars,1862 (syn. *Alonella nana* (Baird,1850)), *A. excisa*, *A. exigua* and *Lynceus rostratus* Koch (at present *Disparalona rostrata*). With increasing number of species attributed to this genus, Birge (1898, 1910, 1918) suggested 3 subgenera, not much used in subsequent literature and unnecessary with consideration of the present-day background of the system. The nearest genus is *Pluroxus*, comprising generally larger chydorids.

Key to three species of *Alonella* Sars, 1862 found in Thailand

1 a. body larger, length is about 1.5-1.7 times of height; quadrangular shape or oblong, rostrum point downwards, shell with polygonal-like ornamentation, postero-ventral angle of valve with denticle……..……...…….2

b. body relatively small, length is about 1.2-1.4 times of height; ovoid shape, rostrum curve inwards, shell with longitudinal striation from anterior to posterior, postero-ventral angle of valve with sharp denticle…....**1. *Alonella nana* (Baird, 1850)**

2 a. body quadrangular, length is about 1.5 times of height, postero-ventral angle with blunt denticle ……..……..**2. *A. excisa* (Fischer, 1854)**

b. body more oblong, length is about 1.7-1.8 times of height, postero-ventral angle with sharp denticle….……..……..…….**3. *A. clathratula* Sars, 1896**

1. *Alonella excisa* (Fischer, 1854)

Materials examined:

Northeast Thailand: ten parthenogenetic females, examined complete and thereafter dissected, from Boak swamp (NE10), Khon Kean Province, northeastern Thailand, collected by SM.

The details of morphological study

Species description (see figures 31-32)

Parthenogenetic female

General shape (figs.31a-b)**:** sub-quadrangular in lateral view, maximum height at 1/3 of body. Length 0.3-0.4 mm, about 1.6-1.7 times maximal height (n=10). Dorsal margin forms slight curve. Postero-dorsal rounded. Posterior margin almost straight, postero-ventral form a spine-like angle. Antero-ventral corner rounded. Ventral margin almost straight, consist of about 50-60 slender setae, gradually decreasing in length toward posterior end. Valve ornamentation pentagonal like shape.

Head (figs.31a-c)**:** Relatively large. Rostrum long, pointing downward. Compound eye present, larger than ocellus, distance between eye and ocellus shorter than distance from tip of rostrum to ocellus distinctively. Posterior margin of head shield rounded (fig 31c). Two major head pores, of same size, with a narrow connection between them (fig.31c), PP about 1.5 times as distance as IP.

Postabdomen (fig.31d)**:** wide, about 2.5-3 times as long as high, distal part about 1.5 times longer than preanal portion. Proximal portion with almost parallel dorsal and ventral margin, gradually narrowing distally. Anal margin relatively straight, with distinct pre-and postanal corner and bearing 4-5 rows of small denticles, each row consisting of 5-10 denticles. Lateral fascicles: 10-11 postanal groups, each consisting of 5-7 denticles. Marginal denticles: 8-9 groups of spines, gradually increasing in size distally and bearing 2 denticles on inner edge. Natatorial setae with long distal end, setulated.

Terminal claw (fig.31d)**:** Equal in length to preanal portion. Basal spine as a half of the claw, fine seta arising proximal to base of basal spine.

Trunk limb: six pairs

First trunk limb (P1) (fig.32a)**:** Outer distal lobe (ODL) with one seta, slender and bearing fine setules. Inner distal lobe (IDL) with three setae, all slender unilaterally armed with fine setules. Rows of setules present on IDL trunk. Endite 3 (E3) with four plumose setae (1-4) subequal in length, seta 1 and 2 armed with well-space short setules distally, seta 3 naked, or may be armed with setules but hardly visible, slender than the others, seta 4 longest, slender armed with well-space short setules distally. Endite 2 (E2) bearing three apical setae (5-7), of which seta 6 the longest, all setulated. Endite 1 (E1) with three apical setae (8-10), all as the same length, bilaterally with fine setules. Trunk with 4-5 rows of slender spines laterally. Basally two long and slender ejector hooks, of the same length, unilaterally armed with short setules. Epipodite and gnathobase not seen.

Second trunk limb (P2) (fig.32b)**:** Epipodite not seen. Exopodite (EX) round-elongated, small setules apically, a setulated seta basally, bending over the exopodite. Endopodite (EN) triangular, with eight scrapers (1-8), generally decreasing in length towards gnathobase though scraper 2 shorter than scraper 3, and scraper 4 shorter than scraper 5; all bisegmented, similar unilaterally armed with fine setules distally. Distal armature of gnathobase (GT) with three elements, element I slender and naked, element II more robust, armed with denticles from base to tip.

Third trunk limb (P3) (fig.32c)**:** Epipodite not seen. Exopodite (EX) globular, bearing six setae (1-6): seta 1 and 2 located laterally, in typical V-formation, seta 1 longer than seta 2, both bilaterally setulated, seta 3 slender and longest, about 5 times of seta 2, bilaterally setulated, setae 4-6 more slender and thin, seta 4 and 6 similar in length and armed with bilaterally setulated, seta 5 armed with long setules.

Endopodite (EN) divided to two rows; number of setae on anterior row unclear, setae 1 and 2 slender and thin, seta 2 shorter than seta 1, distally armed with fine setules; posterior row with five setae, similar in length and all bilaterally

setulated. Gnathobase (GT) with two elements (I-III), element I basally large, unilaterally setulated, element II as the same length but slender, naked, fused at the base of each other. Gnathobasic filter comb with eight setae.

Fourth trunk limb (P4) (fig.32d)**:** Epipodite and pre-epipodite rounded, distally setulated. Exopodite (EX) more round, bearing seven setae (1-7) with generally gradual increasing in length anteriorly, bilaterally setulated with long setules.

Fifth trunk limb (P5) (fig.32e)**:** Pre-epipodite (PEP) round, radial setulated apically, elongated digitiform projection not seen. Epipodite (EP) rounded, smaller than pre-epipodite, elongated digitiform projection presents. Exopodite (EX) not clearly bilobed, bearing four apical setae (1-4); anterior portion larger than posterior portion, setae 1-3 on anterior portion, seta 2 longest, setae 1 and seta 3 gradually smaller, respectively, all setulated; posterior portion smaller, bearing one seta (seta 4).

Endopodite (EN) elongated, setulated apically, two endopodite setae setulated distally, as the same length. Gnathobasic filter comb of three setae.

Differential diagnosis:

This species can be distinguished by its valves with polygons. Posterior-ventral angle of valve with blunt indentation, though almost point in some specimens.

Distribution:

At present *Alonella excisa* has been recorded on all continents but Antarctica. In Thailand it has been recorded in each study in many areas covering throughout Thailand, so it seems quite common in the country.

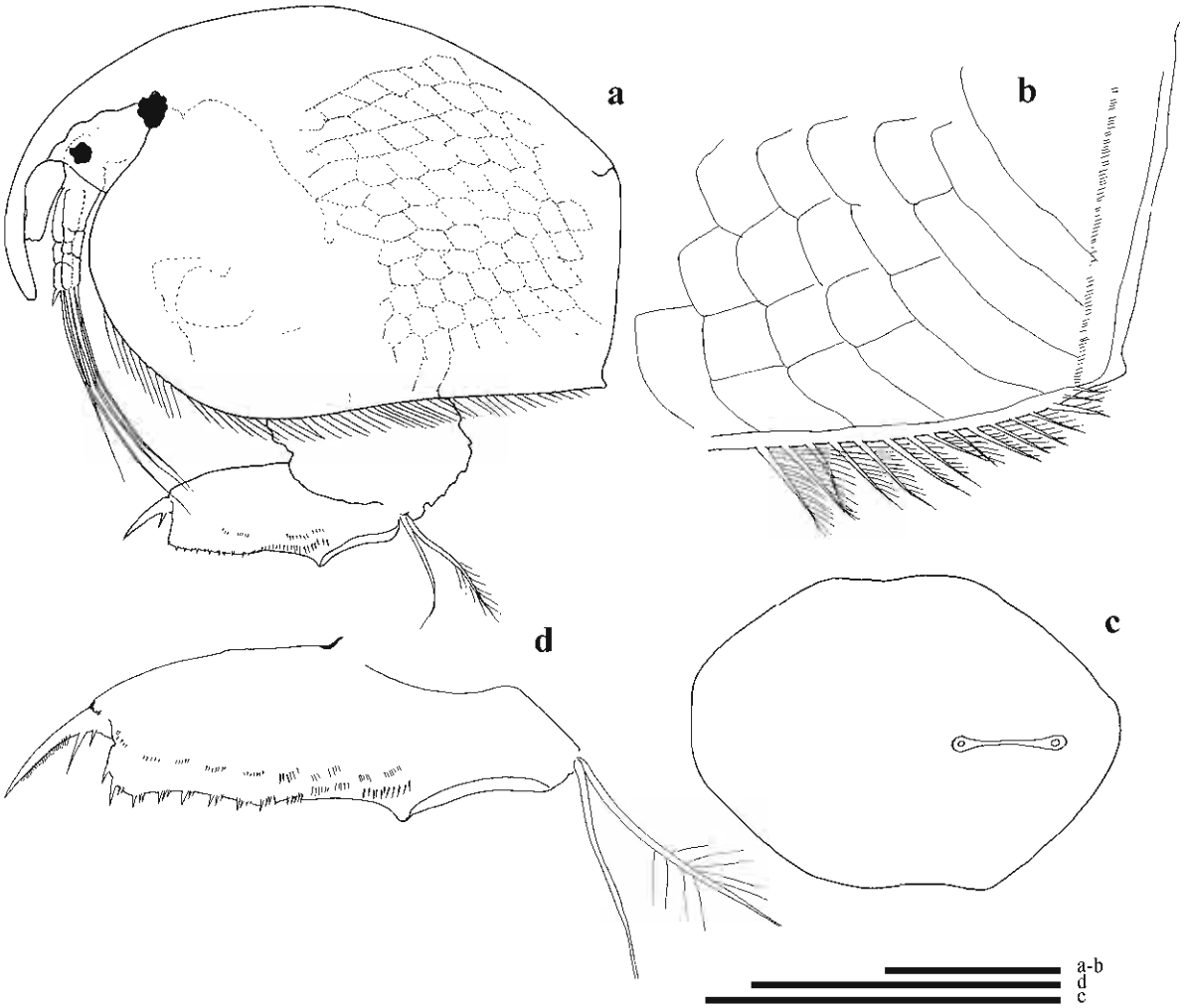


Figure 31. ***Alonella excisa*** **(Fischer,1854):** parthenogenetic female from Boak swamp (NE10), Figure a, adult female in lateral view; Figure b, postero-ventral corner of valve; Figure c, head pores; Figure d, postabdomen. Scale bars denote 100 um.

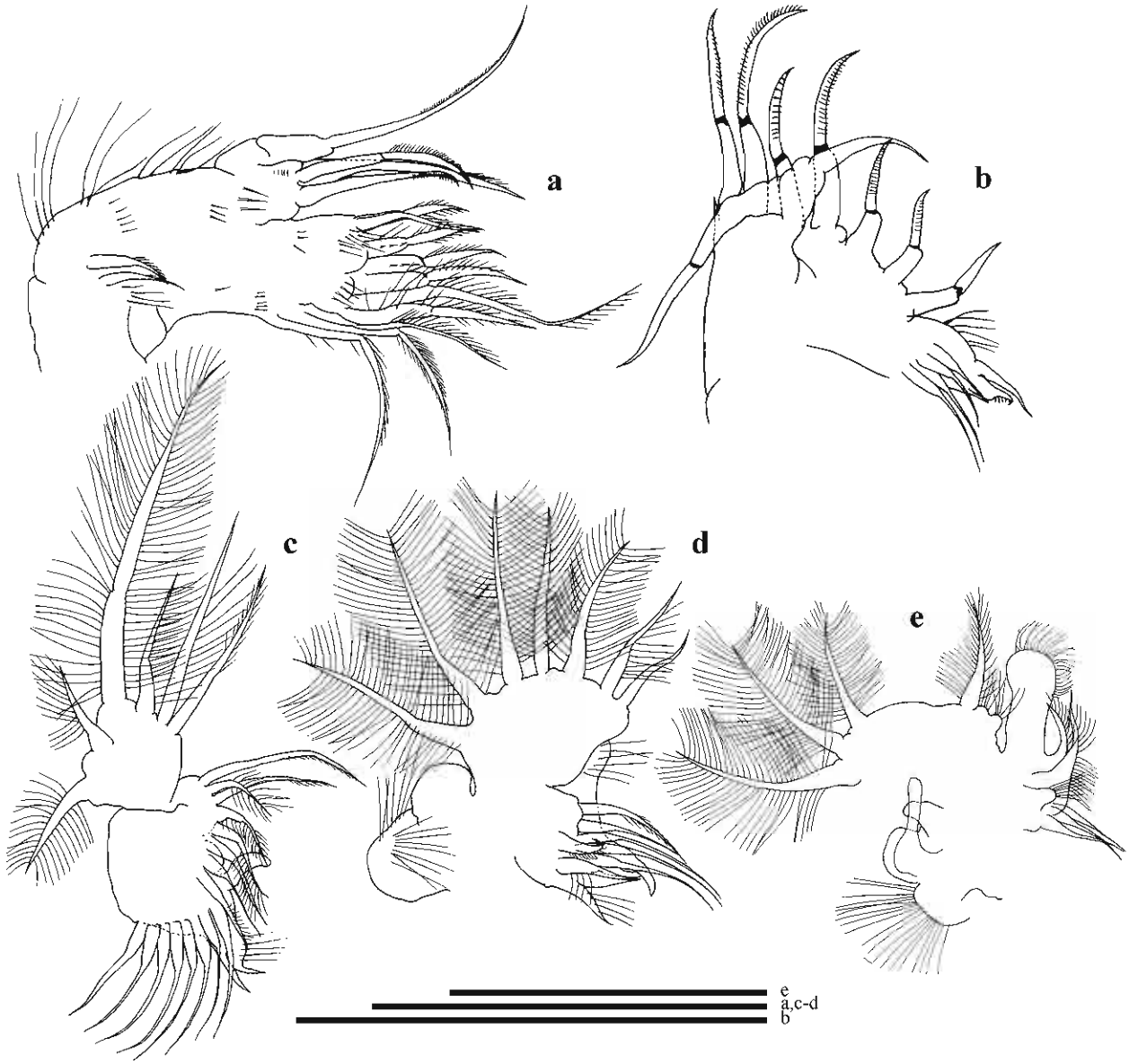


Figure 32. ***Alonella excisa*** **(Fischer,1854):** appendages of parthenogenetic females from Boak swamp (NE10), Khon Kean Province, northeastern Thailand. Figure a, trunk limb 1; Figure b, trunk limb 2; Figure c, trunk limb 3; Figure d, trunk limb 4; Figure e, trunk limb 5. Scale bars denote 100 um.

2. *Alonella nana* (Baird, 1850)

Holotype: Not existent

Materials examined:

Southern Thailand: five parthenogenetic females, examined complete and thereafter dissected, from Yon peatswamp, Trang Province, collected by the author, SM.

The details of morphological study

Species description (see figures 33-34)

Parthenogenetic female

General shape (figs.33a-b)**:** rounded in lateral view, maximum height around the middle of body. Length 0.2-0.3 mm, about 1.2-1.2.5 times maximal height (n=5). Dorsal margin forms slight curve. Postero-dorsal and postero-ventral angles almost round or forming a small hillock. Posterior margin slightly concave, postero-ventral corner broadly rounded one spine pointing latterally. Antero-ventral corner rounded. Ventral margin slightly rounded, anteriormost with 8-10 marginal setae followed by 25-30 slender setae, gradually decreasing in length toward posterior end, all bilaterally setulated. Posteriorventral corner without setules.Valve ornamentation consisting of striation, horizontally, obviously (figs.33a-b).

Head (figs.33a-c)**:** large comparable with body size. Rostrum short, pointing downward. Compound eye present, larger than ocellus, distance between eye and ocellus shorter than distance from tip of rostrum to ocellus. One major head pore (fig.33c).

Postabdomen (fig.33f)**:** wide about 2 times as long as high, distal part as long as preanal portion. Anal margin concave, with distinct pre-and postanal corner and bearing 2 rows of long setules, each row consisting of 4-5 setules. Lateral fascicles: 4-5 postanal groups, each consisting of 8-16 denticles. Marginal denticles: 5 denticles, gradually increasing in size distally, thought the distal most the shortest.

Terminal claw (fig.33f)**:** Equal in length to preanal portion. Basal spine as 1/4 of the claw, row of setules clearly arising from basal spine to distal end.

First antenna (antennule) (figs.33a,d)**:** short, not reaching tip of rostrum. Body compact, rod-like, about twice as long as wide. Distal end with eight aesthetascs equal in length, the shortest as half of the others.

Second antenna (fig.33e)**:** antenna formula, setae 0-0-3/0-1-3, spine 1-0-1/1-0-1. All setae bisegmented, two setae of distal segment of exopodite with a spinule distally. Seta arising from middle segment of exopodite longer than endopodite. Spine of basal segment of endopodite about 1/3 of middle segment length. Terminal spines shorter than terminal segment of exopodite.

Trunk limb: six pairs

First trunk limb (P1) (fig.34a)**:** Outer distal lobe (ODL) with one seta slender and bearing well-space setules. One spine presents at the base of ODL. Inner distal lobe (IDL) with three setae, setae I and II bisegmented, large and slender, unilaterally armed with setules distally; seta III more slender, about half of setae I and II, one small sensilla located between seta I and II. Endite 3 (E3) with four slender setae (1-4) subequal in length. Endite 2 (E2) bearing two apical setae (5-6), equal in length. Groups of slender setules present on outer side of endite 2. Epipodite and gnathobase not seen.

Second trunk limb (P2) (fig.34b)**:** Epipodite not seen. Exopodite (EX) rounded, a slender spine bending over the exopodite. Endopodite (EN) triangular, with eight scrapers (1-8), generally decreasing in length towards gnathobase though scraper 3 longest, all scrapers bisegmented, similar unilaterally armed with fine setules distally.

Third trunk limb (P3) (fig.34c)**:** Epipodite not seen. Exopodite (EX) subquadrangula, bearing six setae (1-6): seta 1 and 2 located laterally (hard to draw in the present study), in typical V-formation, seta 3 large but slender, bilaterally

setulated, seta 4 shortest, as half of seta 3, armed with bilaterally setulated, setae 5- 6 more slender, unilaterally armed with rows of setules.

Endopodite (EN) divided to two rows; anterior row with eight setae (1-8), setae 1 and 2 long and slender, seta 2 as half of seta 1; posterior row with five setae, gradually increasing in length toward gnathobase. Gnathobase (GT) with three elements, each fused at the base of each other.

Fourth trunk limb (P4) (fig.34d)**:** Pre-epipodite and epipodite rounded. Exopodite (EX) rounded, bearing seven setae (1-7) with generally gradual decreasing in length posteriorly, though seta 6 shorter than seta 7; setae 1-4 are of equal in length, bilaterally setulated with long setules, seta 5 and 7 are similar in length, half as long as the first seta.

Endopodite (EN) or inner portion, anteriorly bearing five setae (1-5), seta 1 naked, smallest and rounded basally, setae 2-4 ‘flaming-torch’ setae, distally armed with long-slender setules, counting 4-5 setules each, seta 5 not clear; posteriorly portion not clear. Gnathobase (GT) with two elements, element I large-slender, unilaterally setulated distally with short setules, element II naked, fused at the base with element I.

Fifth trunk limb (P5) (fig.34e)**:** Pre-epipodite and epipodite not studied. Exopodite (EX) rounded, bearing four apical setae (1-4); setae 1-3 on anterior portion, seta 2 longest, setae 1 and seta 3 gradually smaller, all setulated; posterior portion bearing one seta (seta 4), relatively short, as half of the longest.

Endopodite (EN) rounded and elongated, setulated apically, two endopodite setae setulated distally. Gnathobasic comb unclear.

Sixth trunk limb (P6): not studied.

Differential diagnosis:

This species can be distinguished by its small size, about 0.2-0.3 mm. Of which Smirnov (1996) stated that the specimens from Russia show only 0.24 mm in length. Also, its peculiar oblique valve striations.