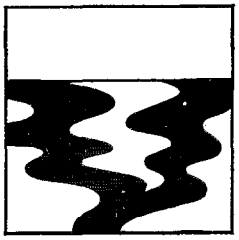

New records of Diaphanosoma celebensis *Stingelin, 1900 (Crustacea : Daphniiformes : Sididae) in tropical Asia with remarks on the morphological variability and biology of the species*

Nicolaï M. Korovchinsky (1)

Abstract

The morphological variability, population structures and geographical distribution of a rare species, Diaphanosoma celebensis *Stingelin, 1900, are described, based on material from South India, Sri Lanka, Singapore and Malaysia. This species is the only member of the family Sididae to be found in fresh (ponds) as well as in saline waters.*

Key words : *Diaphanosoma celebensis* — Tropical Asia — Morphological variability — Biology — Geographical distribution.

Résumé

Nouvelles données sur la variabilité morphologique et biologique de *Diaphanosoma celebensis* Stingelin, 1900, en Asie tropicale

Variabilité morphologique, structure de la population et répartition géographique de l'espèce rare Diaphanosoma celebensis *Stingelin, 1900 sont étudiées à partir de matériel provenant du sud de l'Inde, de Sri Lanka, de Singapour et de la Malaisie. Cette espèce est répandue en Asie tropicale et s'étend jusqu'à la zone subtropicale au nord (Bangladesh) ; elle se rencontre en eau douce (étangs) aussi bien que dans des eaux de salinité élevée, ce qui était inconnu chez les Sididae.*

Mots clés : *Diaphanosoma celebensis* — Asie tropicale — variabilité morphologique — biologie — répartition géographique.

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INTRODUCTION

The rare tropical species *Diaphanosoma celebensis* Stingelin has been redescribed in detail from type material from Sulawesi Island (Indonesia) and extensive material from the South of Vietnam (KOROVCHINSKY, 1989). Indirect data show that this species also occurs in other regions of tropical Asia ; in particular it is most probably in Sri Lanka where it was described under the name "*D. aspinosum*" (RAJAPAKSA, 1981; RAJAPAKSA and FERNANDO, 1982). Study of the extensive collection of tropical zooplankton made by Professor C. H. FERNANDO (University of Waterloo, Canada) provided an opportunity to check these assumptions and to obtain some additional data on the morphology and biology of this species which has recently become the object of experimental laboratory cultivation (SEGAWA and YANG, 1987, 1988).

Table I

Data of measurements of specimens of *Diaphanosoma celebensis* from 5 populations
Données de mensurations de specimens de Diaphanosoma celebensis *provenant de cinq populations.*

	Body length (mm)	Head length: Body length (%)	Head height: Body lenght (%)	Diameter of eye: Body length (%)	Lenght of swimming antennae: Body lenght (%)	Length of 2 - segmented antennal branch: lenght of basipodite (%)	Length of 3 - segmented antennal branch: Length of basipodite (%)	Length of 3 - segmented branch: Length of 2 - segmented branch: (%)	Length of setae natatoriae: Body length (%)
1. Sri Lanka, 7.3.1980 (n=15)	0.67-0.84 0.79 0.049 6.23	31.6-36.0 33.7 1.09 3.25	22.2-26.3 23.8 1.18 4.96	8.3-10.0 8.9 0.53 6.00	64.9-74.0 67.7 2.76 4.06	100.0-124.5 111.6 6.03 5.39	62.3-77.6 69.0 3.81 5.53	58.7-68.0 61.7 2.33 3.77	50.9-58.3 54.8 1.76 3.22
2. Singapore, Lem Chu Kang, fish pond 2 6.4.1974 (n=11)	0.60-0.90 0.65 0.085 13.08	34.9-40.4 36.8 1.72 4.67	22.7-26.7 24.5 1.29 5.30	10.2-11.6 11.1 0.45 4.06	67.4-75.6 71.9 3.14 4.37	83.0-104.4 93.6 5.86 6.27	54.2-65.2 59.2 3.60 6.08	59.6-67.0 63.3 2.55 4.03	53.2-63.6 58.3 3.51 6.02
3. Singapore, Ponggol Lorong Buankok, fishpond 4, 9.4.1974 (n=15)	0.67-1.08 0.80 0.12 14.65	33.3-37.5 35.2 1.21 3.44	23.4-27.1 25.2 0.84 3.33	9.3-11.1 10.4 0.49 4.69	63.3-70.9 67.8 2.08 3.07	85.0-95.0 89.9 3.14 3.50	52.4-58.9 56.4 2.12 3.75	58.6-67.4 62.8 2.39 3.80	46.8-58.9 54.5 6.07 11.13
4. Singapore, Ponggol Lorong Buankok, fishpond 6, 4.4.1974 (n=15)	0.58-0.85 0.65 0.11 16.9	31.3-34.2 32.8 0.93 2.84	21.1-25.0 23.5 1.08 4.62	8.6-10.7 9.4 0.60 6.40	64.1-75.5 71.9 3.10 4.3	89.8-102.4 94.4 4.06 4.30	57.7-65.0 60.6 2.15 3.54	59.6-67.4 64.2 2.54 3.96	56.7-64.8 59.8 2.40 4.01
5. Malaysia (unknown locality) (n=13)	0.76-0.91 0.85 0.04 4.71	27.5-31.2 29.9 1.00 3.34	20.5-23.4 21.5 0.83 3.84	7.2-9.3 8.2 0.60 7.35	60.8-67.9 64.4 2.47 3.83	94.4-106.0 100.4 3.22 3.20	61.1-69.4 64.5 2.57 3.98	62.3-68.6 64.3 3.02 4.69	46.3-52.7 48.9 1.64 3.36

In each column from top to down : limits of variation, mean, SD, CV.

MATERIAL AND METHODS

Material borrowed from Professor C. H. FERNANDO's collection :

Sri Lanka : 1) N II-27 Marawila, small pond, 6.9.1970 : 10 parthenogenetic and 12 juvenile females in formalin; 6.12.1970 : 38 dried females in formalin and 4 total mounts with 16 parthenogenetic females (4 of them are dissected) and 1 dissected male named *"D. aspinosum"*; 2) Unknown locality (Reservoir Parakrama Samudra?), 7.3.1980 : 189 parthenogenetic and 378 juvenile females.

South India (Madras?) : 4 parthenogenetic and 1 juvenile females.

Singapore : 1) N II-218 Lem Chu Kang, fish pond 2, 6.4.1974 : 15 parthenogenetic and 48 juvenile females; 2) N II-229 Ponggol Lorong Buankok, fish pond 4, 9.4.1974 : 109 parthenogenetic and 6 juvenile females; 3) N II-230 Ponggol Lorong Buankok, fish pond 5, 4.4.1974 : 1 parthenogenetic and 17 juvenile females; 4) N II-231 Ponggol Lorong Buankok, fish pond 6, 4.4.1974 : 49 parthenogenetic and 359 juvenile females.

Material borrowed from the laboratory culture of Dr SEGAWA (Tokyo University of Fisheries, Japan) : Malaysia (unknown locality) : 14 parthenogenetic and 15 juvenile females.

Detailed measurements of body parts were made only on adult females. Figures were made by means of an RA-4 drawing apparatus.

RESULTS AND DISCUSSION

INTRA-AND INTER-POPULATION MORPHOLOGICAL VARIABILITY

Data on measurements of body parts of representatives from 5 populations are presented in Table I. All the populations show considerable variation in body length of the specimens as indicated by the coefficients of variation. The Malaysian specimens are the most uniform in this respect.

The form of the posterior margin of the carapace valve and its relative shape with respect to the posterior part of the ventral free valve inflection may vary (Figs 3-5). It is very characteristic of the Sri Lankian specimens, that their posterior valve margin is almost straight and the posterior part of the ventral free valve inflexion is brought closer to it (fig. 2) as in *D. volzi* (KOROVCHINSKY, 1992). The setules on these valve margins are practically invisible which contradicts the previous data concerning this material (RAJAPAKSA and FERNANDO, 1982).

The majority of specimens from Singapore have post-abdominal claws with a straight basal spine (Fig. 9); only in the largest female from Ponggol Lorong Buankok (fish pond 4) is this spine wavy. In contrast, the Malaysian specimens mostly possessed wavy spines, as did representatives from Sulawesi Island and Vietnam (KOROVCHINSKY, 1989).

The representative specimens from Sri Lanka also have swimming antennae with comparatively long branches (up to 133 % of basipodite length). One adult female from Marawila has 8 setae on the distal segment of the 2-segmented antennal branch (Fig. 12); another has 4 basal spines on one post-abdominal claw (Fig. 8).

The males' copulatory appendages (Fig. 6) lack the significant distal broadening previously drawn by RAJAPAKSA and FERNANDO *(op. cit.)*. They have only a funnel-shaped end which may be a consequence of the specimen's deformation.

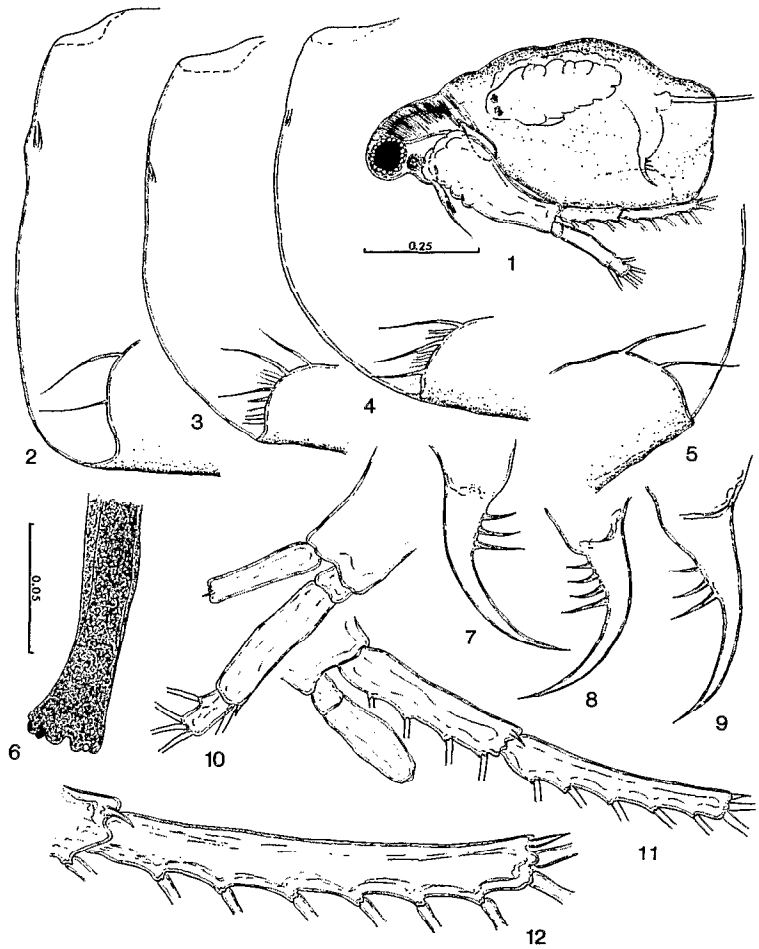
The representatives from Lem Chu Kang (Singapore) are rather peculiar, having a small body size, with large head and eye and short elevated shell (Fig. 1). Their swimming antennae, with an especially developed basipodite, are usually long; possibly it is an age-dependant character because the largest female possesses a comparatively thinner and longer body.

In the representatives of other Singaporian populations, especially from Ponggol Lorong Buankok (fish pond 4), the antennal basipodite is also longer than the upper 2-segmented branch, but, in general, their antennae are not long. A noticeable number of females (20.4 %) of one population (fish pond 6) had deformed branches of the swimming antennae (Figs 10, 11) which might be a consequence of collision with predators. The posterior valve margins of Singaporian specimens compared with those from Sri Lanka are more rounded and their setules may be quite visible (Figs 3, 4).

The representatives from Malaysia have relatively small heads and eyes, short swimming antennae with comparatively long branches and especially short setae natatoriae (see Table I).

The Vietnamese specimens studied before (KOROVCHINSKY, 1989) differ from all others in having an especially low head, very short swimming antennae with relatively long branches and long setae natatoriae.

All these data give more precise details about the diagnostic characters of this species. In general there are insignificant differences between the representatives from the different regions, except in the specific structure of the posterior part of shell valves of Sri Lankian specimens. It is necessary to study more extensive material to specify the taxonomic status of this feature.



FIGS 1-12. - *Diaphanosoma celebensis* Stingelin, 1900
(Singapore : 1 — Lem Chu Kang, fish pond 2; 3, 9 — Ponggol Lorong Buankok, fish pond 5; 4, 5, 10, 11 — Ponggol Lorong Buankok, fish pond 6. Sri Lanka : 2 — unnamed locality, 7.3.1980 : 6-8, 12 — Marawila, small pond). 1. female, general lateral view; 2-4. posterior parts of shell valve; 5. ventro-posterior part of valve; 6. copulatory appendage of male; 7-9. postabdominal claws; 10-11. deformed swimming antennae; 12. unusual distal segment of upper antennal branch with 8 setae.

Diaphanosoma celebensis *Stingelin, 1900*
(Singapour : 1 — Lem Chu Kang, étang à poissons 2; 3, 9 — Ponggol Lorong Buankok, étang à poissons 5, 4, 5, 10, 11 — Ponggol Lorong Buankok, étang à poissons 6. Sri-Lanka : 2 — sans nom de localité, 7.3.1980; 6-8, 12 — Marawila, étang). 1. femelle, vue générale latérale; 2-4. parties postérieures des valves; 5. partie postéro-ventrale de la valve; 6. appendice copulateur du mâle; 7-9. griffe postabdominale; 10, 11. antennes déformées; 12. segment distal anormal de la rame supérieure de l'antenne, avec 8 soies.

SIZE-FREQUENCY AND SEX POPULATION STRUCTURE

All individuals of *D. celebensis* that were measured were attributed to 15 size classes ranging from 0.30 to 1.10 mm (interval width 50 μm).

The results are shown in Fig. 13. In general, the size structures of these three populations (one from Sri Lanka, two from Singapore) are simpler than that observed earlier in the Vietnamese population (KOROVCHINSKY, 1989) because they lack males. The Sri Lankian population and one of the populations from Singapore (Ponggol Lorong Buankok, fish pond 6), are mostly similar to that from Vietnam in their ratios of juveniles to egg-bearing parthenogenetic females (3.7 % and 12 % respectively). At the same time, the size of the smallest individual and the smallest mature female are larger in the Sri Lankian population (0.49 and 0.67 mm respectively) and smaller in the Singaporian ones (0.27 and 0.53 mm respectively) than those from Vietnam.

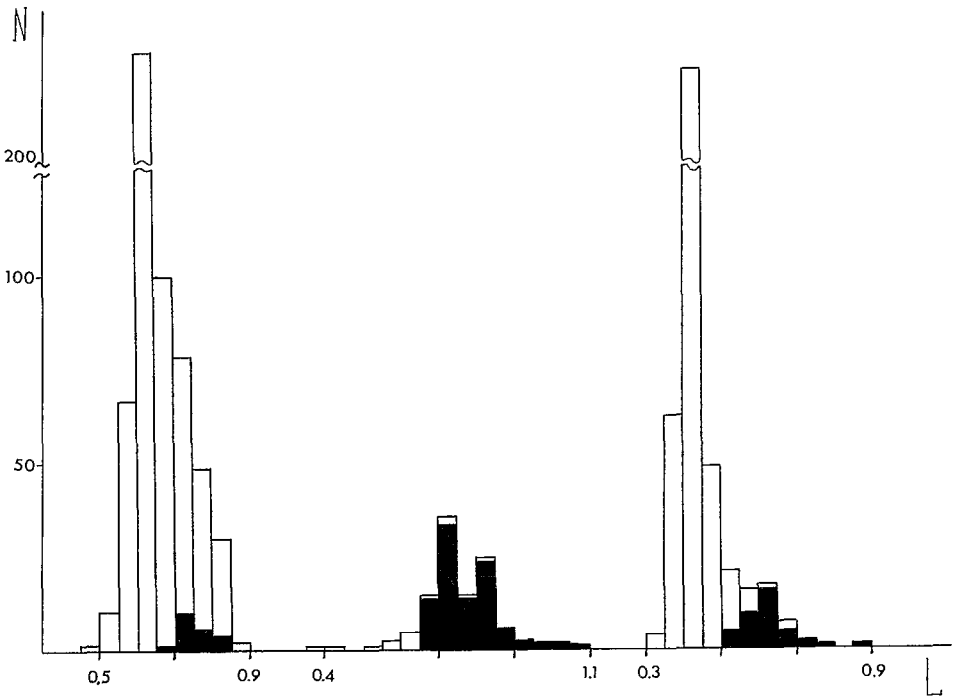


FIG. 13. — Size-frequency and sex structure of three populations of *Diaphanosoma celebensis*. From left to right : 1. Sri Lanka, unnamed locality, 7.3.1980 ; 2. Singapore, Ponggol Lorong Buankok, fish pond 4 ; 3. The same district, fish pond 6 ; White columns : immature females and mature females without eggs ; black colums : parthenogenetic females with eggs or embryos.
Fréquence de tailles et structure des sexes de trois populations de Diaphanosoma celebensis. *De gauche à droite : 1. Sri Lanka, sans nom de localité, 7.3.1980 ; 2. Singapour, Ponggol Lorong Buankok, étang à poissons 4 ; 3. même district, étang à poissons 6 ; Colonnes blanches : femelles immatures et femelles matures sans oeufs ; colonnes noires : femelles parthénogénétiques avec des oeufs ou des embryons.*

In contrast, in another Singaporian population (Ponggol Lorong Buankok, fish pond 4), large, mature egg-bearing females predominated. They bore up to 6-8 eggs or embryos in their brood pouches (on average 3.8 eggs per female and 4.0 eggs per egg-bearing female). The largest female (1.08 mm) was recorded here. SEGAWA and YANG (1987) recorded a size range from 0.4-1.3 mm and a fecundity of up to 14 eggs in their laboratory culture of *D. celebensis*. All females from Lem Chu Kang bore eggs but in smaller numbers (up to 6 eggs, on average 2.9 eggs per female) which is probably connected with their smaller body size.

FREQUENCY OF OCCURRENCE, HABITAT TYPES AND DATA FROM LABORATORY CULTIVATION

At present *D. celebensis* is known from only 11 localities, so to call it rare still seems to be justified. Only in Singapore was it found in more than one place.

This species inhabits small water bodies (small lakes, ponds, fish ponds) including brackish estuarine waters. Possibly it even prefers the latter type of environment because the optimum salinities for its reproduction ranged from 1 to 25 ppt (SEGAWA and YANG, 1987). In general *D. celebensis* is able to survive in salinities of up to 40 ppt, which means that, according to HAMMER (1986), it can be included in the group of hypo-mesohaline species. Previously, only hypo-haline species have been recorded among the Sididae (highest limit of salinity 13-15 ppt) (NEGREA, 1983 ; HAMMER, *op. cit.*).

D. celebensis is relatively small in body size and, possibly as a consequence, it avoids predation by fish, the density of which is especially high in fish ponds (C. H. FERNANDO, personal communication). On the other hand, the deformed swimming antennae of some specimens (see above) indicate that it is probably affected by invertebrate predators.

Gamogenetic populations of *D. celebensis* have not been recorded. The small number of males which was found twice (Vietnam and Sri Lanka) at the end of October and at the beginning of December seems to indicate that late autumn-winter is the possible period of sexual reproduction.

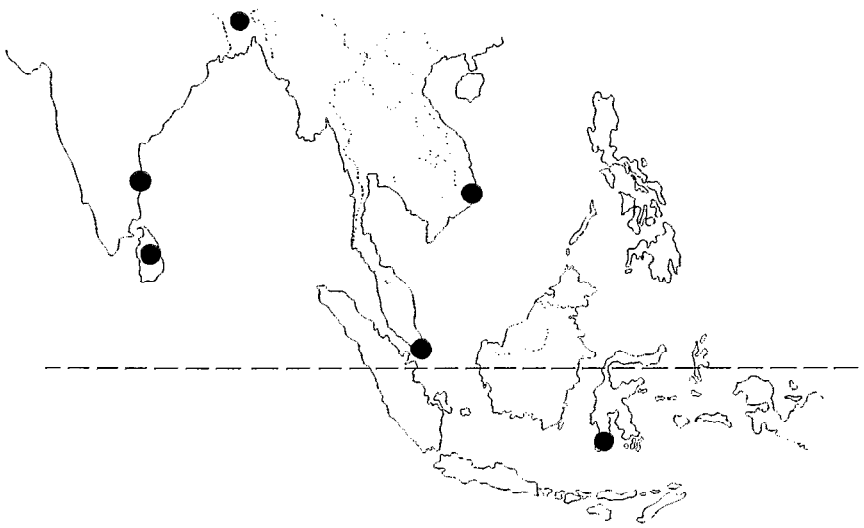


FIG. 14. — Geographical distribution of *Diaphanosoma celebensis*.
Répartition géographique de Diaphanosoma celebensis.

Recently this species, also named "*D. aspinosum*", has been cultivated and investigated in the laboratory (SEGAWA and YANG, 1987, 1988). Its reproductive possibilities, population growth and density were studied. In particular, the authors noted that "parthenogenetic females matured and released their first neonates at the age of 4 to 5 days, producing average broods of 8 to 9 neonates (maximum 14) every two days. Average life span of a female in each salinity ranged from 13.2 to 17.9 days, during which time they produced up to 10 broods and 50 to 60 neonates (maximum 92). Reproduction rates in the laboratory indicated that the population increased 1.11 to 1.63 times per day... The populations of varying initial densities reached to the maximum density in 32-42 days after the inoculation (80.1 to 130.8 ind/ml^{-1}) and the density was maintained at a nearly constant level thereafter. The higher initial population density caused the greater maximum density reached. The mean density after reaching to the maximum density remained from 71.9 to 100.0 ind/ml^{-1}. Such a high reproduction rate and population growth may indicate that this is a promising species for mass culture as food organism for the mariculture of fish and invertebrates".

GEOGRAPHICAL DISTRIBUTION

Data on the distribution of *D. celebensis* in Asia are shown in Fig. 14. This species is known from Sulawesi Island in the East to Sri Lanka and South India in the West and from the equatorial zone up to the subtropical zone of Bangladesh in the North.

This species (under the name "*D. aspinosum*") was recorded for the first time in India and Bangladesh in unpublished theses by KANDURU (1981) and HOSSAIN (1982). The first author mentions its occurrence in South India and also in the centre of that country (Jabalpur) but, due to the similarity of *D. celebensis* to *D. volzi* (both species have been found in one tube with material from South India), this record needs revision. The data of HOSSAIN *(op. cit.)* significantly enlarge the range of *D. celebensis* to the North (Mymensingh in Bangladesh : 24°45′ N ; 90°25′ E) where it exceeds the bounds of the strictly tropical zone.

It thus appears that *D. celebensis* was absent from the extensive collections of Daphniiformes from Malaysia (IDRIS and FERNANDO, 1981). For the first time it has been found in that country by W. T. YANG (RAJAPAKSA, 1981) and subsequently this material was used for the laboratory observations described above. Unfortunately the exact locality for the origin of the material used is not known. Singapore is a new region of occurrence for *D. celebensis*.

CONCLUSION

According to all the observed data, *D. celebensis* is a species widely distributed in tropical Asia whose

range even reaches to the North subtropical zone (Bangladesh).

Until recently it has been exclusively named "*D. aspinosum*", as the closely related species *D. volzi*. Due to confusion of these two species, it was difficult to have any real idea about their biology and geographical distribution.

Studies on the morphological variability within and between populations give new information on the diagnostic characters of *D. celebensis*.

Although we are in possession of limited data on this species, it appears that the biology of *D. celebensis* is quite interesting : on the one hand it lives in fresh waters (fish ponds) and on the other it occurs in water bodies with rather high salinities ; it is the only species in the familiy Sididae to tolerate such a wide range of salinity.

ADDENDUM

After sending the manuscript to the editorial board of the *Revue d'Hydrobiologie tropicale*, *D. celebensis* was found in one additional sample from a brackish shrimp pond (5 ppt) in Japara, Central Java (Indonesia) from which material was kindly presented by Mrs E. ANTIC. This is the southernmost locality of the species.

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