Indian Journal of Geo Marine Sciences
Vol. 50 (04), April 2021, pp. 296-301

Unprecedented report of the calanoid copepod *Acartiella faoensis* Khalaf, 1991 from the estuarine waters of the lower-middle stretch of river Hooghly, West Bengal, India

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Received 01 May 2019; revised 09 October 2020

Acartiella faoensis, previously known as *Acartia* (*Acartiella*) *faoensis*, is a calanoid copepod which was observed during a biodiversity survey, during July-August of 2018, on the lower-middle stretch of the Hooghly River (upper reaches of Hooghly estuary). The species is reported for the first time from the aforementioned locality as well as anywhere from the eastern India and perhaps the entire country. Individuals belonging to both the sexes have been collected and studied. The observed species is native to Khour-Abdullah and Khor Al-Zubair waters of the Northwestern Gulf of Arabia as evidenced by earlier works and its appearance in the presently reported location is of great ecological significance. This account deals with the description of the species using compound microscopes and drawings made by using camera-Lucida, to be used as reference in future works.

[**Keywords**: *Acartiella faoensis*, Biodiversity, Calanoid copepod, Hooghly estuary, West Bengal]

Introduction

The dissemination of a species to a new environment can follow various avenues, but most often is inserted to an ecosystem through ignorance or accident. If the introduced species is not resilient enough to cope with the changes associated with the transition of habitats (only in cases where the two habitats differ in almost every aspect while maintaining only a few constants), the potentially pernicious effects of the introduction gets nullified as the species never attains a strong podium within the ecosystem. However, more often than not, the species finds itself in amicable surroundings with promising opportunities enabling it to establish its own respective niche through successful competition and in rare cases elimination of the native dominant flora/fauna; the availability of the greater portion of resources generally culminates in greater breeding and higher fecundity rates of the species, thereby expediting the takeover.

Perhaps the best examples of such chance releases of adventive species are the cases of introduction of planktonic flora and fauna through ballast discharges which can be held accountable for the circumglobal occurrence of many such now ubiquitous species, while in reality those species would have never been able to overcome the naturally imposed geophysical impediments on their own. Once established in the new environment, although potentially serving as new food items for the native planktivores, they tend to modify the competition either through over aggression or by allelopathy, leading to drastic or gradual overhaul of the species composition and the consequent abatement in biodiversity of the said ecosystems. This usually results in the long term remodeling of the trophic structure and energy flow with emanating impacts.

The members of the Family Acartiidae Sars, 1903[ref. 1] under the Order Calanoida constitute one of the most abundant faunal assemblages in the aquatic ecosystems of the world. Species belonging to the genus *Acartia* Dana, 1846[ref. 2] are so important that almost every coastal and pelagic ecosystem rely on their preponderance to maintain the trophic pyramid and energy flow both vertically and horizontally. The former subgenus *Acartiella* Sewell, 1914[ref. 3] used to be affiliated to the genus *Acartia* but since has been elevated to the rank of genus itself where also most of its subordinate taxa have been assigned, following modern taxonomic refurbishment, to the subgenus *Acartia* (*Odontacartia*) Steuer, 1915[ref. 4].

The presently reported account is of a previously unreported species of the calanoid copepod *Acartiella* (*A. faoensis* Khalaf, 1991)[5] from estuarine waters of

India, and whose documentation in Hooghly estuary is of immense ecological significance (being visibly larger than most of the zooplankton occurring in the area). The presence could very well be attributed to deballasting since in its native habitat (in and around the Gulf of Arabia) the species thrives in alkaline and high saline zones, markedly different from the ecological transect which they were sampled from, being of nearly neutral pH and at the lower end of the brackish spectrum. The hypothetical objective behind the study was to check the morphometry of the individuals and also comparing it with descriptions made on them in their natural habitat to highlight changes in their features, if any, due to prominent differences in their native and supposedly introduced habitats.

Materials and Methods

The study was performed on the lower stretch of the Hooghly River (upper-median stretch of the Hooghly estuary) with the aim of collecting various micro-algal and zooplanktonic species to study community assemblages and biodiversity of the region. The location serving as the commencement site of the survey is at 22°0′55.30″ N, 88°12′0.26″ E and represents the mixed zone of the river with predominant freshwater influence (Fig. 1). The intermediate stations for sampling were stationed at 22°1′3.45″ N, 88°11′11.97″ E; 21°58′59.7″ N, 88°09′37.9″ E; and 21°59′54.5″ N, 88°11′13.6″ E. In all these sub-sampling sites, the 200 m and 1000 m foreshore and offshore study pattern was maintained in tune with CRZ (coastal regulation zone) survey. The locations were so chosen because they were selected sites for a shipyard and port construction in future and the purpose of the study was to prevent that from happening and in turn conserve the biodiversity of the area.

The water samples pertaining to the collection of planktonic assemblages were stored in TARSONS[R] wide mouth amber coloured bottles, mostly without any preservatives in order to ensure the retention of all the body parts and projected appendages that are morpho-taxonomically important for the proper and precise identification of the species. The live plankton samples were kept under ambient temperature (water temperature -28.5 °C). The collections were performed 1000 metres up and downstream of the chosen sites to expand the surveyed area for maximum coverage of the species available. This sampling rhythmicity was maintained throughout the selected area of survey which extended from the designated study site upto five kilometers downstream of the river. The entire site selection was coherent with the norms of a biodiversity survey prior to the potential establishment of a shipyard.

Both quantitative and qualitative samplings were performed using Niskin water sampler and zooplankton net made of bolting silk, with 60 µm mesh size and the latter was equipped with Hydro-

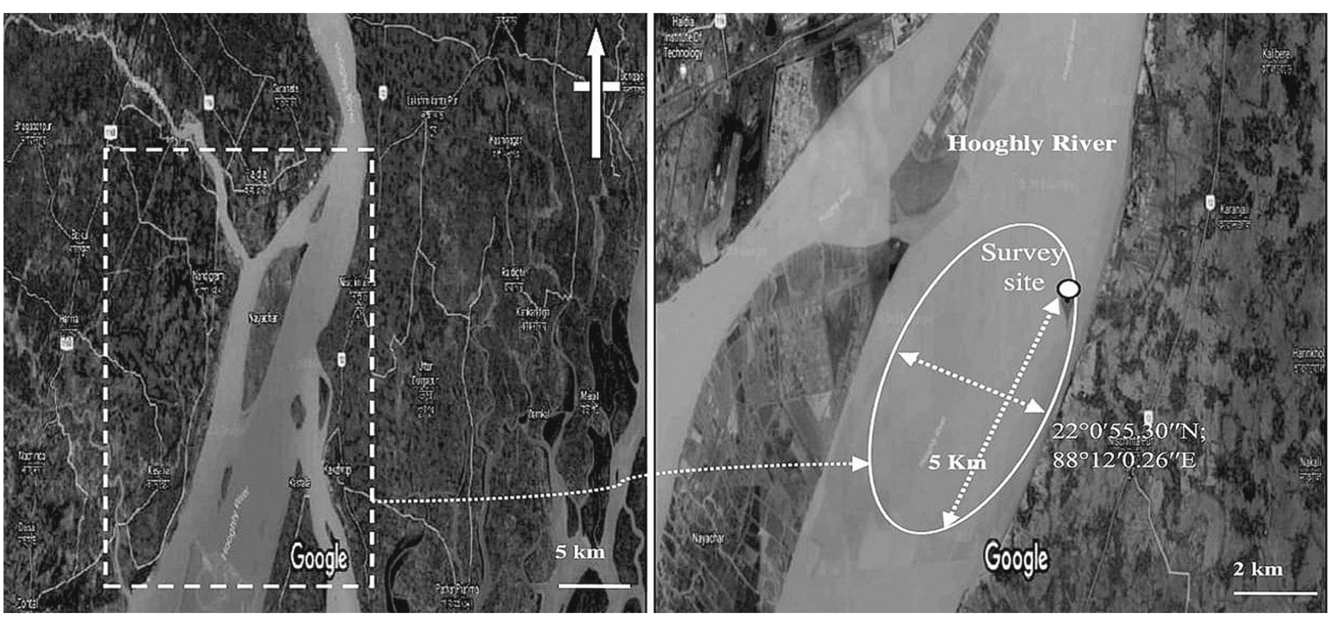

Fig. 1 — The survey was performed on the lower middle stretch of the Hooghly river (starting from 22°0′55.30″ N; 88°12′0.26″ E downwards up to 5 km), a part of the Hooghly estuary [Courtesy https://www.google.co.in/maps]

Bios™ flow meter to register the volume of water filtered by the net within a given period. All the gears were deployed away from the stern side of the boat to avoid the wake and the resultant disturbances of the planktonic assemblages. Half of all the zooplankton net concentrates were preserved immediately upon collection using neutral/buffered (borax) 4 % (v/v) formalin[6] while rest of the tows were performed for the collection of live specimens as well.

The collected samples, upon being brought to the laboratory were grouped into their respective taxa using an inverted microscope (Magnüs®) and also a brightfield stereoscope (Olympus) and the specimens were dissected for description. For dissection, stainless steel pin (No. 00) and needles were used to separate and place mouthparts, legs etc from the cephalothorax and all dissected parts were placed into polyvinyl lactophenol solution[7]. All hand drawings were performed with the aid of a WESWOX prism type camera Lucida at 20X magnification of the objective lens, *i.e.* with a total magnification of 300X (using 15X eyepieces). The species were identified based on previously published literatures[5,8-10]. The reference scale under the specified magnification was standardized using ERMA® stage (1 stage division = 0.01 mm) and ocular micrometers (100 divisions).

Results

Both the male and female representatives of *A. faoensis* were observed (Fig. 2) during the present survey. Either of the sexes lacks rostral appendages on the head which is obtuse with prominent eye spots. Four somites comprise the metasome with no prominent spine and bearing asymmetrical furca[8]. Both the sexes possess caudal rami which are asymmetrical with each ramus bearing six long setae with the comparatively shorter ones positioned laterally. All the maxillary appendages, when expanded fully, resemble a hand fan and at any time on any plane five to six appendages can be viewed with the longest ones positioned at the centre and the surrounding ones gradually decreasing in length.

Most females observed during the study were 0.9 – 1.3 mm in length but mostly were within 1 mm with the prosome being twice as long as the urosome[9]. There exists a separation between the head and the first thoracic segment[5] but this feature was not conservative and many individuals with the female

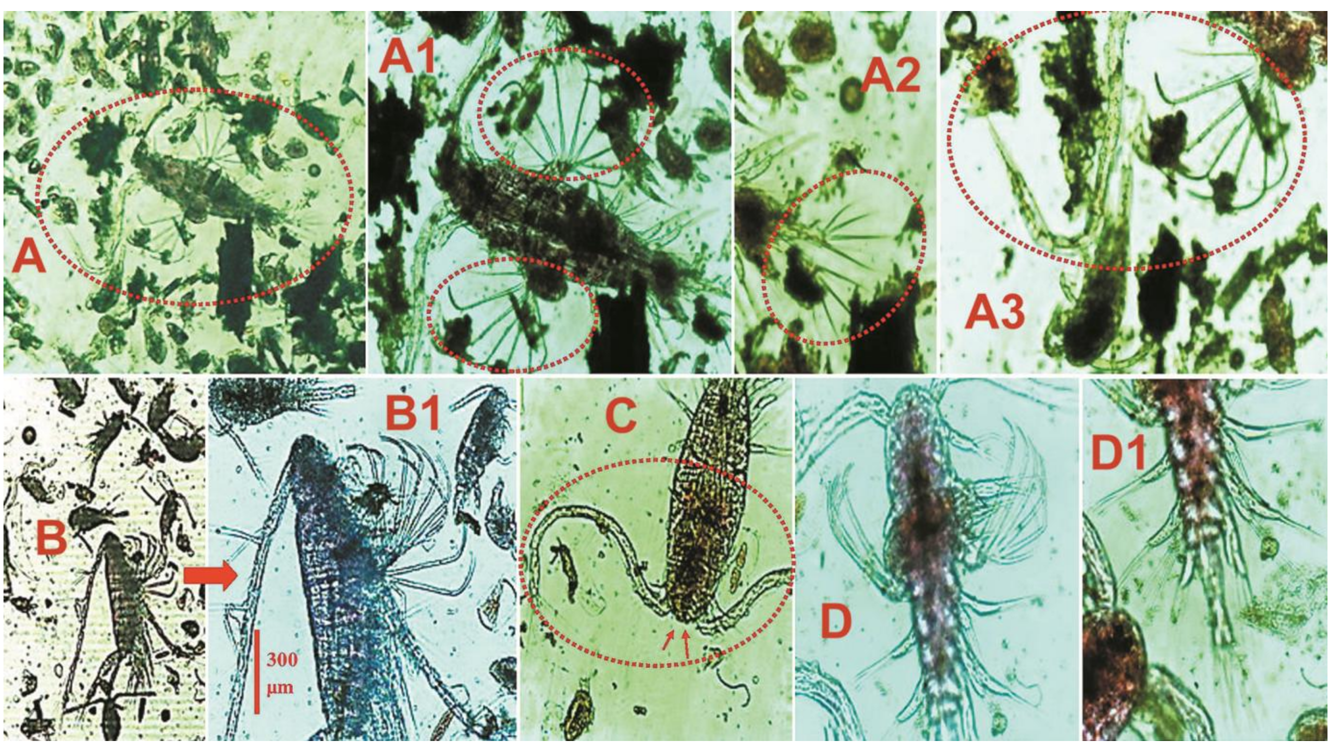

Fig. 2 — A: Female specimen, A1: Focus on the maxilla, A2: Caudal rami; A3: Close up of the left antennule and maxilla; B: Male specimen, B1: Side view of the antennule and maxilla; C: Top view of eye spots; D and D1: Top view antennules and maxilla of the male individual along with the swimming legs

characteristics lacked the distinction of the septum. The urosome contains three segments (often was observed to be apparently fused together) and is elongated, with the genital segment being longer than the other two. The distal segment of the urosome terminates in two long asymmetrical caudal rami, bearing mostly five (seldom six) setae. Similar to the males, the female urosome is also devoid of any spine or spinose outgrowths.

The antennule (Fig. 3) or A1 in females were observed to extend almost up to the middle of the caudal rami and the cephalosome was clearly demarcated from the first somite (pedigerous) and the fourth and fifth such segments were apparently fused together. The A1 contains 22 segments. A2 is rather compressed and appears to be flat and is furnished with many setae at the distal end and few on the proximal end. A total of 19 setae were observed under the microscope. The presence of hairs on the outer margin of A2 was observed presently, but was not prominent enough to be illustrated under Camera Lucida highlighting the details. Hence it was represented as bolder marginal lines. Mx2 were robust with stiff setae and the features of Mnd and Mxp were coherent with the description by Khalaf[5].

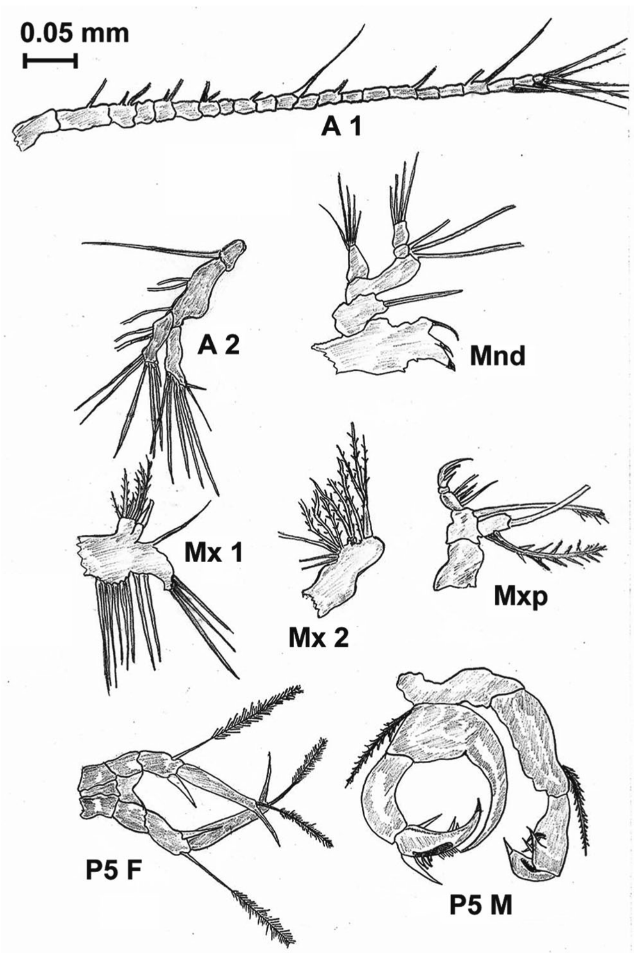

Fig. 3 — A: Antennule, A2: Antenna, Mnd: Mandible, Mxl: Maxillule, Mx2: Maxilla; Mxp: Maxilliped; P5F and P5M: Female and Male 5th Pleopods (Identified from Khalaf[5]; Khalaf *et al.*[10]; Peyghan *et al.*[8]); The Camera Lucida drawing of the appendages were performed under 20X objectives and 15X eyepieces following dissection and mounting of the segments

The observed males were more or less similar in length as the females. In adult males, the P5 or the fifth leg (pleopod) on the abdomen is tripartite and are asymmetrical. The left fifth pleopod bears two spines on the third segment. The right fifth pleopod bears four spines and much smaller hair like outgrowths on the third segment; these features are somewhat consistent with previous literatures[8].

In males the A1 on the right is in the form of a rasping appendage and is supposed to be modified for the purpose of predation and contrary to the females, male A1 consists of only seventeen segments and which for some reason kept on detaching following preservation. Thus the illustrations focused on the females as males with the A1 attached were hard to find in the preserved sample. The environmental stress in terms of osmotic pressure and pH could have been responsible for this phenomenon. The female segment retention however contradicts with this hypothesis apparently. The abdomen in males is five segmented with furcal rami as opposed to the females with four segments.

The P5 were symmetrical and consists of two segments fused nearly at the centre in females. The basiopod and the middle segment were almost equal in length with the middle segment being twice as long as wide. The marginal setae were exposed on the outer sides. Clearly defined exopod and endopod were present with exopod bearing spinose outgrowth, with single setae on the outer side. Both the exopodite and endopodite were observed to bear lateral setae with plumose outgrowths akin to earlier descriptions.

Discussion

The calanoid copepod species concerned was first described by Khalaf[5] from the saline waters of Khour Abdullah and from Khor Al-Zubair waters off the south of Iraq. Post Naupliar developments of the same species was recorded and published by Khalaf[10]. Ali *et al.*[11] recorded the species from the waters surrounding the Bubiyan Island near Kuwait, which was reflected again by Al-Yamani *et al.*[9] in their identification manual. *A. faoensis* was also documented from the Iranian coasts of NW Persian Gulf by Peyghan[8] as well as by Srinui & Ohtsuka[7] from estuarine waters of Thailand, although the latter authors did not work on the concerned species under the genus *Acartiella* but described superficially similar species from Indian Ocean.

In the more recent times Abbas[12] again documented the presence of *A. faoensis* from the Shatt Al-Basrah canal of Basrah-Iraq in addition to Peyghan *et al.*[13] reporting the same from waters around the Hendijan harbor of NW Gulf of Persia. Documentations on the species in the coastal waters of eastern South Africa as well as South China Sea do exist, but they are most likely congeners and not conspecifics.

However, in all the aforementioned instances *A. faoensis* have been described or documented from environmental settings best referred to as saline coastal or marine ecosystems except Shatt Al-Basrah canal. The mean pH and salinity (psu) ranges in these regions have been recorded to be – 7.5 to 8.3 and 5.34 to 9.12 for Shatt Al-Basrah, 8.3 to 8.4 and 22.7 to 39.9 for Bubiyan Island near coast of Kuwait, 7.9 to 9.1 and 36.78 to 50.81 in and around the Hendijan harbor on NW Persian Gulf, 7.8 to 8.6 and 34.20 to 39.50 at Khour Abdullah as well as 7.8 to 8.2 and 22.82 to 31.05 in the waters of Khor Al-Zubair respectively[14-19].

All these evidences suggest that *A. faoensis* has always been observed in areas with high salinity and pH, and even in the brackish water canal Shatt Al-Basrah receives considerable marine influence although this is the only site that can be compared with the site presently being reported as the former receives copious freshwater input from Shatt Al-Arab River as well.

However, the ambient water temperature range of 18 – 29 ºC coupled with constant high salinity and pH should have rendered the species stenohaline at best. But with abilities to cope with changes in the physicochemical parameters, the current report of individuals being documented from waters of Hooghly estuary [mean pH, salinity (psu) and water temperature (ºC) of 7.4, 4.6 and 27[refs. 20,21] at the time of collection during the month of July since almost all the earlier reports were coincidently within the period of June to August] is of utmost ecological significance as this shows that not only the species can survive lower salinities (< 5 psu) and pH (< 8) but in its native region it has been reported as the dominant microzooplankton[11] and may very well begin to dominate its new ecosystem as well if it survives the introduction.

The question that remains to be answered is whether it has already established itself and the report came in just a bit late, thus implying that the introduction took place some years earlier and due to the lack of monitoring, the species has somehow managed to stay below the radar until now. Only thorough and meticulous surveys shall be able to shed light on this issue and the presently reported work will serve as the bench mark for the future studies in this regard.

Conclusion

Acartiella faoensis was observed for the first time ever in Indian (or at least Eastern Indian waters) along the upper Hooghly estuary. The species is endemic to saline waters of Iran/Iraq or Saudi Arabia. The survivability of the species in an environment widely different from its native ecoregion is a matter of considerable perturbation since it can become invasive through outcompetition and dominance if it begins to thrive, with extensive ripple effects in the trophic structure and energy flow. It is prudent to think that further surveys are needed to ascertain the nature of the effect the species will impart on its surroundings.

Acknowledgements

The financial aid for the successful completion of the survey was provided by Bengal Shipyard Limited [Ref No. BSLMCK/KoPT/FY 17-18/06 dated 20.03.2018] and is most gratefully acknowledged.

Conflict of Interest

There exists no conflict of interest among the authors or any other person or institution regarding the procurement, publication and exploitation of the data from the concerned study, nor with the authorship.

Author Contributions

AM – Chief biological analyst, detector and identifier of the species concerned; PS – chemical analyst and collector of the sample; TKD – Adviser to the Principal Investigator; and SKM – Principal Investigator and implementer of the concerned survey.

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