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INTRODUCTION OF THE COPEPOD *LIMNOITHONA TETRASPINA* ZHANG & LI, 1976 (CYCLOPOIDA, CYCLOPETTIDAE) INTO THE SHATT AL-ARAB, IRAQ

BY

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ABSTRACT

The cyclopoid copepod *Limnoithona tetraspina* was collected for the first time in the Shatt Al-Arab, a river in Iraq, in the summer of 2009; its abundance ranged from 2-16 specimens/m^3. Its distribution was restricted to the areas around Al-Sindibad Island and Al-Kornish in waters with temperatures between 27-28°C and salinities less than 4.1‰. A larger number of specimens was collected in August 2012 around Al-Sindibad Island, 134 specimens/m^3, and in July 2013 around Al-Kornish, 378 specimens/m^3 in waters of comparable temperatures and salinities. The copepod initially was described from the mouth of the Yangtze River, China, in 1976. It was introduced from the Yangtze River into the San Francisco Bay estuary, U.S.A., in 1993, with ship ballast water, and into the Columbia River, U.S.A., in 2003, presumably from the San Francisco Estuary. The origin of the Shatt Al-Arab population is unknown, but it is likely to have been introduced.

RÉSUMÉ

Le copépode cyclopoïde *Limnoithona tetraspina* a été collecté pour la première fois dans le fleuve Shatt Al-Arab, Iraq, au cours de l'été 2009; son abondance était de 2 à 16 spécimens/m^3. Sa répartition était limitée aux régions situées autour de l'île Al-Sindibad et de Al-Kornish dans des eaux de température 27-28°C et de salinités inférieures à 4,1‰. Un plus grand nombre de spécimens a été collecté en août 2012 autour de l'île Al-Sindibad, soit 134 spécimens/m^3, et en juillet 2013 autour de Al-Kornish, avec une abondance de 378 spécimens/m^3 dans des eaux de températures et de salinités comparables. Le copépode avait été décrit initialement de l'embouchure du fleuve Yang-Tsé, Chine, en 1976. Il fut introduit du fleuve Yang-Tsé dans l'estuaire de la baie de San Francisco, U.S.A., en 1993, avec l'eau de ballast d'un navire, et dans le fleuve Columbia, U.S.A., en 2003, vraisemblablement à partir de l'estuaire de San Francisco Bay. L'origine de la population du Shatt Al-Arab est inconnue, mais il est probable qu'elle ait été introduite.

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INTRODUCTION

Limnoithona tetraspina Zhang & Li, 1976 and its only congener, *L. sinensis* Burckhardt, 1913, originally were described from the mouth of the Yangtze River, China. In 1979, *L. sinensis* was recovered from low salinity waters near the confluence of the Sacramento and San Joaquin rivers in the San Francisco Bay estuary, and the species was later redescribed from specimens collected there (Ferrari & Orsi, 1984). Specimens of *L. tetraspina* also were recovered from the same area of that estuary in 1993, and subsequently were redescribed (Orsi & Ohtsuka, 1999; Barroso do Abiahy et al., 2007). The latter authors moved the genus *Limnoithona* Burckhardt, 1912 to the family Cyclopettidae when that family and the family Oithonidae were rediagnosed (Barroso do Abiahy et al., 2007). Both *L. tetraspina* and *L. sinensis* were introduced into the San Francisco Bay estuary from Asia by ship ballast water. Of the two species, *L. tetraspina* has been the more successful introduction and as a result more is known about its biology (e.g., Bouley & Kimmerer, 2006; Gould & Kimmerer, 2010; Bollens et al., 2011). In 2003, *L. tetraspina* was reported from the Columbia River between Oregon and Washington (Sytsma et al., 2004); the source of its introduction is assumed to have been the San Francisco Bay estuary (Cordell et al., 2008). More recently *L. tetraspina* has been restudied from the Yangtze River (Chen & Liu, 2009; Zhou et al., 2009). Here we report *L. tetraspina* from a fourth locality, the Shatt Al-Arab, a river between the confluence of the Tigris and Euphrates rivers and the Persian/Arabian Gulf.

METHODS

The Shatt Al-Arab extends from the confluence of the Tigris and Euphrates rivers in Iraq about 200 km to an estuary on the Persian/Arabian Gulf. For about 110 km downriver from Basrah it is the boundary between Iraq and Iran. The Shatt Al-Arab has been sampled for plankton episodically from the early 1980s. More recently four permanent stations (fig. 1) have been established from the confluence of the Tigris and Euphrates to Basrah, about 90 km downriver: Al-Qurna (station 1; 31°1′00″N 47°29′00″E, 4-8 m), Al-Hartha (station 2; 30°40′00″N 47°50′00″E, 8-10 m), Al-Sindibad Island (station 3; 30°33′00″N 47°50′0″E, 4-23 m) and Al-Kornish (station 4; 30°26′00″N 47°58′00″E, 10-12 m). Plankton samples were collected at stations 1-4 monthly over twelve months between September 2008 and August 2009 (table I). In addition, a plankton sample was collected at station 3 in August 2012 and another at station 4 in July 3013. Plankton samples usually were taken around 9:30 am at depths between 30 and 100 cm. Temperatures were recorded with a simple thermometer and salinities with a hand-held conductivity

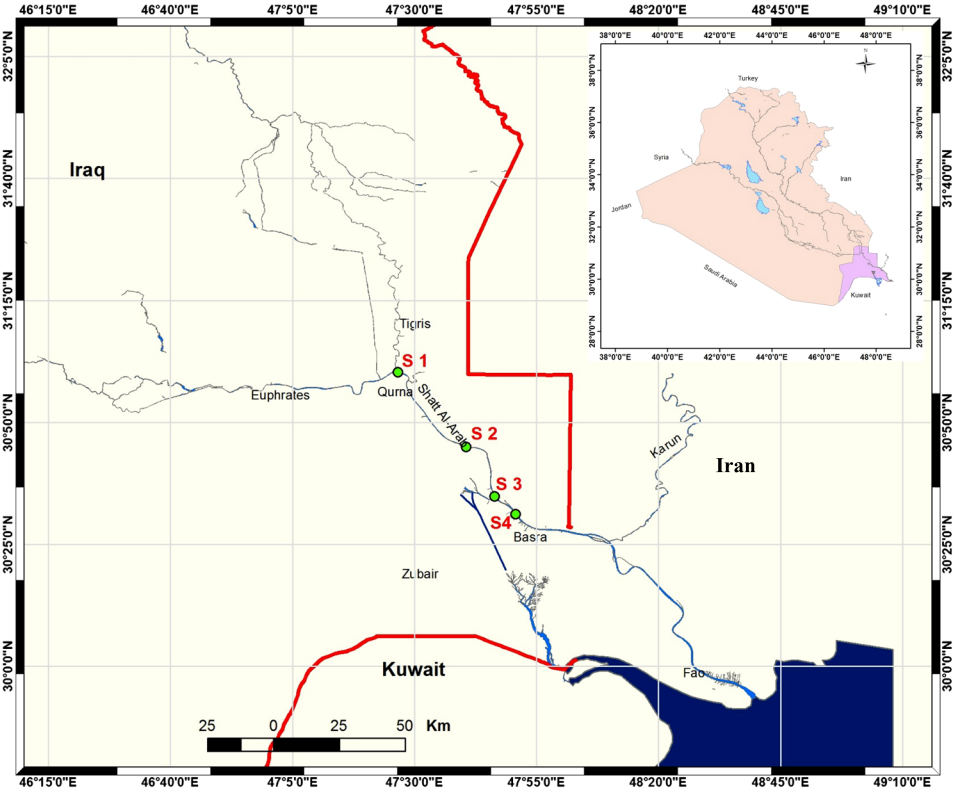

Fig. 1. Location of stations 1-4 on the Shatt Al-Arab, Iraq. This figure is published in colour in the online edition of this journal, which can be accessed via http://booksandjournals.brillonline.com/content/journals/15685403.

meter. Plankton was collected with a simple conical net, mouth aperture 40 cm and mesh 120 μm. Only adult specimens of *Limnoithona tetraspina* were studied.

In the laboratory, adult specimens of *L. tetraspina* (USNM 1174918) were cleared and dissected in lactic acid, stained by adding a solution of chlorazol black E dissolved in 70% ethanol/30% de-ionized fresh water, and examined in glycerin with bright-field and differential interference optics. An elongate leg 5 separates the two species of *Limnoithona*, the only planktonic genus of cyclopettid, from planktonic species of Cyclopidae whose leg 5 is much shorter. A rounded projection between the labrum and rostrum separates species of *Limnoithona* from species of Oithonidae, that lack such a projection. In addition, the simple proximal endopodal segment of the maxilliped of *Limnoithona* bears a single seta, in contrast to three setae on the proximal segmental complex of the endopod of the maxilliped on species of Oithonidae (see Ferrari & Ivanenko, 2001; Barroso do Abiahy et al., 2007). *Limnoithona tetraspina* is identified with two dorsal setae on the exopod

TABLE I

Environmental conditions for samples taken at stations 3 and 4, Shatt Al-Arab, Iraq, and abundance of *Limnoithona tetraspina* Zhang & Li, 1976

Month	Abundance (No./m^3)	Salinity (‰)	Water temperature (°C)	Air temperature (°C)
STATION 3				
2008				
September	0	2.8	26	30
October	0	2.4	24	27
November	0	2	19	20
December	0	2.6	12	16
2009				
January	0	2.4	11	13
February	0	2.4	14	18
March	0	2.6	18	24
April	0	2.6	20	26
May	0	1.7	24	28
June	0	1.5	26	31
July	0	1.1	36	31
August	16*	2.2*	27*	32*
2012				
August	134*	2.5*	27*	35*
STATION 4				
2008				
September	0	2.7	27	32
October	0	2.5	25	28
November	0	2.1	20	24
December	0	2.3	12	18
2009				
January	0	2.4	11	14
February	0	2.4	15	19
March	0	2.6	19	25
April	0	2.6	22	26
May	0	1.8	25	28
June	0	1.8	26	31
July	2*	1.7*	27*	32*
August	5*	4.1*	28*	33*
2013				
July	378*	3.3*	27.5*	33*

* Samples with *L. tetraspina*.

of leg 5, the only articulating segment of the leg, and four setae total on this exopod. *Limnoithona sinensis* has one dorsal seta on the exopod of leg 5, and three setae total. In addition, the middle endopodal segment of swimming legs 2-4 of *L. tetraspina* bears two ventral setae, in contrast to *L. sinensis* with only one ventral seta on these limbs (Barroso do Abiahy et al., 2007).

RESULTS

Limnoithona tetraspina initially was collected at station 4, closest to the Arabian Gulf of the four stations sampled, during July and August 2009. The number of specimens collected was 2/m^3 in July and 5/m^3 in August. Temperature and salinity at the time of collection were 27°C and 1.7‰ in July, and 28°C and 4.1‰ in August, respectively (table I). The species also was found at station 3 in August 2009. There the number of specimens collected was higher, 16/m^3; temperature and salinity were 27°C and 2.2‰ (table I). In August 2012, *L. tetraspina* again was collected from station 3, and was much more abundant, 134 specimens/m^3; the temperature then was 27°C and the salinity 2.5‰. The greatest abundance for the copepod was 378 specimens/m^3 at station 4, July 2013 when the temperature was 27.5°C and the salinity 3.3‰.

L. tetraspina was absent at station 4 from September 2008 to June 2009, and at station 3 from September 2008 to July 2009. From September 2008 to June 2009, temperatures at station 4 ranged from 11°C in January 2009 to 27°C in June 2009; salinities ranged from 1.8‰ in September 2008 to 2.7‰ in June 2009 (table I). The monthly temperature range from September 2008 to July 2009 at station 3 was comparable, but salinities were slightly lower, 2.8‰ in September 2008 to 1.1‰ in July 2009 (table I).

L. tetraspina was absent from stations 1 and 2 throughout the sampling period from September 2008 to August 2009. Temperatures and salinities at these stations were slightly lower than those at stations 3 and 4.

DISCUSSION

To date *Limnoithona tetraspina* has been collected at station 3 (Al-Sindibad Island) in August 2009 and August 2012, and station 4 (Al-Kornish) in July and August 2009 and July 2013. The copepod seems to have increased in abundance through 2013. It is not clear if the yearly occurrence of the copepod is restricted by temperature or salinity because comparable salinities exist from May through July, and comparable temperatures from June through September. Nor can temperature or salinity explain the absence of the species upriver at stations 1 and 2. Downriver from station 4, *L. tetraspina* has not been reported from the northern Arabian Gulf (Al-Yamani & Prusova, 2003; Al-Yamani & Skryabin, 2011). In the San Francisco Bay estuary, it is most abundant in the late summer and fall (Bouley & Kimmerer, 2006). In the Shatt Al-Arab, *L. tetraspina* is more limited, being absent from the plankton during most of the year. This may be explained if the copepod is more closely associated with the benthos during most of the year; species of the other four cyclopettid genera are known only from benthic and benthopelagic habitats

(Martínez Arbizu, 2000). A restricted riverwide distribution for *L. tetraspina* may be explained if this copepod, like its congener *L. sinensis*, is found only in the turbulent mixing zone of low salinity, estuarine waters (Ferrari & Orsi, 1984). The year of introduction also is not settled. Although the species first appeared in the sampling area in 2009, it may have been introduced into the Shatt Al-Arab before 2009 if the mixing zone was located farther downriver from station 4.

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REFERENCES

AL-YAMANI, F. Y. & I. PRUSOVA, 2003. Common copepods of the northwestern Arabian Gulf: identification guide: 1-126. (Kuwait Institute for Scientific Research, Basra, Iraq).

AL-YAMANI, F. Y. & V. SKRYABIN, 2011. Marine zooplankton practical guide for the northwestern Arabian Gulf: 1-196. (Kuwait Institute for Scientific Research, Basra, Iraq).

BARROSO DO ABIAHY, B., C. E. F. DA ROCHA & F. D. FERRARI, 2007. Redescription of *Limnoithona tetraspina* Zhang and Li, 1976 (Copepoda, Cyclopoida) with a discussion of character states shared with the Oithonidae and older cyclopoids. Invertebrate Zoology, **3**: 115-135.

BOLLENS, S. M., J. K. BRECKENRIDGE, R. C. VANDEN HOOFF & J. R. CORDELL, 2011. Mesozooplankton of the lower San Francisco Estuary: spatio-temporal patterns, ENSO effects, and the prevalence of non-indigenous species. Journal of Plankton Research, **33**(9): 1358-1377.

BOULEY, P. & W. J. KIMMERER, 2006. Ecology of a highly abundant, introduced cyclopoid copepod in a temperate estuary. Marine Ecology Progress Series, **324**: 219-228.

BURCKHARDT, G., 1912. Ein zweites Cyclopidengenus im süssen Wasser. Zoologischer Anzeiger, **39**: 725-727.

— —, 1913. Wissenschaftliche Ergebnisse eine Reise um die Erde von M. Pernud und C. Schröder. III. Zooplankton aus ost-und südasiatischen Binnengewässern. Zoologische Jahrbücher (Abteilung für Systematik, Geographie und Biologie der Tiere), **34**: 341-472.

CHEN, H. & G. LIU, 2009. Zooplankton community structure in Yangtze River Estuary and adjacent sea area in summer 2006. Journal of Beijing Normal University (Natural Science), **45**(4): 393-398.

CORDELL, J. R., S. M. BOLLENS, R. DRAHEIM & M. SYTSMA, 2008. Asian copepods on the move: recent invasions in the Columbia-Snake River system, USA. International Council for the Exploration of the Sea, Journal of Marine Science, **65**(5): 753-758.

FERRARI, F. D. & V. N. IVANENKO, 2001. Interpreting segment homologies of the maxilliped of cyclopoid copepods by comparing stage-specific changes during development. Organisms, Diversity and Evolution, **1**: 113-131.

FERRARI, F. D. & J. J. ORSI, 1984. *Oithona davisae*, new species, and *Limnoithona sinensis* (Burckhardt, 1912) (Copepoda: Oithonidae) from the Sacramento-San Joaquin estuary, California. Journal of Crustacean Biology, **4**: 106-126.

GOULD, A. L. & W. J. KIMMERER, 2010. Development, growth, and reproduction of the cyclopoid copepod *Limnoithona tetraspina* in the upper San Francisco Estuary. Marine Ecology Progress Series, **412**: 163-177.

MARTÍNEZ ARBIZU, P., 2000. A new species of *Cyclopetta* from the Laptev Sea (Arctic Ocean), with the recognition of Cyclopettidae fam. nov., a new monophylum of free-living Cyclopoida (Copepoda). Bulletin de l'Institut Royal des Sciences Naturelles de Belgique (Biologie), **70**: 91-101.

ORSI, J. J. & S. OHTSUKA, 1999. Introduction of the Asian copepods *Acartiella sinensis*, *Tortanus dextrilobatus* (Copepoda: Calanoida), and *Limnoithona tetraspina* (Copepoda: Cyclopoida) to the San Francisco Estuary, California, USA. Plankton Biology Ecology, **46**: 128-131.

SYTSMA, M. D., J. R. CORDELL, J. W. CHAPMAN & R. C. DRAHEIM, 2004. Lower Columbia River Aquatic Nonindigenous Species Survey 2001-2004. Final Technical Report: Appendices: 1-164. (United States Coast Guard and the United States Fish and Wildlife, Service, Seattle, WA).

ZHANG, C. & Z. LI, 1976. A new species of *Limnoithona* (Oithonidae, Cyclopoida) from China. Acta Zoologica Sinica, **22**: 403-405.

ZHOU, S., B. JIN, H. QIN & J. WU, 2009. Spatial distribution of zooplankton in the intertidal marsh creeks of the Yangtze River Estuary, China. Estuarine Coastal and Shelf Science, **85**(3): 399-406.

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