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INSIGHTS INTO THE ECOLOGY OF *CRYPTORCHESTIA GARBINII* ON THE SHORES OF THE URBAN LAKE TEGEL (BERLIN, GERMANY)

L. FANINI[1], C. O. COLEMAN[2], J. K. LOWRY[3]*

[1] Institute for Marine Biology Biotechnology and Aquaculture, Hellenic Centre for Marine Research, Thalassokosmos, Gournes Pediados (former US base), 71500 Crete, Greece
[2] Museum für Naturkunde Berlin, Invalidenstaβe 43, 10115 Berlin, Germany
[3] Australian Museum Research Institute, 1 William Street, Sydney, NSW 2010, Australia
** Corresponding author: lucia@hcmr.gr*

TALITRIDAE
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ACTIVITY

ABSTRACT. – Talitrid amphipods find their optimal zonation in humid substrates, from the supralittoral of sandy beaches, to damp wracks cast up on river and lake banks, to the moist soil of gardens, and are known to adjust behavior in order to fit within a broad range of environmental constraints. The stones along urban shores of Lake Tegel offer shelter to a resident population of *Cryptorchestia garbinii;* while the stones can offer a stable shelter, the lakeshore undergoes seasonal changes. To investigate how *C. garbinii* responds and copes with changes in such urban habitat, we carried out a preliminary study to assess mobility and daily activity of a resident population. The population was sampled with pitfall traps, emptied in the morning and in the evening avoiding dusk and dawn. Sampling lasted 48 hours in each season, along one year. A test for survival in water on 14 adults was paired with the summer sampling. A consistent pattern of activity was found: only the traps closest to the stones contained talitrids (including in condition of 0 °C air temperature), except in winter when the soil was frozen, incorporating the stones. The night captures were consistently more numerous than the daylight ones. All individuals survived in water, with a female observed to release live offspring. The results indicate a steadily nocturnal mobility, yet limited to less than one meter on the land side. The connectivity potential of this riparian-hopper hence relies either on the alongshore dimension or via water.

INTRODUCTION

Talitrid amphipods are semi-terrestrial organisms and find their optimal zonation in humid or water-saturated substrate. Some talitrids live on the beach, in the wet sand, where they represent one of the most abundant taxa in temperate areas (McLachlan & Defeo 2017). They are well studied in terms of ecology and behavior, gene flow, phylogeography and population features – including life-history and behavioral traits – are also being proposed as bioindicators of environmental changes (see Fanini *et al*. 2017 for the study of population traits expressed in different environmental conditions, and a review of behavioral adaptations to changes in Scapini 2006). This is because 1) talitrid mobility is limited, due to direct development of juveniles in the females' pouches, hence missing larval dispersion in water and 2) talitrids are forced to keep their zonation on the supralittoral, avoiding both the risk of dehydration and of being swashed by waves by means of an active behavior, which can include local features as cues (see Hartwick 1976 for the inclusion of man-made features in local landscapes).

Other talitrid groups, like those belonging to the genus *Cryptorchestia* (Lowry & Fanini 2013), live in moist soil. Environmental constraints in this case might be different than those on a beach. However, in spite of their potential interest as key species for moist soils paired with current needs for groups capable of indicating changing environments through their behavioral ecology (Wong & Candolin 2015), information available about these groups is extremely scarce (Davolos *et al*. 2018). In particular, *Cryptorchestia* species may live in urban parks, where the human modification of the landscape and the presence of man-made infrastructure define settings adequate to target the study of urban ecology and related patterns defined at population level.

The Lake Tegel offers shelter to a resident population of talitrids, *Cryptorchestia garbinii* (Ruffo *et al*. 2014). Under the stones along the shore can be found numerous individuals of the species (Coleman, preliminary observations). While the stones can offer a stable shelter, talitrids are undergoing seasonal environmental changes, with cold winters and hot summers, having to cope with frozen and dry substrate, depending on the time of the year. At the same time, the urban park features street lighting at short distance from the shore.

Given the lack of basic information about land-hoppers' (to which *Cryptorchestia* belongs) ecology (see Pavesi & De Matthaeis 2010), general traits of the family Talitridae (http://www.marinespecies.org/amphipoda on 2019-06-21, Horton *et al*. 2019) were hence used as reference for this study. Namely, our goal was to test: 1) occurrence and timing of surface activity; 2) spatial range of activity; 3) survival in water of *Cryptorchestia garbinii* Tegel population. In particular for points 1) and 2), information was expected to provide insights about behavioral adaptations such as periodical activity and mobility potential of talitrids inhabiting environment other than sand beaches, and environments subjected to urban characteristics (such as road presence and artificial lighting).

MATERIALS AND METHODS

We targeted a sector of the lake which has been used as urban green area since more than a century, with tall trees, bushes and grasses providing shading and litter to the shore banks. A road open to car traffic grants access to the lake sector, where a small path for walkers and bicycles only runs closer to the shore and in parallel to the road. The path features benches and is regularly cleaned. There is no direct lighting on the small path – the closest lighting source is related to the road.

The population was sampled by pitfall trapping. Sets of pitfalls (plastic cups 9 cm diameter and 13 cm depth) were placed every meter along two transects running along the shore-normal direction from the stones up to the Park's walking path, and in parallel at one meter distance from each other. Each transect consisted of two traps, one adjacent to the stones along the shore, and the other one meter landward. After the second trap, the walking path, up on a steep slope of about 10°, defined the ending point for transects (Fig. 1)

To discriminate between nocturnal and diurnal activity, traps were emptied in the morning and in the evening, about 8:00 AM and 8:00 PM, adjusting to the seasonal timing to avoid dusk and dawn (in littoral species in fact, activity peaks may occur at dusk and dawn, even if with remarkable differences among species and populations, Fallaci *et al*. 1999, Colombini *et al*. 2013, Fanini *et al*. 2016). Collections lasted 48 hours in each season, from August 2016 to April 2017 (Table I). Differences within the two groups of captures (nocturnal and diurnal) were tested with the non-parametric Mann-Whitney U test (one tailed) on pooled data for the 48 hours seasonal replicates.

Ranges of air temperature and water temperature for the periods of activity of the pitfalls were obtained from local recording stations. Nocturnal light intensity was measured as lux on the ground via the free app for iphone Lux Light Meter Pro.

Samples were sorted at the Museum für Naturkunde Berlin immediately after collection.

In the month of August 2016, when adult individuals and ovigerous females were present, it was performed a test for survival

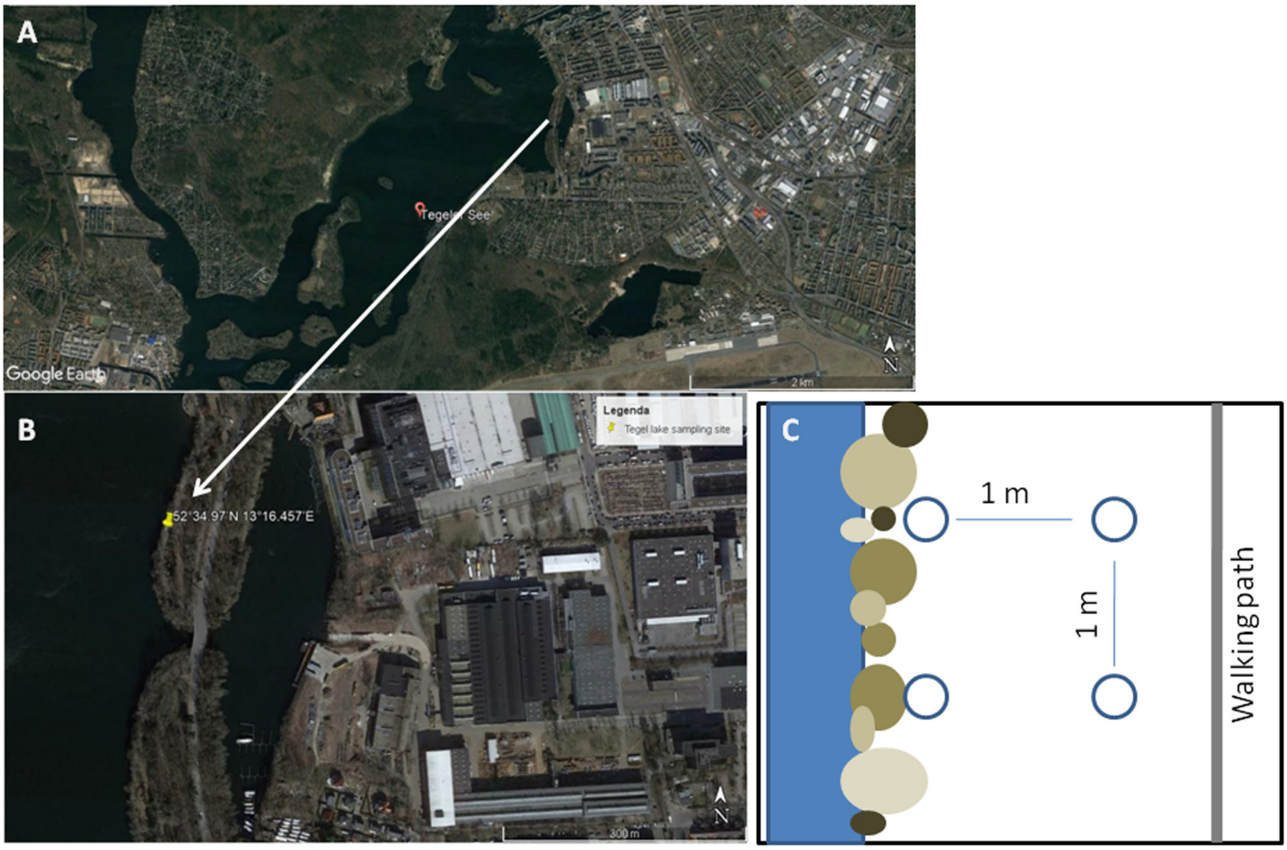

Fig. 1. – Sampling site on the lake Tegel shore (52°34.97'N 13°16.457'E) and trapping scheme. **A**, **B**: Aerial pictures of the lake sector, at two different scales. **C**: Design of pitfall (represented as blue circles) placement. Full circles represent stones along the shoreline. "Walking path" refers to the walking-cycling road, running parallel to the asphalt road and closer to the lakeshore, partly covered by the vegetation and not fully visible in the aerial picture.

Table I. – Environmental features during the seasonal replicates of *Cryptorchestia garbinii* collection: sunrise and sunset from https://www.timeanddate.com/sun/germany/berlin; air temperature range from http://www.bbc.com/weather/2950159 retrieved on the days of collection; water temperature range from local sailing club.

Season	Days	Sunrise-Sunset	Air temperature range	Water temperature range
Summer	16-17 August 2016	5:49 AM-8:33 PM	9-22 °C	21-23 °C
Autumn	24-25 November 2016	7:45 AM-4:00 PM	0-6 °C	9-11 °C
Winter	31 January-1 February 2017	7:47 AM-4:53 PM	–6-0 °C	4 °C
Spring	9-10 April 2017	6:19 AM-7:54 PM	6-13 °C	7-10 °C

in water. Nine males and five females were tested after Fanini & Lowry (2014): individuals were kept singly in aerated cups, each one containing 250 cc of water proceeding from the lake. Cups were kept in conditions of natural light/dark, and external temperature. The test lasted 96 hours, as best compromise to test survival in a time lapse allowing for resettling after passive transportation, and to avoid starvation and ageing. Survival of individuals was checked every 12 hours.

RESULTS

Cryptorchestia garbinii was found to be dominant in abundance throughout the year, with few other species sampled in the traps (Table II).

The activity of *C. garbinii* was found to be mainly nocturnal, consistently across seasons ($z = 2.80$; $p = 0.002$). Activity patterns related to increasing air temperature in the night time were investigated, but the large amount of individuals found active in the autumn replicate (with minimum air temperature 0 °C) prevented the identification of a clear correlation (Fig. 1). In the winter season, the frozen soil sealed the stones in the substrate, and no organisms were found in the traps. Water temperature showed a trend consistent to air temperature, though (as expected) with less fluctuation and without freezing. No light effect was recorded at the site, with luxmeter indicating only fractions of lux (below 0.05), while the expected urban twilight at its lower was expected to be 3.4 lux (Waynant & Ediger 2000) (Fig. 2).

Consistently throughout the year *C. garbinii* was found in the first traps only (those closer to the stones), indicating a limited mobility across-shore.

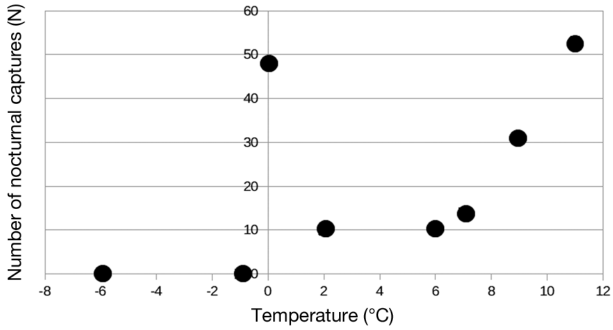

Fig. 2. – Plot of individuals of *C. garbinii* (Y axis) active overnight under different conditions of air temperature (X axis).

Survival rate was 100 %, with one female observed to release live offspring in the water after 72 hours. They remained alive until the end of the test (in contrast to what was observed on beach talitrids, Fanini & Lowry 2014).

DISCUSSION

With respect to Talitridae general traits, *C. garbinii* was found to keep surface activities nocturnal, even if the riparian habitat and the use of stones as shelter could have driven towards a less sharp circadian rythmicity (Rossano *et al.* 2008). Effect of temperature on surface movements, observed by Scapini *et al.* (1992) and Cardoso *et al.* (2002) on supralittoral species could not be confirmed here, suggesting that surface activity of *C. garbinii* may be subjected to other co-occurring drivers than temperature.

Table II. – Number of nocturnal and diurnal captures by pitfall traps. Common names of the organisms are reported in square brackets.

	Summer		Autumn		Winter		Spring	
	Night	Day	Night	Day	Night	Day	Night	Day
Cryptorchestia garbinii [riparian-hopper]	84	10	58	2	0	0	24	0
Trychoptera sp.1 [caddisfly]	0	1	0	0	0	0	0	0
Arctosa sp.1 [wolf spider]	0	2	0	0	0	0	0	0
Formicidae sp.1 [ant]	2	2	0	0	0	0	0	0

However, the recorded surface activity indicates the potential for this species to be included within the Animal Movement framework (Nathan *et al.* 2008), which is gaining relevance specially in the case of urban contexts and emerging drivers (both internal and external) likely to affect population dynamics. The use of pitfall traps might not return a reliable background for population dynamics given the differential mobility of different age classes, though it is becoming a standard for sampling across a range of substrates, allowing for broad comparisons in terms of diversity and activity range (Mantzouki *et al*. 2012, Fanini & Lowry 2016). An extension to urban environments is promising in this respect.

Estimates of talitrids' mobility were made by Wildish (2012) and Wildish *et al*. (2016), related to ecological niches and based on molecular data, given the scarce circumstantial information. Wildish's hypotheses relate to passive transportation and drift, indicating potential for broad dispersal for driftwood and wrack-related species, and synanthropic dispersal for the leaf-litter specialist species (*Talitroides alluaudi*). In the case of the riparian-hopper *C. garbinii* though, results suggest the exclusion of dispersal along the across-shore dimension: only the trap placed at one meter above the shoreline contained individuals, in a consistent fashion throughout the year. In this context, the boundary created by the road did not seem to affect such already reduced across-shore mobility. Instead, connectivity potential seems to be related either to the long-shore (as nocturnal surface activity was recorded from trapping data) or water passive (from survival experiment) dispersal, while the role of other resident species as vectors (e.g. ducks) should be investigated. The role of season needs further investigation, however our results point to summer as the most likely season for *C. garbinii* population dispersal and connectivity, due to the coupling of 1) higher air temperature with lower water level (exposing more stones along the shore) and 2) the presence of adults in reproductive stage, and female individuals capable of releasing offsprings in water – with water temperature in its warmest range – without affecting survival.

Even basic data can add to the knowledge of otherwise neglected yet relevant urban and peri-urban species (Kodama & Shimizu 2017). As the collection of this kind of data remains much needed, we would like to conclude this paper by highlighting the potential role of citizen science in filling such gap on one hand, and the potential role of some species in becoming experiential key species (EKS), i.e. establish meaningful connections between citizens and own environment, on the other. In fact, the organized observation of basic features to be observed via citizen science actions can effectively feed with locally relevant data broad initiatives such as MIReAD (Rund *et al*. 2019, with specific reference to Table II within) and implicitly improve the Findable, Accessible, Interoperable, and Reusable (FAIR) data approach. Furthermore, via the use of the very same questions investigated within by this paper about time and space of activity, it would be possible to fill gaps also identified by Rund *et al*. (2019), allowing citizens to ask also "why" and not only "what" was done.

Characteristics of *C. garbinii* populations such as: abundance; easiness to retrieve; low cost of collection and observation; presence in urban environments, make the species a candidate to extend to invertebrates the consideration as EKS suitable to provide nature-related experiences for otherwise nature-disconnected people (Battisti 2016). Finally, the small-scale at which the observed phenomena occur is facilitating the increasing societal need of "personalized ecology" (as reported by Gaston *et al*. 2018), implying a potential to go beyond mere biodiversity reports and 1) counteract nature-disconnection; 2) favour the creation of urban outlets for environmental stewardship (Bennett *et al*. 2018).

The present preliminary study hence provides strong recommendations towards the study of talitrid amphipods as urban resident species, for both the identification of biodiversity-related patterns in urban environments, and their use as experiential species in awareness-raising activities with citizens.

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Data Availability. – The authors confirm that all the data supporting the findings of this study are available upon request.

REFERENCES

Battisti C 2016. Experiential key species for the nature-disconnected generation. *Anim Conserv* 19(6): 485-487.

Bennett NJ, Whitty TS, Finkbeiner E, Pittman J, Bassett H, Gelcich S, Allison EH 2018. Environmental stewardship: A conceptual review and analytical framework. *Environ Manage* 61(4): 597-614.

Cardoso R 2002. Behavioral strategies and surface activity of the sandhopper *Pseudorchestoidea brasiliensis* (Amphipoda: Talitridae) on a Brazilian beach. *Mar Biol* 141(1): 167-173.

Colombini I, Fallaci M, Gagnarli E, Rossano C, Scapini F, Chelazzi L 2013. The behavioral ecology of two sympatric talitrid species, *Talitrus saltator* (Montagu) and *Orchestia gammarellus* (Pallas) on a Tyrrhenian sandy beach dune system. *Estuar Coast Shelf Sci* 117: 37-47.

Davolos D, Vonk R, Latella L, De Matthaeis E 2018. The name of a model species: the case of *Orchestia cavimana* (Crustacea: Amphipoda: Talitridae). *Eur Zool J* 85(1): 228-230.

Fallaci M, Aloia A, Audoglio M, Colombini I, Scapini F, Chelazzi L 1999. Differences in behavioral strategies between two sympatric talitrids (Amphipoda) inhabiting an exposed sandy beach of the French Atlantic coast. *Estuar Coast Shelf Sci* 48(4): 469-482.

Fanini L, Lowry JK 2014. Coastal talitrids and connectivity between beaches: a behavioral test. *J Exp Mar Biol Ecol* 457: 120-127.

Fanini L, Lowry JK 2016. Comparing methods used in estimating biodiversity on sandy beaches: pitfall vs. quadrat sampling. *Ecol Indic* 60: 358-366.

Fanini L, Zampicinini G, Tsigenopoulos CS, Barboza FR, Lozoya JP, Gómez J, Celentano E, Lercari D, Marchetti GM, Defeo O 2017. Life-history, substrate choice and Cytochrome Oxidase I variations in sandy beach peracaridans along the Rio de la Plata estuary. *Estuar Coast Shelf Sci* 187: 152-159.

Gaston KJ, Soga M, Duffy JP, Garrett JK, Gaston S, Cox DT 2018. Personalised ecology. *Trends Ecol Evol* 33(12): 916-925

Hartwick R 1976. Aspects of celestial orientation behavior in Talitrid Amphipods. *In* DeCoursey PJ Ed, Biological Rhythms in the Marine Environment. University of South Carolina Press: Columbia SC: 189-187.

Horton T, Lowry J, De Broyer C, Bellan-Santini D, Coleman CO, Corbari L, Costello MJ, Daneliya M, Dauvin JC, Fišer C, Gasca R, Grabowski M, Guerra-García JM, Hendrycks E, Hughes L, Jaume D, Jazdzewski K, Kim YH, King R, Krapp-Schickel T, LeCroy S, Lörz AN, Mamos T, Senna AR, Serejo C Sket B, Souza-Filho JF, Tandberg AH, Thomas JD, Thurston M, Vader W, Väinölä R, Vonk R, White K, Zeidler W 2019. World Amphipoda Database. Accessed at http://www.marinespecies.org/amphipoda on 2019-06-21.

Kodama M, Shimizu S 2017. Collection of terrestrial amphipods using a yellow pan trap. *Crustaceana* 90(5): 639-642.

Lowry JK, Fanini L 2013. Substrate dependent talitrid amphipods from fragmented beaches on the north coast of Crete (Crustacea, Amphipoda, Talitridae), including a redefinition of the genus *Orchestia* and descriptions of *Orchestia xylino* sp. nov. and *Cryptorchestia* gen. nov. *Zootaxa* 3709(3): 201-229.

Mantzouki E, Ysnel F, Carpentier A, Pétillon J 2012. Accuracy of pitfall traps for monitoring populations of the amphipod *Orchestia gammarella* (Pallas, 1766) in saltmarshes. *Estuar Coast Shelf Sci* 113: 314-316.

McLachlan A, Defeo O 2017. The Ecology of Sandy Shores (third edition). Academic Press: 558 p.

Nathan R, Getz WM, Revilla E, Holyoak M, Kadmon R, Saltz D, Smouse PE 2008. A movement ecology paradigm for unifying organismal movement research. *Proc Natl Acad Sci USA* 105: 19 052-19 059.

Pavesi L, De Matthaeis E 2010. Life history and temporal distribution of *Orchestia* sp. cf. *cavimana* (Amphipoda, Talitridae) on a lake shore in central Italy. *Limnologica* 40(4): 300-306.

Rossano C, Morgan E, Scapini F 2008. Variation of the locomotor activity rhythms in three species of talitrid amphipods, *Talitrus saltator*, *Orchestia montagui*, and *O. gammarellus*, from various habitats. *Chronobiol Int* 25(4): 511-532.

Ruffo S, Tarocco M, Latella L 2014. *Cryptorchestia garbinii* n. sp. (Amphipoda: Talitridae) from Lake Garda (Northern Italy), previously referred to as *Orchestia cavimana* Heller, 1865, and notes on the distribution of the two species. *Ital J Zool* 81(1): 92-99.

Rund SS, Braak K, Cator L, Copas K, Emrich SJ, Giraldo-Calderón GI, Johansson MA, Heydari N, Hobern D, Kelly SA, Lawson D 2019. MIReAD, a minimum information standard for reporting arthropod abundance data. *Sci Data*, 6(1): 40.

Scapini F 2006. Keynote papers on sandhopper orientation and navigation. *Mar Freshw Behav Physiol* 39(1): 73-85.

Scapini F, Chelazzi L, Colombini I, Fallaci M 1992. Surface activity, zonation and migrations of *Talitrus saltator* on a Mediterranean beach. *Mar Biol* 112(4): 573-581.

Waynant RW, Ediger MN 2000. Electro-optics Handbook. New York: McGraw-Hill.

Wildish DJ 2012. Long distance dispersal and evolution of talitrids (Crustacea: Amphipoda: Talitridae) in the northeast Atlantic islands. *J Nat Hist* 46(37-38): 2329-2348.

Wildish DJ, Smith RS, Loeza-Quintana T, Radulovici AE, Adamowicz SJ 2016. Diversity and dispersal history of the talitrids (Crustacea: Amphipoda: Talitridae) of Bermuda. *J Nat Hist* 50: 1911-1933.

Wong B, Candolin U 2015. Behavioral responses to changing environments. *Behav Ecol* 26(3): 665-673.

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