NOTES AND NEWS

SOME ASPECTS OF THE POPULATION ECOLOGY OF THE EXOTIC AMPHIPOD, *TALITROIDES TOPITOTUM*, IN AN ATLANTIC FOREST RESERVE IN BRAZIL

BY

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INTRODUCTION

Terrestrial amphipods live in forest litter and its interface with the soil, and they shelter under leaves and in fallen trees and other pieces of wood on the ground, i.e., habitats very similar to those of terrestrial isopods (Hurley, 1968). They feed on decomposing plant matter. When established in favourable environments, some alien species can replace native amphipods (Costello, 1993; Alvarez et al., 2000). They are usually nocturnal, a habit that minimizes dehydration and predation by birds (Friend & Richardson, 1986). Many species take an active part in soil dynamics, increasing oxygenation rates when moving within the soil and speeding up decomposition processes (Lam & Ma, 1989; Alvarez et al., 2000; Lopes & Masunari, 2004b).

Terrestrial amphipods are able to reproduce up to two times during their life time, with a brood size of 3 or 4 eggs and a mean life span of 10 months, giving rise to a mean of 3 to 4 generations per year (Lam & Ma, 1989). The sex ratio varies seasonally and is usually biased towards females (Wenner, 1972).

Talitroides topitotum (Burt, 1934) has its origins in the tropical and subtropical regions of the Indo-Pacific (Lemos de Castro, 1972; Lopes & Masunari, 2004a), and has become a cosmopolitan tropical and temperate species (Alvarez et al., 2000). It is usually associated with the introduction of non-native plants (sympatric

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spread) (Alvarez et al., 2000; Cowling et al., 2004). This species is always associated with high-humidity environments (Alvarez et al., 2000; Lopes & Masunari, 2004b), occurring at altitudes ranging from 120 m to over 2400 m a.s.l. (Lam & Ma, 1989; Richardson, 1992; Alvarez et al., 2000). In Brazil, *T. topitotum* was introduced with young trees imported for commercial purposes (Ulian & Mendes, 1987; Lopes & Masunari, 2004a), and has probably spread via human gardening and landscaping activities. The species seems closely associated with areas that were reforested with *Eucalyptus* spp., a culture that covers extensive areas in Brazil (Ulian & Mendes, 1988; Lopes & Masunari, 2004b). Initial records of the presence of *T. topitotum* in several countries appear to be related to the introduction of exotic species of plants, as is the case in Brazil (Lemos de Castro, 1972; Lemos de Castro & Pereira, 1978), Mexico (Alvarez et al., 2000), and the United States, where other terrestrial species of amphipods have also been introduced (Visscher, 1874; Medcof, 1939; Lazo-Wasem, 1984).

We studied some aspects of the population ecology of *T. topitotum* in an Atlantic forest area in southeastern Brazil. Some population studies on *T. topitotum* were performed earlier in Hong Kong by Lam & Ma (1989), in Mexico by Alvarez et al. (2000), and in southern Brazil by Lopes & Masunari (2004a, b, c). However, although it is an alien organism and its invasion may have unknown biotic consequences, few general studies exist on the population biology of this species (Lam & Ma, 1989; Alvarez et al., 2000; Lopes & Masunari, 2004a, b, c).

MATERIAL AND METHODS

Fieldwork was carried out in the Parque Estadual da Serra do Mar (Serra do Mar State Park), Núcleo Santa Virginia (NSV) (23°17′-23°24′S 45°03′-45°11′W), in the state of São Paulo, Brazil. The local geomorphological relief features steep escarpments with embedded valleys, ranging from 740 to 1620 m a.s.l. (Tabarelli & Mantovani, 1999). The climate is humid, with no dry season, and the mean yearly precipitation is 2180 mm (Setzer, 1949; Tabarelli & Mantovani, 1999). In the past, the original Atlantic forest of some parts of the area that currently forms the NSV underwent slash-and-burn management and subsequent pasture plantation, while hardwood was logged in other parts. Nowadays, the area is covered by dense ombrophilic montane forest, interspersed with patches of forest in several stages of regeneration, abandoned pastures, and eucalyptus plantations (Tabarelli & Mantovani, 1999; J. P. Villani, pers. comm.).

Sampling was carried out using pitfall traps made of 500 mL plastic cups with an 8.5 cm opening, set level with the soil surface and containing 30% propylene glycol, 0.1% formaldehyde, and a few drops of detergent to break the surface tension. The traps were protected from direct rainfall and falling leaves by a circular styrofoam shield placed above each cup. They were arranged in transects of 5 traps, 2 m apart, per area. A group of 5 traps was considered a sampling unit. The pitfall traps were kept open six days per month during the sampling period.

Twelve sampling units were installed in the study area, placed at least 100 m apart. Sampling was done from November 2004 to May 2005, encompassing late spring, summer, and early autumn, a period in which terrestrial amphipods are more active due to higher temperatures (Lopes & Masunari, 2004b). After each sampling event, the material collected was sorted, preserved in 70% ethanol, and labelled. All collected material has been deposited in the Museu de Zoologia, Instituto de Biologia, UNICAMP.

The number and the sex of individuals in each sample were determined in all samples. Individuals were sexed following Lopes & Masunari (2004c; females have an oostegite and males have a penis). Mature individuals were recognized based on size, following Lopes & Masunari (2004c); an individual was considered mature when its size was larger than 4.57 mm (the size of the smaller ovigerous female in all samples). The samples were analysed under a stereo-microscope fitted with a calibrated ocular micrometer. Individuals from each sampling unit were counted in a Petri dish filled with 70% ethanol to avoid dehydration, which could affect body size. For morphometric assessment, the individuals were placed in a standard position, with legs facing right in relation to the ruler. Two measures were done: (1) head length as the linear distance from the base of the antennae to the beginning of the first thoracic somite; and (2) body length, as the linear distance from the base of the antennae to the last abdominal somite before the telson (following Leite & Wakabara, 1989). The presence of eggs was recorded, and the eggs were removed from the marsupium to be counted (number of eggs per female) (Lam & Ma, 1989; Alvarez et al., 2000; Lopes & Masunari, 2004c). Samples with $N > 40$ were re-sampled from the Petri dishes: after having been poured into the dishes, only one-fourth of the individuals (located in a predefined sector of the dish) was measured.

RESULTS AND DISCUSSION

Throughout the study, 3,593 individuals of *T. topitotum* were collected, all females. Abundance varied among sampling units, from zero to 1,602 individuals. Data about size were based on a subsample of 1,533 individuals following the methods described above. Based on this subsample, 87% of all individuals were immatures (including juvenile and non-ovigerous females), with only 13% ovigerous females. During the study period, two population peaks occurred, one

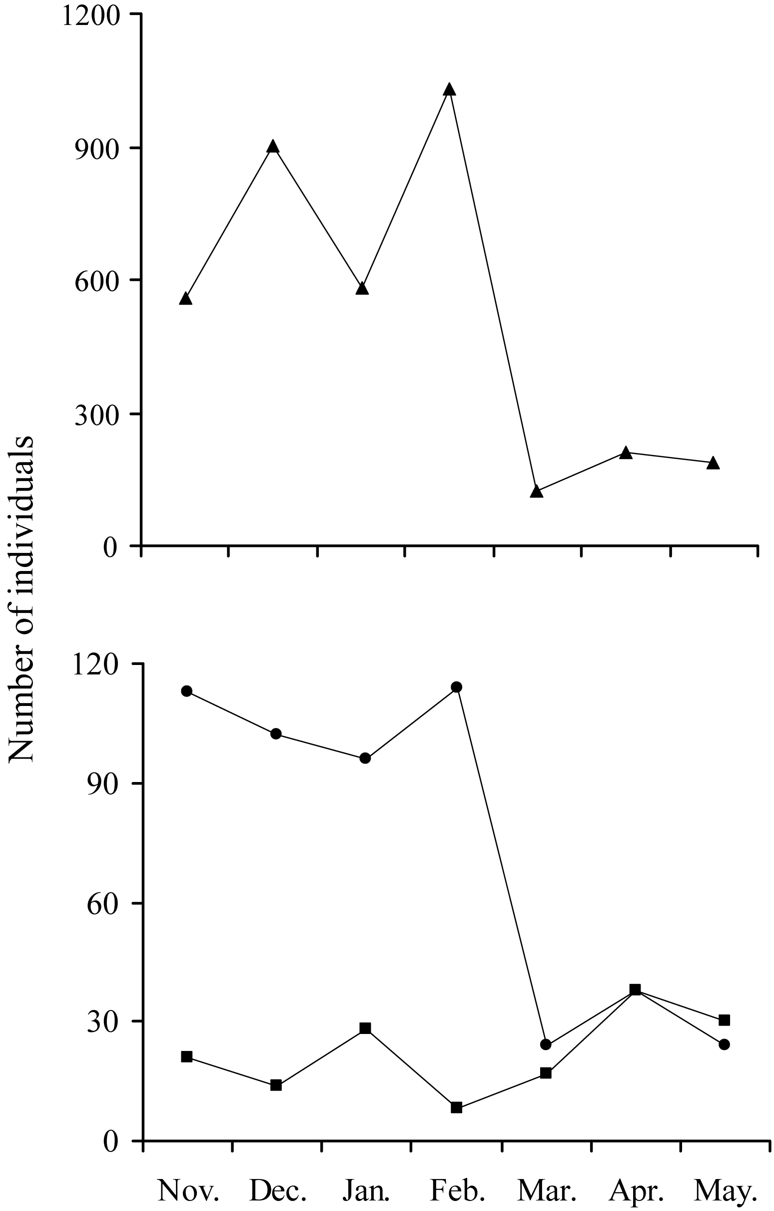

Fig. 1. *Talitroides topitotum* (Burt, 1934): variation in population abundance during the sampling period at the Parque Estadual da Serra do Mar–Núcleo Santa Virgínia: above, total population (▲); below, immatures (see text) (■) and ovigerous females (●).

in December, and the other in February (fig. 1). A peak of abundance of ovigerous females was observed in February. Two peaks of abundance of immatures were also seen, in January and April (fig. 1).

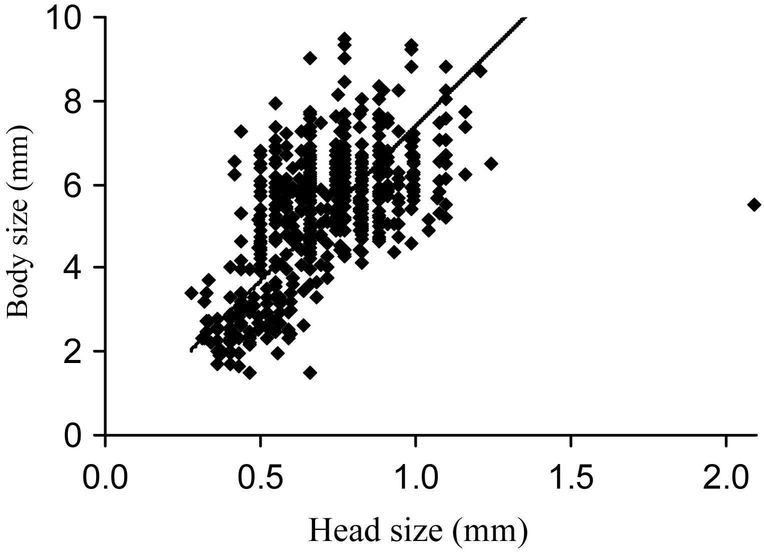

Fig. 2. Correlation between head size and body size of *Talitroides topitotum* (Burt, 1934) collected in the Parque Estadual da Serra do Mar–Núcleo Santa Virgínia, Brazil.

Head length was positively correlated with total length (Spearman Coefficient, rs = 0.517; t = 16.32; $P < 0.001$; $N = 602$). Therefore, the former measurement can be used as a size indicator for this species (fig. 2). The total body length of *T. topitotum* ranged from 1.48 to 10.12 mm, with the modal interval between 5.00 and 5.9 mm (fig. 3). Total body length of ovigerous females ranged from 4.57 to 9.02 mm. Mean egg production was 2.4 per female. The total number of eggs was positively correlated with total body length (Spearman Coefficient, rs = 0.2982; t = 2.88; $P = 0.005$; $N = 87$) (fig. 4).

Interactions among rainfall, relative air humidity, and temperature largely determine the population dynamics of terrestrial amphipods, both stimulating their activity (Lopes & Masunari, 2004b), and possibly also determining variations in fecundity and development time (Lindeman, 1991). In the study area, summer is the season that merges optimum levels of many of these factors for *T. topitotum*, probably leading to the observed population growth at this time of year, associated with the increase in immature (juveniles and non-ovigerous females) recruitment. The same pattern was described in other studies, as was the decrease in abundance in winter and spring (Lam & Ma, 1989; Alvarez et al., 2000; Gonçalves et al., 2003). If, during summer, higher abundance is related to both population growth and higher individual activity, the winter drop may be related not only to the reduction in population size, but also to migration into more favourable environments, or displacement of individuals into deeper layers of the soil where microclimate conditions are more favourable (Gonçalves et al., 2003).

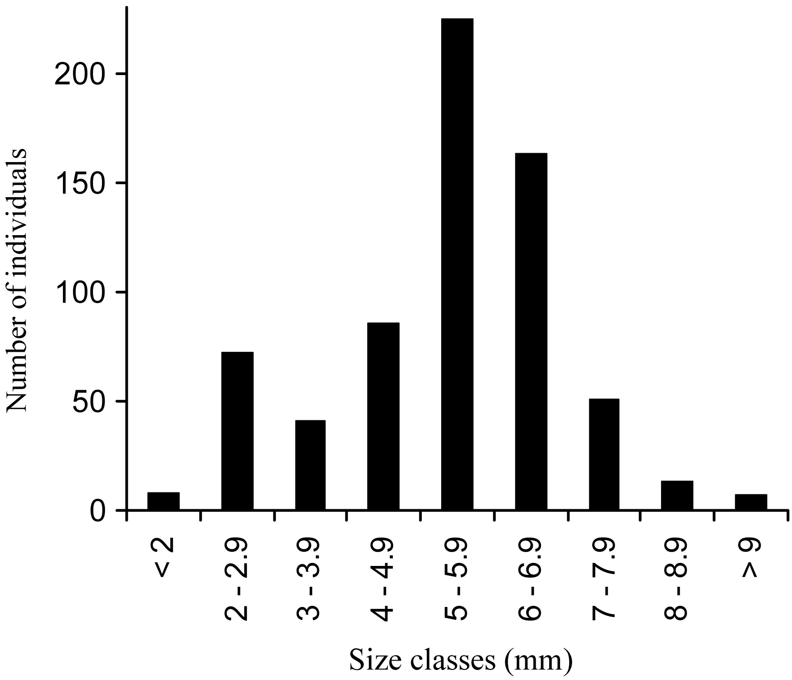

Fig. 3. Number of individuals of *Talitroides topitotum* (Burt, 1934) in each body-size class.

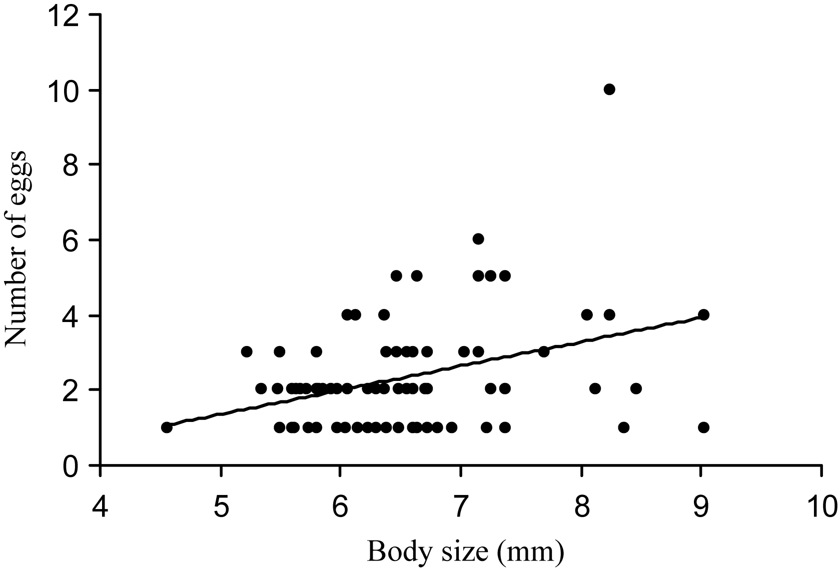

Fig. 4. Ovigerous female body size vs. number of eggs produced in *Talitroides topitotum* (Burt, 1934).

The body size of the individuals in this population ranged from 1.48 to 10.12 mm. This is within the expected range for the species, upon comparison with previous studies (Biernbaum, 1980; Lam & Ma, 1989; Alvarez et al., 2000; Lopes & Masunari, 2004c). The largest individual ever recorded was 14.43 mm long (Lopes & Masunari, 2004a). Mature females, however, show a great variation among the several studies that have been performed. In Hong Kong, females begin to produce eggs when they reach a length of 5.56 mm (Lam & Ma, 1989). In Brazil, the smallest ovigerous females ranged from 4.57 mm (present study) to 7.00 mm in the south of the country (Lopes & Masunari, 2004c). This difference in the minimum size of mature females may be related to differences in several factors regarding the various regions studied, such as mean temperature, food availability, and predation (O'Hanlon & Bolger, 1997a; Gonçalves et al., 2003).

Previous studies have shown that temperature greatly influences some population parameters of amphipods (Gonçalves et al., 2003; Ingólfsson et al., 2007), and may affect the reproduction period of *T. topitotum* throughout its geographical range. Gonçalves et al. (2003) showed that populations of the estuarine amphipod, *Talorchestia brito* (Stebbing, 1891), had longer reproductive periods in warmer areas, and Ingólfsson et al. (2007) showed that temperature was the most important factor in triggering the reproductive phase in the coastal amphipod, *Orchestia gammarellus* (Pallas, 1766). In the present study, the recruitment period of *T. topitotum* was relatively short, from January to April, and comparison with other populations at different latitudes may help to clarify how temperature affects recruitment in this species.

In the present study, no males were recorded throughout the total sampling period, but other studies on *T. topitotum* have detected the presence of males in varying proportions (Lam & Ma, 1989; Alvarez et al., 2000). For crustaceans in general (Wenner, 1972), and amphipods in particular, sex-ratio biases seem to be common, especially toward an excess of females (Jones & Wigham, 1993; Cardoso & Veloso, 1996; Persson, 1999; Gonçalves et al., 2003, and references therein). In the literature, the main explanations for female predominance are: (1) shorter longevity of males; in some species, the males die immediately after copulation (Hastings, 1981; Carrasco & Arcos, 1984); (2) differences in the degree of catchability between the sexes, resulting from horizontal and vertical displacement (Williams, 1995); and (3) intersexuality (Ford & Fernandes, 2005). The reasons that lead to intersexuality are still little known, and parasitism seems to be one of the most common explanations (Ginsburger-Vogel, 1991; Lindeman, 1991; O'Hanlon & Bolger, 1997a; Ford & Fernandes, 2005). In the present work, intersexuality was not investigated, and future studies will be needed for a better understanding of the factors behind this bias in sex ratio in some *T. topitotum* populations.

Finally, if environmental factors influence the growth, recruitment, and fluctuation levels of populations of *T. topitotum*, then many factors have an indirect effect on the production of offspring. The present study shows that body size is positively correlated with female fecundity. Although this association was not found in a study carried out with the same species in southern Brazil (Lopes & Masunari, 2004c), the same pattern was detected for this species by Alvarez et al. (2000) in Mexico, and by Lam & Ma (1989) in Hong Kong, as well as for *Arcitalitrus dorrieni* (Hunt, 1925) by O'Hanlon & Bolger (1997b) in Ireland. Lam & Ma (1989) suggested that females may benefit from delaying the reproduction process until they reach a large body size, thus increasing their reproductive success. More, and more specific studies are needed to test this hypothesis.

Talitroides topitotum as a potential bioindicator

Though *Talitroides topitotum* is a cosmopolitan species, few studies of its biology exist (Lopes & Masunari, 2004b). However, some conditions that favour its establishment are known, such as soil properties (high porosity and high organic-matter content) and climate (relative air humidity above 52%, temperature gradient from 13 to 30°C, and abundant rainfall, at least about 100 mm per month) (Ulian & Mendes, 1987; Richardson, 1992; Alvarez et al., 2000; Cowling et al., 2003; Lopes & Masunari, 2004b). There is also evidence that anthropogenic disturbance favours this species, whose presence is especially associated with non-native plants (Alvarez et al., 2000), mainly *Eucalyptus* spp., in Brazil (Lemos de Castro, 1972; Lopes & Masunari, 2004b). NSV offers many of these properties, including high humidity year-round and *Eucalyptus* spp. plantations (see Tabarelli & Mantovani, 1999), making it especially favourable for the establishment of populations of this species. The same properties are shared by a large portion of the Atlantic forest throughout the Serra do Mar, a large mountain range along coastal southeastern Brazil. In the particular case of environments that have suffered human impact, the presence of introduced plants seems especially important for the establishment of *T. topitotum* populations. Additionally, when there is a mosaic of natural vegetation and plantation areas, the junction of different habitats may favour the movement of individuals among them, in search of a more suitable microhabitat. The invasion of these natural areas by *T. topitotum* and other exotic species may have consequences for the local biota that are still unknown. The presence and abundance of terrestrial amphipods may be a powerful tool in biomonitoring activities of these mosaics (see Lawes et al., 2005), and more studies on this subject are needed in the Brazilian Atlantic Forest.

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