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Preliminary data on adult sex-ratio in *Phyllognathus excavatus* (Coleoptera: Scarabaeidae) in central Italy

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The adult sex-ratio of a widespread dynastine beetle characterized by remarkable sexual shape dimorphism, *Phyllognathus excavatus* (Forster, 1771), is reported herein for the first time with regards to the Italian populations. These beetles were studied in a coastal locality of Mediterranean central Italy (Latium), and showed a significantly female-biased sex ratio (4.2 females for each male), with a daily sex-ratio fluctuating from equality to 7:1 towards females. Comparisons are presented with sex-ratios of other dynastine beetles studied elsewhere.

Key words: Scarabaeoidea, Dynastinae, Pentodontini, adult sex-ratio, Italy.

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INTRODUCTION

Studying adult and operational sex-ratios is essential in order to understand multiple aspects of demography and evolutionary ecology of organisms (e.g., Kvarnemo & Ahnesjo 1996; Jennions & Fromhage 2017; Rosa et al. 2017). Nonetheless, despite the great relevance of studies on sex ratios of free-ranging animal populations, there are many species that have been scarcely studied with regard to this topic. In particular, adult sex-ratios in the wild have been poorly studied in Coleoptera species, in both temperate and tropical regions, although more extensive research has been carried out during the recent years (e.g., Rosa et al. 2017; Keena & Sanchez 2018; Saxena & Mishra 2020).

In this note, we report a field study on the adult sex-ratio of a widespread dynastine beetle (Dynastinae): *Phyllognathus excavatus* (Forster, 1771), that however has never been studied so far in Italy concerning its adult sex-ratio. *Phyllognathus excavatus* is a sexually dimorphic beetle, about 18-20 mm in body length, that inhabits Mediterranean maquis habitats in coastal Italy, Spain, Portugal, Southern France including Corsica, Balkanian peninsula, North Africa, Turkey, Iran, and central Asia (Ballerio et al. 2014).

MATERIALS AND METHODS

The field study was carried out between July and early September 2021 at Lavinio, a coastal locality of Latium (central Italy) situated in the surroundings of Anzio, province of Rome. This is a suburban area, with green patches inside private gardens and with planted *Quercus ilex* L. at the borders of a busy paved road. The road was lighted at night by street lamps of about 6 m height, spaced about 8 m from each another and positioned only on one side of the road.

Field surveys were carried out during the night hours, using a suite of handheld torches (10-W, 390-lumen CFG Patriot), by three surveyors per night (Visual Encounter Surveys methodology). Overall, approximately 54 man-hours were spent in the field (three field researchers). A line transect, 828 m long (from 41.502632, 12.581628 to 41.508292, 12.577319 coordinates), was walked during the late evening and early night hours (22^{00}-00^{15}h). Each surveyor searched for beetles by scrutinizing carefully the ground and the surroundings of the trees situated at the borders of the road, as well as the surroundings of the street lamps, and recorded each individual observed. In order to avoid pseudoreplication, we counted individuals encountered only along one direction of the transect in each survey day, and removed all the already counted specimens. So, resighting of a same individual was impossible during a same survey night. All the observed individuals were identified to sex by examining their external features, their sighting site was defined by recording its geographic coordinates, and the hour of sighting was recorded. The specimens found already dead were collected and deposited in the private entomological collection of L. and R. Luiselli in Rome, Italy.

Correlation between observed number of beetles per day and daily sex-ratio was evaluated by nonparametric Spearman's rank correlation coefficient. In order to assess whether the observed sex-ratio differed from equality, we performed a observed-versus-expected contingency χ^2 test. All statistical analyses were performed by using PAST 4.0 statistical software, with alpha being set at 5%.

RESULTS

Daily sex ratio varied from 1:1 up to about 1:7 (towards females) (Fig. 1), and overall there was no effect of daily sample size on sex ratio (Spearman's $r = 0.210$, $P = 0.733$). The overall observed sex-ratio was significantly skewed towards females (1 : 4.3, n = 53) (observed-versus-expected $\chi^2 = 19.7$, df = 1, $P < 0.0001$), and this difference was statistically significant in four out of six sampling days (in all cases, at least $P < 0.01$ at Yates' corrected χ^2 test with df = 1).

In the period July-August, almost all the specimens (except for three females) were found on the seafront of a narrow area included within the coordinates 41.502632, 12.581628 and 41.503665, 12.581252. Only two females were found in the stretch of waterfront (and adjacency) that goes in the opposite direction, near the "Tor Caldara" protected area. Given that no individuals were observed in August, and four in the beginning of September, it is presumed that a second phase of flickering, after the first one occurring in July, took place between the last days of August and the first week of September. Indeed, two females were found in this latter period near the "Pineta di Anzio-Lavinio" (respectively, at 41.515824, 12.570176 and at 41.515426, 12.572130), and one female was observed along the selected transect, at 41.502632, 12.581628.

DISCUSSION

Our study clearly demonstrated that the adult sex-ratio was significantly biased towards females in the studied *Phyllognathus excavatus* population. However, there was a remarkable daily fluctuation in the sex-ratio, ranging from equality to 1 male every 7 females. However, if we look to the data in more detail, we can notice that during July the total number of males re-

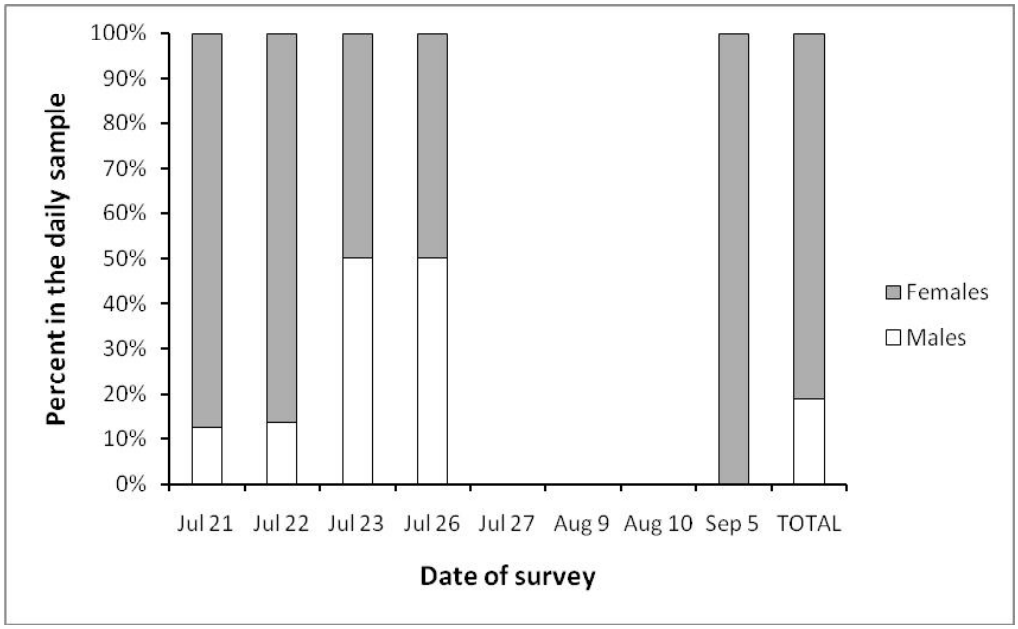

Fig. 1. Daily sex-ratio variations of adult *Phyllognathus excavatus* (Forster, 1771) in Lavinio, central Italy. For statistical details, see the text. Sample sizes: July 21 = 16, July 22 = 22, July 23 = 4, July 26 = 6, July 27 = 0, August 9-10 = 0, September 5 = 5 (two outside the transects)

mained more or less constant (2/3 individuals), whereas the females showed a strong drop in numbers when comparing July 21/22 with July 23/26. Therefore, we can conclude that the observed fluctuations are mainly due to changes in activity of females. We hypothesize that these intersexual differences in above-ground activity maybe due to searching for food or aspects of reproduction.

Biased sex-ratios are not uncommon in beetles, with some cases in which males may account for as much as 95% of the observed individuals (e.g., Luiselli et al. 2021). Concerning dynastine beetles, the literature data showed a considerable species-specific variability, whereas nothing is known on the intraspecific sex-ratio variability or even on the daily fluctuations in the sex-ratio of a same population. For instance, in the Afrotropical *Augosoma centaurus* (Fabricius, 1775), Dendi et al. (2021) observed an almost equal sex-ratio in beetles randomly encountered along transects, whereas the number of females greatly exceeded that of males for the opportunistically encountered individuals, especially those that were attracted by night lights. In *Augosoma centaurus* from Ivory Coast, night light trapping also revealed a significant female-biased sex-ratio (Venard-Combes & Mariau 1983), but in another study of the same species, the number of males surpassed females in banana plantations (Guérout 1974), the same as in Egyptian *Oryctes rhinoceros* (Linnaeus, 1758) with males accounting about 60% of the total sample sizes (El-Deeb et al. 2009). Frequency of females also frequently exceeded that of males in South American dynastines of the genus *Cyclocephala* Dejean, 1821 (Albuquerque et al. 2016), as well as in Indian *Phyllognathus dionysius* (Fabricius, 1792) (Pathania 2015). Therefore, we suggest that a prevalence of females in adult sex-ratios may not be a unusual pattern in dynastine beetles, although with considerable variability across populations. For instance, in another population of *Phyllognathus excavatus* from Egypt, males were more abundant than females but moderately varying month-by-month from about 59% (February) to about 61% in June (El-Deeb et al. 2009).

The implications of the uneven sex-ratio for the population biology and demography of these species should still be analysed. However, it cannot be ruled out the possibility that in dynastine beetles the females in some populations are more attracted by light traps than males, although the reason behind this would be unclear. The fact that one sex is more attracted by night-time artificial lights has already been frequently reported in insects, especially in males (e.g., Altermatt et al. 2009; Garris & Snyder 2010).

In conclusion, the data presented herein show that sex-ratio assessments cannot be done on a daily basis with this species also if it is locally abundant and many individuals may be captured on a same day during the flickering peak period. Instead, at least some days of monitoring are needed even during the flickering peak in order to minimize the daily sex-ratio fluctuations that have been recorded during the present study.

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