

Spatial distribution of *Calomera littoralis nemoralis* (Olivier, 1790) in a coastal habitat of Southern Italy and its importance for conservation (Coleoptera Carabidae Cicindelinae)

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ABSTRACT

The spatial distribution of *Calomera littoralis nemoralis* (Olivier, 1790) (Coleoptera Carabidae Cicindelinae) was studied on the marine sandy beach area of 1 km, near the mouth of a stream in Catanzaro province (Southern Italy, Calabria). During the sampling period (July-August 2011- 2012) we investigated the distribution of adults of *C. littoralis nemoralis* by visual census method and the spatial distribution of larval burrows of *C. littoralis nemoralis* along three transects (A, B, parallel to the coast line; C, embracing the river mouth). All the transects were selected by soil microclimate (a higher or lower humidity) and food availability. Larval burrows distribution was performed using QGIS. The dispersal index (ID) shows regular distribution of adults along transects A and B while in C the individuals are aggregated. Concerning the larval galleries distribution, the QGIS analysis shows a significant difference in their spatial distribution. The sampled data were analyzed using univariate and multivariate statistical methods. This is the first report on spatial distribution of adults and larvae of *C. littoralis nemoralis* in relation to soil humidity and food availability. The adult home range of this species is much larger than the reproductive habitat, that seems limited to wet sandy river bank around the mouth. The importance of such experimental studies for cicindelid conservation is briefly discussed.

KEY WORDS

Tiger beetles; *Calomera littoralis*; adults distribution; larval burrows.

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INTRODUCTION

The subfamilia Cicindelinae (Coleoptera Carabidae) classified in the suborder Adephaga includes many species with predatory habits. Both adults and larvae are predators hunting for small arthropods (insects and spiders) (Larochelle, 1974; Pearson, 1988; Pearson & Vogler, 2001) though cannibalistic behavior was described in some species (Acorn,

1991; Cassola et al., 1988; Hoback et al., 2001). Adults, usually prey visually and catch them after short and fast running (Gilbert, 1987, 1997; Pearson & Vogler, 2001). Tiger beetles species prefer hunt individually for active and usually fast moving preys (Larochelle, 1974; Wilson, 1978; Gilbert, 1987, 1997; Lovari et al., 1992). Few species have been observed eating on plant material (Hori, 1982; Hill & Knisley, 1992; Jaskuła, 2013) and rarely on

dead vertebrates (Schultz, 1981) or dead arthropods (Świecimski, 1956; Pearson & Vogler, 2001; Riggins & Hoback, 2005). *Calomera littoralis* (Fabricius, 1787) s.l. has wide habitat range compared to other tiger beetles and, in Europe, the species lives in different sandy habitats like sandy beaches, salt-marshes, river and lake banks (Magistretti, 1965; Contarini, 1992; Audisio, 2002; Jaskuła, 2013). *Calomera littoralis nemoralis* (Olivier, 1790) is the common subspecies distributed along the sandy shores of the Italian peninsula and Sicily (Magistretti, 1965).

Females lay eggs in the sand and the larvae dig a burrow which emerges on the surface of the sand by a steep vertical pit. The larvae feed on insects and they draw back into their dens when the temperature drops. In Italy, in the past, the species was found along the coasts and in Sicily. In the last decade, the human activity has contributed to the disappearance of the species on many Italian coasts (Contarini, 1992). Today in Italy, as well as in other geographical areas, the species is endangered (Zanella et al., 2009). The aim of this paper is to define the spatial distribution of adults and larvae of *C. littoralis nemoralis* in response to human induced disturbance, food availability and habitat suitability, in order to refine basic ecological knowledge for conservation purposes.

Types of spatial distribution of a population

The spatial dispersion of a population is defined as the distribution or disposition of the individuals in the space (Southwood & Henderson 2000). Knowing the type of dispersion of individuals in a population is a highlight in demographic and ecological studies (Tremblay, 2003). The dispersion of the sample data provides important information on the distribution of a population (Pedigo et al., 1994), often closely linked to the ecology and ethology of the species. The pattern of spatial distribution (see Tremblay, 1988) are traditionally classified according to three categories: uniform (uniform, regular, underdispersed), random (random), and aggregated (clumped, contagious, overdispersed). The statistical measure of aggregation easiest commonly used is the ratio between the variance of the sampling data and the average number of individuals counted. In the theory of probability this ratio is a measure of dispersion of a probability distribu-

tion or density. If individuals are dispersed randomly in the sample according to a Poisson distribution, the variance of the distribution of individuals is approximately equal to the average. In the case of an aggregate distribution, however, the variance is larger than average.

A ratio variance/mean greater than unity, thus indicating a deviation from randomness and a tendency to aggregation that will be greater with increasing ratio. This aggregation index is simple to calculate and there are also simple statistical tests to assess the significance of the deviation between the ratio variance / mean observed and the value associated with a random distribution. A deviation from random distribution can be tested by multiplying the ratio between the variance and the average for the number of samples minus one (n-1). This index is called the dispersion index (ID) and can be compared with the distribution of the chisquare (χ^2) with n-1 degrees of freedom. For more details on mathematical formulas see Selby (1965) and Cicchitelli (2004). A more general approach to the relationship between the mean and the variance is given by an equation known as Taylor's Power Law (Taylor, 1961), for more details see Burgio et al. (1995); Pasqualini et al. (1997), and Furlan & Burgio (1999).

MATERIAL AND METHODS

The observations were made in the morning hours in the July-August 2011 and 2012. The sampling site was the seaside beach located near the mouth of the Fiumarella di Guardavalle River in the Catanzaro province (Lat. 38° 28.142'N, Long. 16° 34.926'E) (Fig. 1).

The sampling of adults of *C. littoralis nemoralis* was performed using the visual census method consisting in daily observations carried out in morning hours (7.45-10.30 a.m.) from 20th July to 10th August 2011 and 2012. Three transects (A, B, C) (Fig. 1), 400 meter long and 1.5 meter wide, were chosen after a preliminary investigation of the study area. The transect A is located north of the mouth, beside a tourist resort that increases the human-induced habitat alterations. The transect B is located south of the mouth where human activity is lower than in the transect A. The transect C is U-shaped and includes the river mouth where human activity is very low.

The distribution scheme of adults along the transects was evaluated applying the Dispersion Index (DI) (Cicchitelli, 2004): this index is directly proportional to the variance of a sample. A sample with a variance higher than the mean value may be defined as aggregate, while a sample with a variance lower than the mean may be defined as regular. A sample having higher value of DI may be defined as aggregate, a sample having lower values of DI may be defined as regular.

To quantify the spatial distribution of individuals, has performed the verification of the adaptation of the data collected in the Poisson model (random distribution), the model of the binomial (grouped distribution) and the Rectangular model (uniform distribution) were performed. For the correlation of data models (Poisson, Binomial and Rectangular), was chosen the χ^2 test. In case of significant values χ^2 was rejected the hypothesis of randomness in the Poisson model, or the hypothesis of aggregation in the case of the Binomial or uniformity in the case of the rectangular model, with $p < 0.05$). According to the χ -square test results, we may conclude that the observed distribution significantly deviates from the distribution model adopted. The numerical analysis of the data was performed with the program STATISTICA (StatSoft, 1999).

The spatial distribution of larval burrows was investigated along the river on a surface of 100 square meters, 30 meters from the shoreline, where two water bodies are present: one with flowing water and another with stagnant water. The investigated area was partitioned in 100 cells 1x1 m (Fig. 2). The abundance of larval burrows was evaluated within any cell resulting in density values. The localization of any burrow was georeferenced using QGIS. Geostatistical analysis was performed using the Minimum Distance Analysis algorithm from Processing plugin, thus being able to calculate the values of minimum and maximum distance of burrows for each cell. The investigated area was subdivided according to the soil surface wetness because this soil property contributes to the survival of eggs, facilitates the digging of larval burrows and prevents the dehydration of larvae. We defined the soil surface as wet when sandy grains may stay at rest like a solid and dry when sandy grains don't show this property.

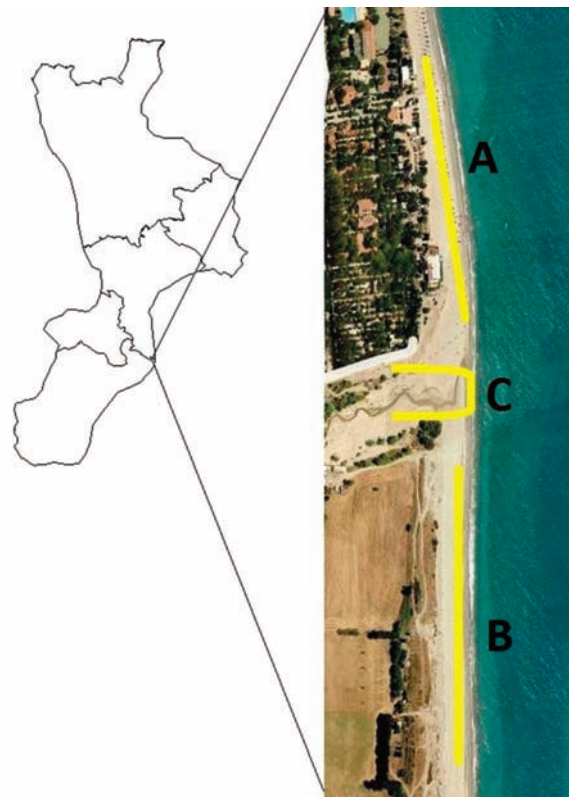


Figure 1. Location of study area. Letters indicate the sampled transects for adults sampling.



Figure 2. Location of the experimental plot for the study of larval distribution along the river.

RESULTS

A total number of 3,934 observations of adults was recorded for the study area subdivided in the sampled transects as follows:

Transects A: 1,015 observations (Mean = 36.3

individuals; SD = ± 4.00 ; variance = 18.56; DI = 13.98. Data trend shows that individuals have a regular distribution ($\chi^2 2.81$ con $p = 0.24$).

Transects B: 1,382 observations (Mean = 49.4 individuals; SD = ± 5.13 ; variance = 26.31; DI = 14.39). Data trend shows that individuals have a regular distribution ($\chi^2 3.62$, $p = 0.06$).

Transects C: 1,537 observations (Mean = 54.9 individuals; SD = ± 8.45 ; variance = 92.80; DI = 45.66). Data trend shows that individuals have an aggregated distribution ($\chi^2 2.93$, $p = 0.23$).

265 larval burrows were found in the study area. They were found only on wet soil surface, as showed in figure 3. We found a significant difference of burrow density between the banks of flowing and stagnant water body ($p < 0.05$). In fact, on the bank of flowing water body we recorded 85 burrows (4.25 ± 3.11 burrows/m²), while on the bank of stagnant water body we recorded 180 burrows (16.36 ± 9.93 burrows/m²). The minimum distance between larval burrows was 4.3 cm, the maximum within a cell was 72.6 cm, and the mean distance was 13.4 ± 10.6 cm (Fig. 3).

DISCUSSION AND CONCLUSIONS

The distribution of adults showed two clear patterns. They are less abundant in the more disturbed sand beach and more abundant where the human disturbance is weaker, with no significant differences between undisturbed sandy shore and river banks. Furthermore, they showed a gregarious habit only on the river banks and not on the coastal strips. Then, abundance depends on habitat disturbance but distributional pattern depends on habitat type. *C. littoralis* is mainly a predator, as all tiger beetles, and probably it uses the sand banks as hunting territory, where it preys visually by inspecting the entire soil surface. This behavior should result in a homogeneous distribution of adults on the investigated sand habitat. But both sexes show a gregarious behavior in habitats where a high trophic resource is disposable also for the alimentation of larvae such as the monitored river banks. This behavior was described also in riparian species of ground beetles (Zetto Brandmayr et al., 2004, 2005; Mazzei et al., 2006). This biotope could support the adult aggregation because vegetable material, such algae and aquatic plants are easily available for their

prey. In fact, the high prey availability inhibits the aggressive behavior between adults within aggregation sites. In this investigation, the bank river seems to fulfill the optimal conditions for environmental and alimentary issues for adults and immature stages. Females search also for optimal soil moisture that prevents dehydration of eggs and larvae that complete their development cycle inside the sandy soil.

The larvae showed a clear preference toward wet soils, avoiding to dig burrows on the dry side of river banks. An optimal soil humidity rate ensures the survival of individuals inside the burrows and an easier maintenance of their rest site where they stay for prey. For larvae more than for adults, the soil moisture is a determinant parameter because it determines where to dig a burrow. The high density of burrows near to the stagnant water is probably due to a higher concentration of preys, mainly Diptera, in these sites compared to sites located along the flowing water. In fact, saprophagous dipteran communities are more abundant and species rich on decaying plant materials and around still waters.

In conclusion, the structure of *C. littoralis* populations is strictly dependent on food availability and habitat suitability and seems to be linked to the resources provided by the river mouth. The adult home range seems to be much larger than the reproduction sites, and wet and fine-grained sand banks along the stream mouths seem to be of outstanding importance for the conservation of this cicindelid species.

Studies on conservation biology of tiger beetles have become very common especially in the last 20 years. Pearson & Cassola (2007) assert their evolution is consistent with a historical model defined GCSPN (General Continuum of Scientific Perspectives on Nature, by Killingsworth & Palmer, 1992), that comprises six steps from 1, "descriptive natural history" to 6, "Technical terminology and methods so refined that they now limit the audience that can fully comprehend it". This short study demonstrates that intermediate steps from 2, "simply experimental" to 5, "research teams and increasing evidence of socialization" are still of importance in defining measures for tiger beetle conservation, and that species ecology of too many cicindelid species is unsatisfactorily endeavoured.

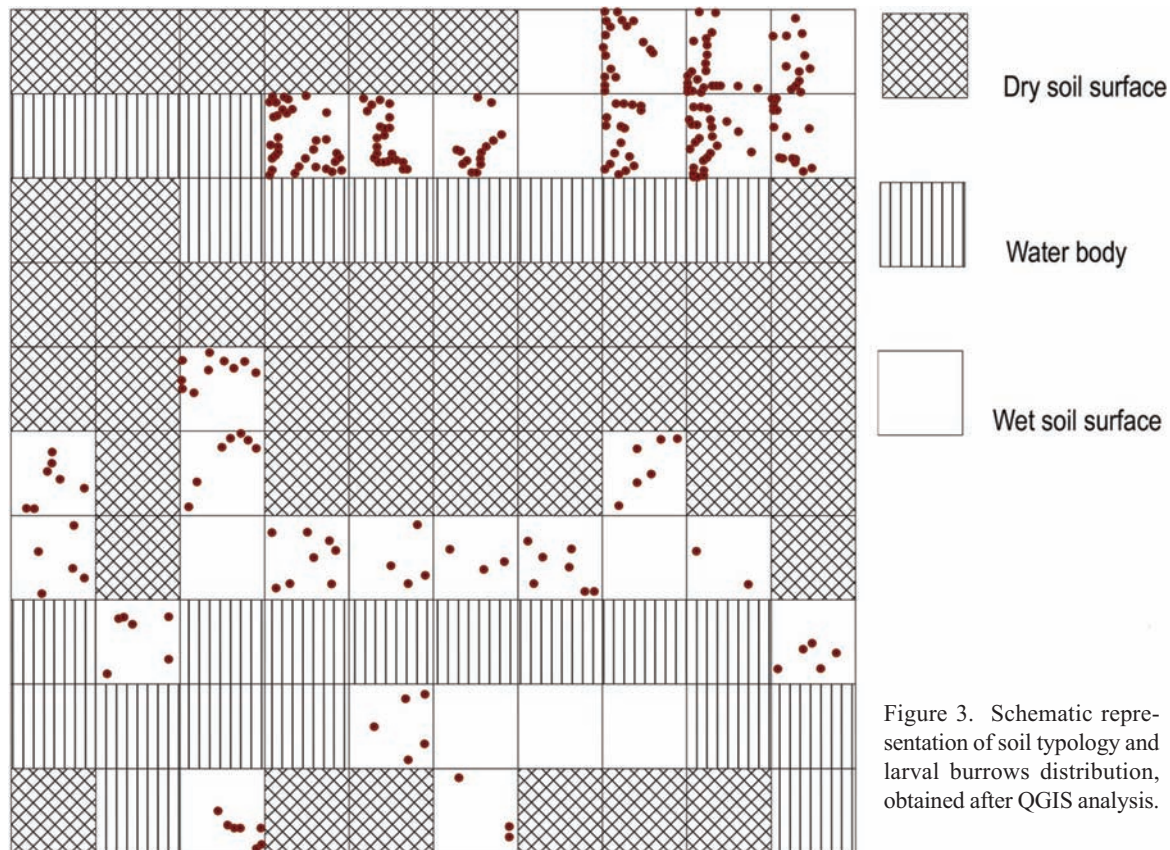


Figure 3. Schematic representation of soil typology and larval burrows distribution, obtained after QGIS analysis.

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