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DATA ON THE BIOLOGICAL CYCLE OF *STEROPUS GLOBOSUS* (COLEOPTERA CARABIDAE) IN THE SOUTH WEST OF IBERIAN PENINSULA

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BIOLOGICAL CYCLE
COLEOPTERA CARABIDAE
STEROPUS GLOBOSUS

ABSTRACT. – In this paper, preliminary data on the reproductive biology and larval development of *Steropus globosus* (Fabricius, 1792) from the southwest of the Iberian Peninsula are given. The research has been based on field data, rearing experiments in laboratory and anatomic studies referring to the degree of ovarian development in females and the wear of mandibles and setae in imagoes. The results comprise data on both – biology and phenology – of the reproductive period and of the larval development. Moreover, the duration and the survival rate of each stage (*i.e.* egg, first, second and third larval instars and pupa) under similar conditions to the environmental ones are given.

CYCLE BIOLOGIQUE
COLEOPTERA CARABIDAE
STEROPUS GLOBOSUS

RÉSUMÉ. – Dans ce travail sont apportés des résultats préliminaires sur le cycle biologique et le développement larvaire de *Steropus globosus* du sud-ouest de la Péninsule Ibérique. Les données proviennent de l'échantillonnage sur le terrain, de cultures en laboratoire et d'études anatomiques concernant le développement de l'ovaire et le degré de détérioration des mandibules et des soies des adultes. Les résultats obtenus mettent en évidence quelques aspects de la biologie et de la phénologie de la reproduction et du développement larvaire. La longévité et le taux de survie des différents stades du développement (œuf, premier, second et troisième stades larvaires et pupe) dans des conditions similaires à celles de la nature sont également étudiés.

INTRODUCTION

As is known, Carabids are a Group of Coleopterans with a high ecological relevance in a large number of terrestrial ecosystems. They are very different in form, life-cycles, behaviour and other adaptative strategies. For these reasons and because of advanced knowledge on the systematics of Carabidae, ground beetles have been the subject of work of many researchers.

Most of these investigations have been carried out in arctic, subarctic, continental and oceanic climates, and a few correspond to the meridional areas of the temperate zone. In our opinion, research designed to study the biology and the annual rhythms in southern Europe is necessary to understand the evolution and the life-cycles of the Carabidae inhabitants of this area.

With respect to the Iberian Peninsula, particularly to the meridional middle, the studies concerning the biology or the ecology of Carabid populations are scant, and include those of de los Santos *et al.* (1985), Cárdenas & Bach (1988a, 1992a and 1992b) and Cárdenas *et al.* (1996).

The aim of this study is to collect some data relative to the reproductive biology and larval development of *Steropus globosus,* one of the most common Pterostichinae living in the southwest of the Iberian Peninsula, both in open areas and in forest environments. Its distribution area comprises the Mediterranean Iberian Basin, from the Atlantic slope to the west of Almería (Zaballos & Jeanne 1994), and it can also be found in North Africa (Antoine 1957).

The insect is large (15-25 mm), slender, convex, black and apterous. The head is quite thick and the pronotum is transverse, regularly rounded on each side and with the hider angles completely bent. The elytra are subparallel with the shoulder which is totally effaced, and the striae are usually regular and well marked across the entire length. The legs are normally conformed, but the mesotibiae have a characteristic cleaning organ; the males have the front tarsomeres 1-3 dilated, with adhesive setae.

Research has been focussed on this species because it is one of the most abundant inhabiting forests, and also being present in open areas such as farmyards or cultivated fields. In the Sierra

Morena community *S. globosus* is among the most abundant species, with a specific abundance index 20% (Cárdenas & Bach 1988b), and could therefore play an important role in the ecosystem. Moreover, as it is widespread in the Mediterranean area, its biological cycle is a good example to show the adaptations in the life-history of carabids to Mediterranean environments.

THE STUDY AREA

The activity pattern of *Steropus globosus* was recorded in the Hornachuelos Natural Park, situated in Central Sierra Morena (SW Iberian Peninsula), a geologically and geographically natural region (average altitude up to 400 m), with a low population density whose main resource is forestry. The soil is physically and chemically homogeneous with a friable and porous structure and clayey texture, a pH ranging between 5.2 and 7.7, and high levels of organic matter and carbon (Cárdenas & Bach 1989).

According to Marvizon-Preney & Fernandez Caro (1981), its climate corresponds to the subtropical Mediterranean type, characterized by subtropical heat and Mediterranean subdry relative humidity.

Vegetation in the area is typical of a Mediterranean mixed forest and belongs to the Duriilignose formation, represented in Spain by the *Quercetea ilicis* type. It is constituted by perennial leaf and phanerophyte communities where shrubs and bushes predominate. The most representative species are *Quercus suber, Q. rotundifolia, Pistacia lentiscus, Asparagus albus* and different species of *Erica* and *Cistus* (Cárdenas & Bach *op. cit.*).

METHODOLOGY

To find data about the biology of reproduction and larval development of *Steropus globosus,* three different types of methods were followed :

1. Field data. In order to record the annual activity pattern, systematic sampling was carried out in Sierra Morena (SW Iberian Peninsula) in 1990. The sampling site was the Hornachuelos Natural Park (see above section). Pitfall-traps (with 4% formaldehyde) were used in the two sampling stations at biweekly collecting intervals.

2. Anatomical studies. These studies consisted of determining the sex and the age of the specimens, and of examining the gonadal state of females. For this, the wear of mandibles and setae in imagoes, and the ovarian development degree, the number of ripe eggs and the presence of *corpora lutea* in females were considered.

3. Laboratory data. In the winter of 1992/93 laboratory-rearing experiments were carried out to study the reproductive biology of the species, their oviposition rate and larval development. The methodology proposed by van Dijk (1973) and Mols *et al.* (1981) was followed.

Table I. Egg number laid per female/control day. Date : day of control. / $_n$: different females used in the experiment. The outputs marked with * are considered as a massive laying because they are consecutive and summarize n = 20 eggs.

DATE	♀1	♀2	♀3	♀4	♀5	♀6	♀7	♀8	♀9	♀10
2-XII-92	-	-	-	97	-	-	-	-	25	-
23-XII-92	-	1	-	-	-	-	-	2	-	46
30-XII-92	1	-	-	-	1	-	-	-	-	-
4-I-93	-	-	11*	-	-	-	-	-	-	-
7-I-93	-	-	3*	1	-	-	-	-	36	-
10-I-93	-	1	6*	-	-	-	-	-	-	-
15-I-93	-	1	-	-	-	-	-	-	-	-
17-I-93	-	-	-	-	3	-	-	-	-	-
22-I-93	1	-	-	-	4	-	-	-	-	-
27-I-93	-	-	-	-	1	-	-	2	-	-
31-I-93	-	-	-	-	1	-	-	-	-	-
3-II-93	-	-	-	1	-	-	-	-	-	-
5-II-93	1	-	-	-	-	-	-	-	-	-
7-II-93	1	-	-	-	-	-	-	-	-	-
13-II-93	-	-	1	-	-	-	-	-	-	-
17-II-93	-	-	-	-	-	-	1	-	-	-

I. For monitoring the oviposition, cultures of *Steropus globosus* Fab. were made in which 10 pairs (1♀ 1♂) of the species were arranged in cylindrical glass recipients (6.5 cm and 8 cm h) with a 5 cm thick substrate of peat, soaked in moisture, and an excessive amount of maggots was supplied as food. The culture was placed in a laboratory chamber with controlled photoperiod, temperature and humidity : 12 hours light/12 hours darkness, 20 °C day/15 °C night and 70-80% relative humidity (these conditions are considered appropriate for autumn-breeder species). The substrate from each recipient was renewed three times a week and the eggs found were removed on each occasion. The eggs were isolated in Petri-dishes with a substrate of carbon filter paper, soaked in moisture, and kept under similar conditions to those of the imagoes.

II. In order to determine the rate and time of hatching at each stage in different conditions, the eggs obtained in the culture described above (Table I) were separated in two similar groups of which $n > 100$. One of them was kept in environmental conditions (Fig. 1A), whilst the other was placed under similar conditions to those of the imagoes (see previous paragraph). As the females laid eggs in a clustery and another sparse way, in the experiment the eggs were distributed as follows : 109 from clusters and 15 sparses in environmental conditions; 115 from clusters and 10 sparses in controlled conditions.

The larvae from each group were isolated in Petri-dishes and reared following the same methodology as for the adults.

The survival rates were calculated as percentage of survivors at the end of each stage with respect to the initial number of individuals in each developmental period. The average duration of the developmental stages was also determined.

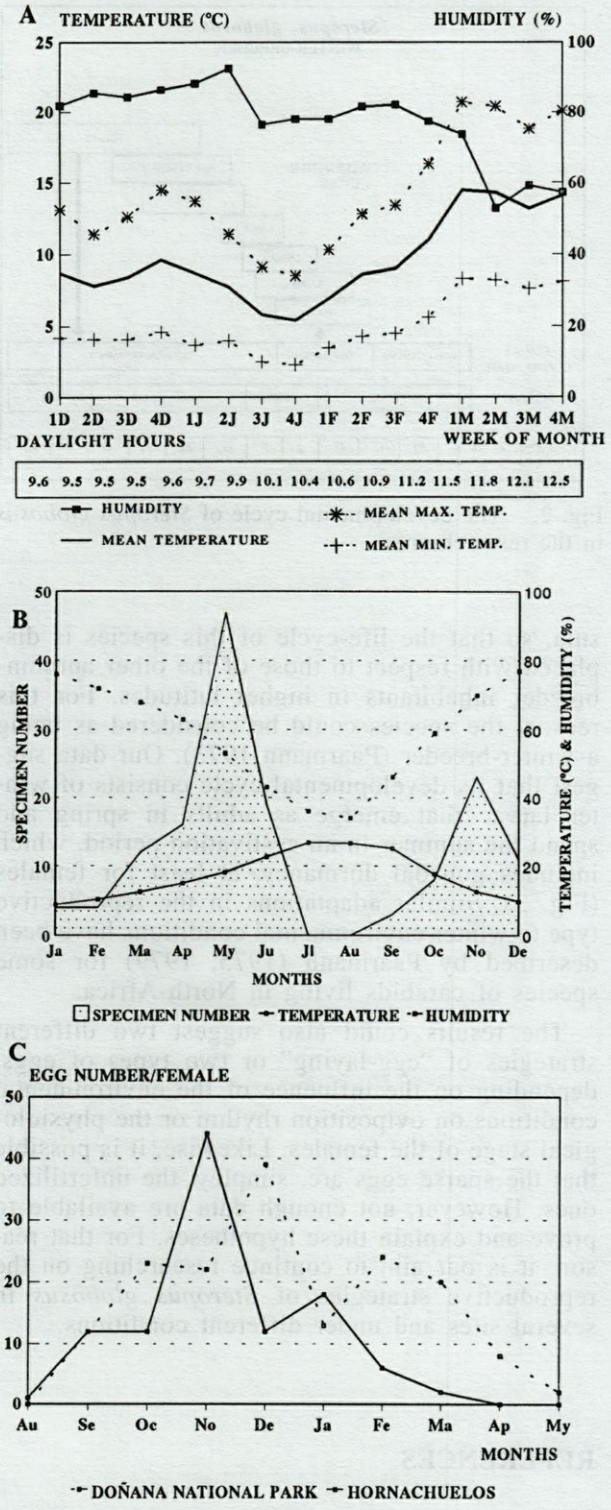

Fig. 1. A, The course of the weekly mean of maxima, minima and average temperatures, and of the relative humidity and daylight hours in environmental conditions (Córdoba, winter 1992/93) during the rearing period. B, Evolution of the adult activity pattern of *Steropus globosus* in field, including the course of the monthly average temperature and relative humidity. C, Average egg number per female during the ovarian maturation period.

RESULTS AND DISCUSSION

Taking into account the data of our research in field, laboratory experiments and anatomical studies, together with those of other authors (de los Santos *et al.* 1985) related to the life cycle of some Carabidae species in the South of the Iberian Peninsula (next to Doñana National Park) we were able to obtain the following information regarding the life-history of *Steropus globosus* :

The activity pattern of the adults in our research area peaks twice (see Fig. 1B) : the first maximum is located between May-June and the second approximately in the middle of the interval October-December.

A morphological examination of the specimens captured in the field showed that the spring maximum corresponds to the young (from the new generation) and to old imagoes (which were going through gonadal dormancy). The second peak results from the reproductive activity, firstly on the part of the males ("searching" activity) and afterwards on the part of the females (oviposition activity).

Anatomical studies referring to the ovarian developmental stage revealed, in accordance with de los Santos *et al.* (*op. cit.*), that vitelogenesis occurs between the end of September and November. Later, oviposition starts and goes on until the end of January (Fig. 1C) in our research area. Nevertheless, data from Doñana indicated that the oviposition period may be longer in that location, even continuing until the end of April.

In the laboratory-rearing experiments two types of "egg-laying" were observed (Table I) : a "concentrated and numerous" type (number of eggs was between 20 and 97, $\bar{X} = 45$) and an other "scant and more or less scattered" (number of eggs ranging between 4 and 1, $\bar{X} = 1.4$). In the first case, the eggs showed a high level of fertility (over 65 %), and in the second the viability of the eggs did not reach 5 % (one hatched egg). Thus, the following up of the development was made only with concentrated layings.

With respect to embryonic development under environmental conditions (Table II), the average incubation time was approximately two weeks, and the survival rate was 56 %. When the eggs were kept under controlled conditions, the larvae hatched after only a week of incubation time, and the survival rate was close to 80 %.

As is common for most Carabidae, after hatching, the larvae went through three larval instars. Under environmental conditions, the mean time for the first instar was around a month and the survival rate for this period was 75 %. Contrary to what happened for the embryonic development, if the first stage larvae were reared under

Table II. Rearing data for *Steropus globosus* under environmental conditions in winter 1992/93.

Eggs (Initial number of eggs= 109)	
- Number of larvae I	61
- Average Incubation time (days)	15
- Standard Deviation	0.99
- Survival rate (%)	56
First instar (Initial number of L-I= 61)	
- Number of larvae II	46
- Mean time for first instar (days)	33
- Standard Deviation	5.97
- Survival rate (%)	75
Second instar (Initial number of L-II= 46)	
- Number of larvae III	28
- Mean time for second instar (days)	34
- Standard deviation	7.27
- Survival rate (%)	61
Third instar (Initial number of L-III= 28)	
- Number of Prepupae	6
- Mean time for third instar (days)	40
- Standard deviation	12.14
- Survival rate (%)	21

controlled conditions all of them died within a few days after hatching. The same fact is described by de los Santos (*op. cit.*). Due to the fact that in our experiments the remainder variables were kept under similar conditions (same nourishment, same kind of substrate, no decisive differences in photoperiod, and saturation humidity), in our opinion a high temperature in cultures is not suitable for larvae development because of the winter-reproductive condition of *Steropus globosus*.

Necessarily, the study of the remaining larval stages was continued only under environmental conditions.

The mean duration of the second instar was 34 days and mortality did not reach 40%. For the third larval stadium the data are not significant enough because of the low number of larvae which reached the prepupal stage. Anyway, our data for this period indicate that the mean time for the third instar is nearly 40 days and the survival rate approximately 21%.

On the whole, when the eggs came from concentrated layings, the duration of the immature stages from oviposition until pupation is around 100 days, and although the average survival rate when considering all the developmental phases was over 50%, the total survival rate was nearly 5%.

In conclusion, *Steropus globosus* belongs to the autumn-breeder reproductive type of Thiele (1977), but needs humid and cold conditions for larval development. These conditions happen in the winter in the south-west of the Iberian Peninsula, so that the life-cycle of this species is displaced with respect to those of the other autumn-breeder inhabitants in higher latitudes. For this reason, the species could be considered as being a winter-breeder (Paarmann 1973). Our data suggest that its developmental cycle consists of winter larvae that emerge as adults in spring and spend the summer in an aestivation period, which includes gonadal dormancy, at least for females (Fig. 2). Similar adaptations in the reproductive type to winter environmental conditions have been described by Paarmann (1975, 1979) for some species of carabids living in North-Africa.

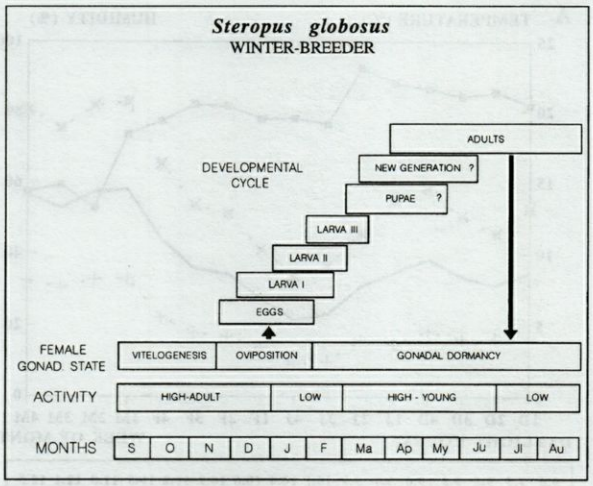

Fig. 2. The developmental cycle of *Steropus globosus* in the research area.

The results could also suggest two different strategies of "egg-laying" or two types of eggs, depending on the influence of the environmental conditions on oviposition rhythm or the physiological stage of the females. Likewise, it is possible that the sparse eggs are, simpley, the unfertilized ones. However, not enough data are available to prove and explain these hypotheses. For that reason, it is our aim to continue researching on the reproductive strategies of *Steropus globosus* in several sites and under different conditions.

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