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A STUDY ON THE LIFE HISTORY OF *LECANOPSIS CLODIENSIS* (PELLIZZARI) N. COMB. (HEMIPTERA: COCCOIDEA: COCCIDAE).

ABSTRACT

A STUDY ON THE LIFE HISTORY OF *LECANOPSIS CLODIENSIS* (PELLIZZARI) N. COMB. (HEMIPTERA: COCCOIDEA: COCCIDAE).

The biology of *Lecanopsis clodiensis* (Pellizzari) has been studied in Italy, where the species is widespread and lives on Gramineae. The species has one generation/year. Adult emergence takes places in April-May, depending on the meteorological conditions. After mating, the females lay eggs and the crawlers hatch within a month and disperse to the root-crowns of the host plant (a Gramineae) and settle under the leaf-sheath in very protected positions. The 3rd-instar female nymphs and 2nd-instar male nymphs overwinter. All nymphal stages are covered by a glassy wax test. Some aspects of its life history have been investigated in their natural environments (a sandy beach and a meadow) and in the laboratory, particularly its reproductive behaviour, the behaviour of both fertilised and virgin females, its mating behaviour and the dispersal of the adult female. Other observations on the remarkable biology of this species are reported.

Key words: voltinism, sex ratio, eggsac, pupa, phototaxis, host plants, sex pheromones.

INTRODUCTION

The first brief account on the biology of a *Lecanopsis* species was by Green (1921), who made several observations on the unusual life history of *L. formicarum* Newstead. Thirty years later, Schmutterer (1952) added further biological information (overwintering stage and possible presence of the male). It was only in 1982 that Boratynski *et al.* (1982) presented a comprehensive work on the biology of the same species. In their excellent paper, the authors also clarified for the first time the morphology of the different male and female nymphal stages of *Lecanopsis formicarum.*

Little is known about the biology and even less about the ethology of the other *Lecanopsis* species. Generally, researchers report only the date of collection, the different stages collected and the host plant (Borchsenius, 1957; Tereznikova, 1981; Kosztarab & Kozár, 1988). Moreover, the identity of some species is somewhat obscure.

This paper is part of a larger study devoted to the revision of the genus *Lecanopsis* and highlights some biological aspects of a recently described species, *Lecanopsis clodiensis* (Pellizzari) **n. comb**. (Pellizzari, 1995).

Distribution

L. clodiensis was discovered in 1985 on a sandy beach facing the Adriatic sea in the district of Venice, living on Gramineae. Investigations carried out over the following years led to the discovery of numerous biotopes where this species is present in Italy.

So far *L. clodiensis* has been found only in Italy, where it appears to be widespread throughout the peninsula. It colonises, sometimes with large populations, different environments and has been recorded in North-Eastern Italy on the sandy beaches and in the hills, in the Apennine meadows, and in the South on rocks near the sea and in arid areas.

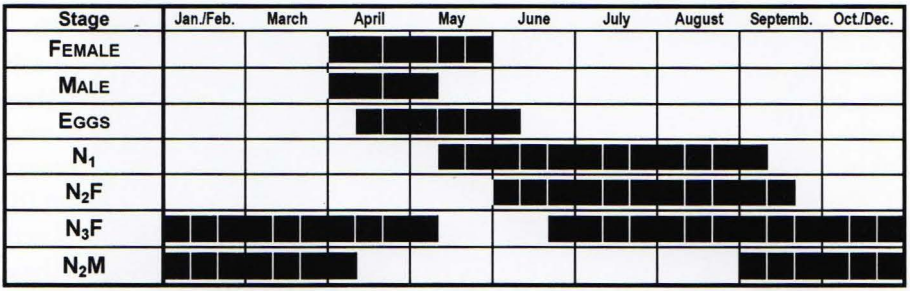
Life cycle

The biology of *L. clodiensis* has been studied since 1994 on a sandy beach near Venice, where this species lives on *Agropyron pungens*. Occasional observations have also been carried out in other natural environments in Central and Southern Italy. Further observations have also been made in the laboratory, with the purpose of studying particular aspects of the behaviour of this species.

As previously mentioned, the life cycle of a *Lecanopsis* was highlighted for the first time by Boratynski *et al.* (1982), who studied the biology of *L. formicarum* in the field and in the laboratory. The biology of *L. clodiensis* appears to be very similar (Table 1). The female of *L. clodiensis* develops through three instars. The 2nd- and 3rd-instar females are characterised by a considerable reduction in the size of the legs and antennae, which is usual in this genus. The male has two nymphal stages and then passes through the prepupal and pupal stages, finally becoming an winged adult male. The 2nd-instar male differs from the 2nd-instar female in having well-developed legs and antennae. The nymphs of both sexes are enclosed within a thin, transparent, waxy test.

Lecanopsis clodiensis has one generation/year. The adult males and females emerge between the second half of April and the first half of May, depending on the meteorological conditions and localities. A few days after fertilisation, the females start to secrete a loose, white eggsac, that encloses part of the female body, and she then lays her eggs. Each female lays an average of 670 eggs (minimum 280; maximum 1350). Virgin females do not lay eggs but do usually produce an empty eggsac. The eggs hatch after 15-30 days and the crawlers try to reach the root-crown of the host plant, where they settle under the leaf-sheath, in very protected positions.

Table 1: Life cycle of *Lecanopsis clodiensis* (Pellizzari) on *Agropyron pungens* on a beach on the Adriatic Coast near Venice, 1994.
Where: Female = adult female; Male = winged male; Eggs = eggs and eggsacs; N^1 = first-instar nymphs; N_2F = second-instar female; N_3F = third-instar female, and N_2M = second-instar male.



Settled 1st-instar females are present on the plants until September, although 2nd-instar females appear in June and are present until September. Rare 3rd-instar females can be found at the end of June, but their number increases later and from September until the following spring they are the only female stage present on the plants (Fig. 2a).

The 2nd-instar males occur from the end of August until April-May of the following year, but then, within a few days, they all move from the crown of the host plant in search for a suitable place to secrete a puparium and then moult to prepupa, pupa and adult male.

The peak of emergence of the adult females takes place within a few days in any particular locality, so that the simultaneous appearance of the females in places where a large population is present assumes the characteristics of an outbreak. We observed one of these outbreaks on 11 April 1997, when we found thousands of adult females on the beach, far from their host plants, wandering singly on the sand or forming groups (Fig 1a). All of these wandering females were without an eggsac. Several groups of egg-laying females were found only in the shade, under plants or in other protected places. As females with eggsacs were found only in shady or protected locations, we hypothesised that, after mating, the females move again towards shaded areas. Because of the high number of females present on the beach, we were able to collect several living specimens to perform laboratory tests for confirmation of our hypothesis.

Fig. 1a: adult virgin females wandering on the sand; Fig. 1b,c: aggregations of adult virgin females.

LABORATORY TESTS

Tests in the laboratory were performed in April 1997, to verify the ability of the adult females to move and to evaluate the preference of fertilised females for protected or exposed places for egg-laying. Other tests were performed in February, 1998, to observe their reproductive behaviour.

1. *Capacity to move*: a group of 34 females without eggsacs, collected in the field in April 1997, were divided into two groups and put on a sheet of polystyrene for ten minutes. Their start and final positions were marked with pins. During the experiment, only two females did not move. The others covered a distance varying from 0.5 to 12cm, with an average of 4.5cm in the 10 minutes, i.e. an average speed of 27cm/h with a maximum of 72cm/h. In this test, the adult females of *L. clodiensis* showed that they could move easily and, therefore, could colonise new plants and new territories.

2. *Behaviour of fertilised females*: this test was designed to verify in the laboratory a hypothesis based on field observation, that ovipositing females laid eggs in shady, protected places. Only fertilised females lay eggs, virgin females only producing empty egg-sacs. A group of 125 females without eggsacs were collected in the field in April, 1997. They were divided into groups of 25 individuals in 14cm diam. petri-dishes, the bottoms of which were covered with blotting-paper. Into each petri-dish was placed a 4x4cm piece of dark, thin, folded card as a shelter. We therefore gave each female the choice between an open or a sheltered place in which to lay her eggs. A total of 76 females laid eggs. Of these, 66 (87%) laid eggs under the dark, folded card or under the blotting-paper. A total of 46 females did not lay eggs, but produced empty egg-sacs. Of these, only 11 (23%) were recovered under the shelter. This test, therefore, demonstrated that the fertilised females tended to search for protected places in order to lay their eggs.

3. *Reproductive behaviour of* L. clodiensis *under laboratory conditions*: on the 11th December 1997, several plants of *Agropyron* with 3rd-instar females and 2nd-instar males on the crown were collected in the field, put in small pots and brought to the laboratory with the purpose of obtaining adult males and adult virgin females so as to observe mating and the behaviour of the virgin females. Before putting the plants in the laboratory, four plants were carefully checked to verify the sex ratio, which was about 1:1 on this date.

One month after the plants were brought into the laboratory, where the average temperature was 20°C, we noticed the emergence of the adult females. Just after the last moult, they broke through the glassy test and emerged into the open by moving backwards among the leaf-sheaths. After emergence, most females climbed the leaf blades, reaching the top where

they stopped. Other females stayed on the ground, without any great possibility of moving because of the small dimension of the pot. Some of them were transferred to petri-dishes where they continued to move. After a period of 12-15 days, all of the virgin females had secreted a white, loose eggsac but none had laid eggs.

A few days after the emergence of the females, the 2nd-instar males left the crown of the host plant and started to wander to find a place to secrete the puparium. A very few climbed the green leaves of the host plant and here secreted the puparium (Fig. 2b). After about a week, they moulted to prepupa, pupa and finally to winged adult male. However, many 2nd-instar males moved towards the saucers under the pots but they all died without secreting the puparium or failed to secrete it. No puparia were observed on the soil, although we cannot exclude this possibility - because of their small size, they could have escaped our observation. On the contrary, Boratynski *et al.* (1982) reported that the male nymphs of *L. formicarum* formed puparia on the soil and these authors specified that they had never seen them on plants.

The leaves with the puparia were cut from the plants and preserved in a small cage to perform mating tests. One male puparium with a male inside was put in a small plastic cage with a virgin female to observe the mating behaviour. Just after emerging, the male started to move quickly and, on reaching the female, mounted the dorsum, walked over her whilst vibrating the antennae rapidly, and then inserted his aedeagus into the genital opening through the anal cleft, at the same time raising the caudal filaments upwards (Fig. 2e). The mating lasted a few seconds after which the male quickly left the female to wander in the cage but he promptly mated again when he met the female during his rapid exploration of the cage. In the observed situation, the male mated 17 times with the same female, but then became inactive and died within a few hours. The female started to lay eggs a few days after copulation.

The other 5 male puparia were kept in small boxes, each with several virgin females (from 5 to 30 females) in order to ascertain how many females could be fertilised by one male. The best performance was 7 females fertilised by one male but two of the seven females laid only a few eggs. Altogether 5 males fertilised 12 females; two males failed to fertilise any females. From the results of this test, we can infer that a male can mate with several females. Besides, it seems likely that subsequent copulations by a male result in progressively lower fecundity of the females, probably because

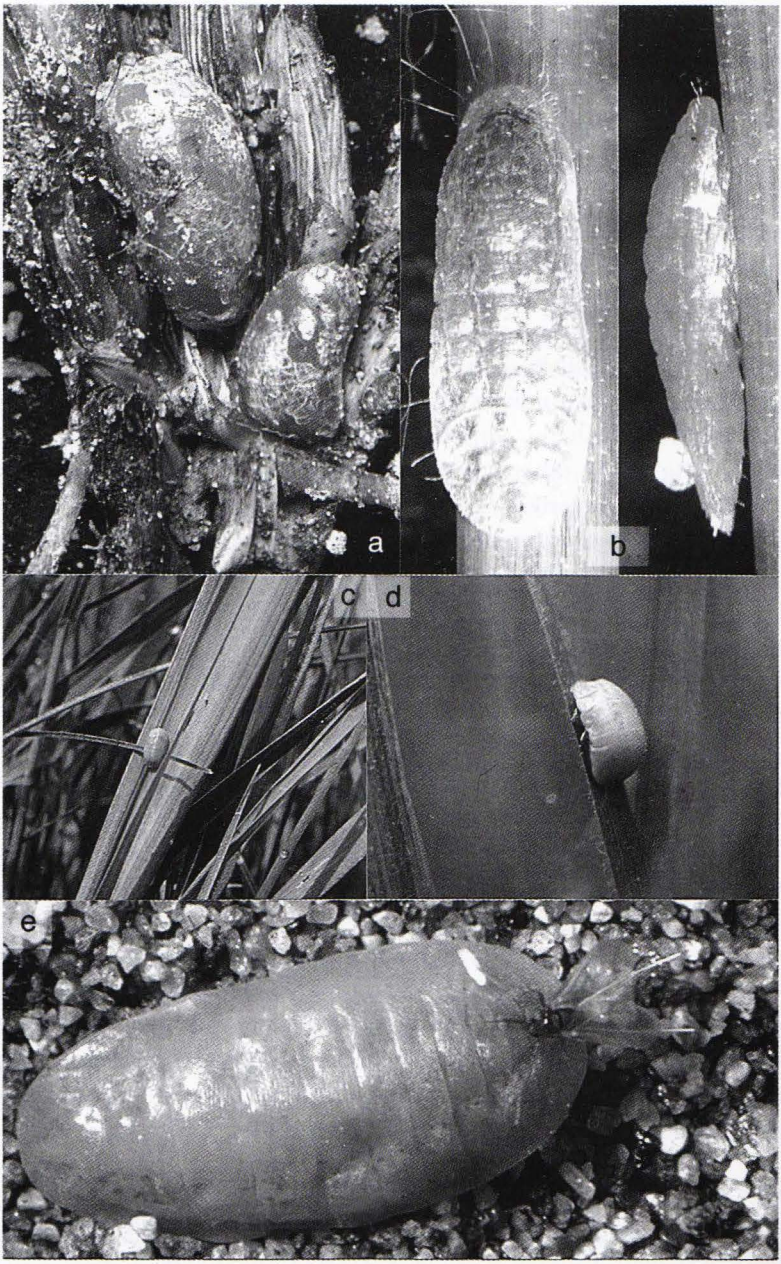


Fig. 2a: 3rd-instar females settled on the crown of *Agropyron pungens*; Fig. 2b: puparia of males; Fig. 2c, d: virgin females climbing the leaf blades; Fig. 2e: mating.

of the lesser amount of spermatozoa they receive. These tests need to be repeated.

Under laboratory conditions, 123 females emerged from the infested plants but only 7 males, giving a sex ratio of 18:1.

Reproductive behaviour

These observations, which were carried out under natural environmental conditions and in the laboratory, allowed us to clarify the reproductive behaviour of *L. clodiensis*.

The adult virgin females are apparently positively phototactic. After emergence, they exhibited two different types of behaviour, probably depending on the environment in which they lived. Those living amid the grass of meadows usually climbed to the top of the leaf blades just after emergence (Fig. 2c,d), where they stayed waiting for the male. After mating, they descended and started to lay eggs on the ground or under stones or moss. In several cases, unfertilised females remained on the top of blades and here produced their empty eggsac. This behaviour was also recorded by Green (1917, 1921) for *L. formicarum*, but not by Boratynski *et al.* (1982), who cast doubt on Green's observation.

The females which lived on the beach, where the host plants are scattered, generally moved to open, sunny places on the sand, where they formed groups of tens of individuals (Fig. 1b,c). After mating, they moved from these sunny sites to shady places, usually the base of grasses or under stones (although unusual protected places were also chosen by the wandering females, such as pieces of plywood, polystyrene, and so on) and here they stopped moving and started to lay eggs. It is the crawlers who have the task of finding the host plant.

Unfertilised females usually did not exhibit any preference for shady, protected places but remained for a long time in sunny or exposed sites such as the top of leaves or stems, presumably waiting for the male, eventually secreting an eggsac but never laying eggs. In several cases, the empty eggsacs of these virgin females were longer than those with eggs because the virgin females continued to move, thus changing the shape of the eggsac.

Comments

In the life history of *L. clodiensis,* we can recognise several interesting peculiarities, some of which were also pointed out by Boratynski *et al.* (l.c.) for *L. formicarum*.

The adult females varied considerably in size, from 3 to 8mm. The

dimensions attained by the adult females were similar to those of the 3rd-instar female before the last moult, the size of the latter clearly depending on their feeding position, which is chosen by the crawler. In fact, we have found 3rd-instars in very different positions and sizes on the host plant on the same date, with some nymphs squeezed by the growth of the plant and consequently with a misshapen and dwarf body.

Adult females have no connection with the host plant and do not feed. Just after emergence from the last moult, each female leaves the host plant and wanders on the ground or climbs up blades of grass. During these wanderings, they stop near different plants. However, finding a female, with or without an eggsac, near a plant does not mean that the plant is the scale's host. The only true host plants of *Lecanopsis* are those on which nymphal stages have been collected.

We make the following speculations about the behaviour of *L. clodiensis*. The congregation of the females into groups on the beach could favour mating, where the greater amount of sex pheromone secreted by the group of females could help males to locate them. In addition, it was noted that each male was able to fertilise several females without any new, hazardous search. In a meadow, the fact that the females remain on the leaf blades rather than on the ground would also facilitate location by the males.

Several questions still remain unsolved: i.e. 1. What is the sex ratio of the species in natural environments? The sex ratio of the nymphal instars on the host plants in December was 1:1, but in the laboratory, at the end of metamorphosis, we obtained 123 females and only 7 males, with a sex ratio strongly in favour of females (18:1). 2. Where are the puparia secreted in the field? On the plants or on the soil surface? We were not able to locate them on the beach. 3. Why did we find adult females on the beach so far from their host plant? This behaviour appears highly risky, even though it could be partly explained by the attempt to colonise new plants.

These and several other open questions (i.e. the factors involved in ending diapause) will be the stimulus for further studies on the behaviour of species in this fascinating genus.

REFERENCES

BORATYNSKI, K., PANCER-KOTEJA, E., KOTEJA, J., 1982 - The life history of *Lecanopsis formicarum* Newstead (Homoptera, Coccinea). *Annales Zoologici. Warszawa*, 36(27): 517-537.

BORCHSENIUS, N. S., 1957 - Fauna of USSR, Homoptera, Coccidae (in Russian). *Zoological Institute Akademia Nauk, SSSR (n.s. 66)*, 9: 1-443.

GREEN, E. E., 1917 - Observation on British Coccidae, with description of new species. No. III. *Entomologist's Monthly Magazine*, 53: 201-210.

GREEN, E. E., 1921 - Observation on British Coccidae, with description of new species. No. VI. *Entomologist's Monthly Magazine*, 57: 189-200.

KOSZTARAB, M., KOZÁR, F., 1988 - Scale insects of Central Europe. Series Entomologica, Vol. 41. Junk Publishers. Dordrecht. 456pp.

PELLIZZARI, G., 1995 - A new species of *Paralecanopsis* (Homoptera, Coccoidea) from Italy. *Bollettino di Zoologia agraria e Bachicoltura, Ser. II*, 27: 35-44.

SCHMUTTERER, H., 1952 - Die Ökologie der Cocciden (Homoptera, Coccoidea) Frankens. 2. Abschnitt. *Zeitschrift für Angewandte Entomologie*, 33: 544-584.

TEREZNIKOVA E. M., 1981 - Scale Insects. Eriococcidae, Kermesidae, Asterolecaniidae, Coccidae. In "The fauna of Ukraine". Vol. 20, part 19 (in Ukrainian). Akademia Nauk Ukrainian, RSR Zoological Institute. 215pp.