ISRAEL JOURNAL OF ENTOMOLOGY VOL. XII 1978

OBSERVATIONS ON THE BIOLOGY AND HOST PREFERENCE OF *CARYEDON SERRATUS PALAESTINICUS* (COLEOPTERA :BRUCHIDAE) IN ISRAEL *

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ABSTRACT

The life history of *Caryedon serratus pa/aestinicus* Southgate, a bruchid feeding on seeds of *Prosopis farcta* (Mimosaceae) was studied in the field, and under laboratory conditions of 25°C and 50% RH, and 30°C and 70% RH. The difference between the prothoracic plates of the larvae of ***C.s.*** *palaestinicus* and *C.s. serratus* (Olivier) is described. In oviposition preference tests, it was found that ***C.s.*** *palaestinicus* always prefers seeds of *P. farcta* over seeds of groundnuts *(Arachis hypogea)*. When offered groundnuts separately, oviposition by *C.s. palaestinicus* does occur, but development of the larvae is much longer than in seeds of *P. farcta.*

INTRODUCTION

Caryedon serratus (Olivier 1790) ssp. *palaestinicus* Southgate 1976 (Fig. 1), was first recorded from Israel as *Caryedon fuscus (= Bruchus fuscus* Goeze, 1777) by Calderon (1959). He mentioned that its larvae developed in the seeds of *Acacia spirocarpa* Hayne and *A. tortilis* Hochst in the Negev and the Arava Valley.

Decelle (1966) examined the types of *C. fuscus* and C. *serratus*, removed the former from the genus *Caryedon* and showed that *C. serratus* was synonymous with *C. gonagra (= Bruchus gonagra* Fabricius 1798), a known pest of groundnuts in West Africa, that has been redescribed by Southgate and Pope (1957). Because of priority, *Caryedon serratus* is the valid name for the Groundnut Bruchid.

* This work was supported by a P.L. 480 grant of the United States Department of Agriculture.

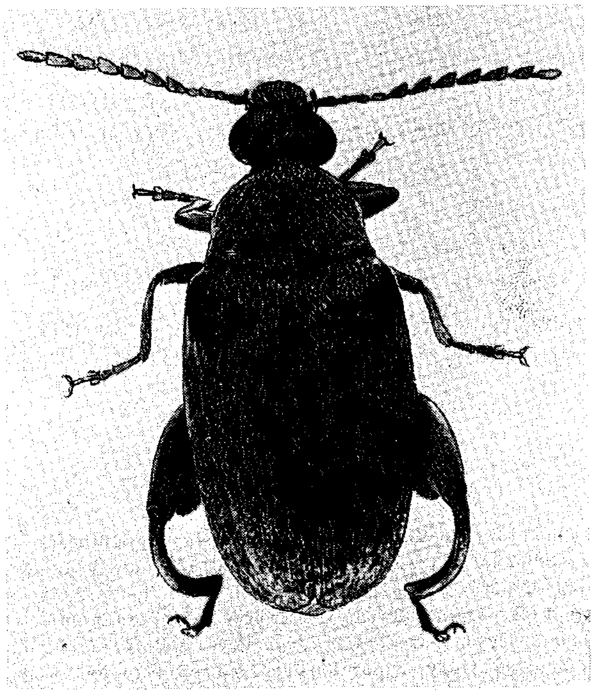

Fig. 1. *Caryedon serratus palaestinicus* Southgate.

The groundnut Bruchid, *C. serratus* has a very wide distribution. According to Davey (1958), it has been recorded under different names from tropical Asia, Iraq, Jordan, Sudan, tropical Africa, the Caribbean Islands, Dutch Guiana and Hawaii. According to Prevett (1954), the origin of the Groundnut Bruchid may be in India, and *Tamarindus indica* L. (Caesalpiniaceae) may be its primary host plant. Its wide distribution may be due to transportation by man of infested fruits or seeds along trade routes. Davey (1958) gives a list of the recorded plants believed to be hosts of the Groundnut Bruchid; *Prosopis farcta* is not amongst them, although other species of this genus are mentioned.

Although groundnuts are grown in Israel, no damage by *Caryedon* has ever been reported, but considering the possibility that the bruchids could pass from *Acacia* to groundnuts, the development of *C. serratus* from *Acacia* on groundnuts was studied by Donahaye *et al.*(1966) and by Calderon *et al.* (1967). They found that under laboratory conditions (26°C and 70% RH), the bruchids from *Acacia* developed normally on groundnuts.

Between 1970 and 1973, a survey of the insects attacking several noxious plants in Israel was carried out by Gerling and Kugler (1974). Among the plants examined was *Prosopis farcta* (Banks et Sol.) MacBride (Mimosaceae). More than 90 insect species were found living on the different parts of this shrub. Larvae of a species of *Caryedon* were the most damaging to the seeds in all distribution areas of *P. farcta* in Israel. No morphological differences between the adults reared from these larvae and adults reared from *Acacia* were found. Dr. Southgate (Pest Infestation Control Laboratory, Slough, England), compared the *Caryedon* specimens from Israel, reared from *Acacia* and *Prosopis farcta,* with specimens of Groundnut Bruchids from West Africa and found important differences. Subsequently he described a new subspecies, *Caryedon serratus palaestinicus,* for the Israeli specimens (Southgate, 1976).

The distribution, developmental history and reproductive biology of *C.s. palaestinicus* living on *P. farcta* in Israel were studied. The host preference and development of this subspecies on *P. farcta* and on groundnuts were also studied.

METHODS

Between 1970 and 1973, biweekly trips were made to different parts of the country where *P. farcta* shrubs grow. The state of the plants was noted. When present, samples of fruits were collected.

In the laboratory the fruits were examined externally for eggs or exit holes of *C. s. palaestinicus* and then opened to check the number of infested seeds and the development stage of the bruchid. The amount of damage was also noted. Samples of a hundred fruits were taken monthly from Gadot (Upper Galilee), Mishmar David (Central Coastal Plain), Bet Guvrin (Foothills of Judea) and Ein et Turaba (Dead Sea area). These were similarly examined to ascertain the life history of *C. s. palaestinicus*. In order to check the seed finding ability of the penetrating first instar larva, copulated females of the bruchid were introduced, together with *P. farcta* fruits, into rectangular plastic rearing boxes, 37 × 20 × 19 cm, with two fine net metal windows 17 × 8 cm on the walls, and a glass lid. After egg laying, the females were removed, and the number of viable (hatched) eggs were counted. The fruits were then opened and the number of entrance holes of the larvae in infested seeds was checked.

In order to investigate any differences between the structure of the prothoracic plate of the first instar larva of *C. s. palaestinicus* and *C. s. serratus*, microscope slides of the plate of larvae of *C. s. palaestinicus* from *P. farcta* and *Acacia radianna* were prepared according to Prevett's method (1971). They were compared with the prothoracic plate of *C. s. serratus* as given by Prevett (1967).

The stock of *C. s. palaestinicus* used in these studies originated from fruits of *P. farcta* and was maintained on *P. farcta* seeds. They were kept in clear plastic rearing containers diameter 5.5 cm, height 7 cm, covered with a plastic lid which had a fine metal net window 1½ cm × 1½ cm. Experiments were carried out in two sets of conditions. At first, the containers were kept in a controlled temperature room of 25°C and about 50% RH, which was 12 hours lit. Later an incubator, controlled at 30°C and 70% RH with a constant light regime was used. Adult beetles of *C. s. serratus* do not feed on solid food and survive without water for three weeks (Davey, 1958). Thus, in the present experiments, neither was provided. One day old pairs of the beetles were placed in separate rearing containers each with 40 seeds of *P. farcta*. The number of eggs laid was counted every 24 hours and seeds with eggs were replaced by non-infested seeds. The death of any adult was recorded. The results are given together with their standard error. The sex of all beetles that emerged from eggs laid by ten females was checked.

Ten pairs of *C. s. palaestinicus* were kept in separate containers with seeds of *P. farcta*. Seeds on which eggs had been laid were removed daily and placed in separate vials. The number of eggs laid was noted. Four weeks later, when oviposition had ceased, the vials were opened and a count was made of the number of eggs which had hatched.

The following experiments were carried out to establish the host preference of *C. s. palaestinicus* in relation to *P. farcta* and groundnuts (*Arachis hypogea* L.) and to study its development in these different hosts. These experiments have economic importance for clarifying the potential of *C. s. palaestinicus* to become a pest of groundnuts in Israel.

(a) Thirty pairs of *C. s. palaestinicus* obtained from *P. farcta* were enclosed (in pairs) with uninfested seeds of *P. farcta* in rearing containers and kept at 30°C and 70% RH. The number of eggs laid each day was noted and seeds with eggs on them were transferred to separate containers and replaced by uninfested seeds. A similar experiment was carried out with thirty other pairs of *C. s. palaestinicus* which were enclosed with seeds of groundnuts of the Virginia variety. The infested seeds of *P. farcta* and groundnuts were kept separately and the duration of development from egg to pupal cocoon was recorded. The duration of development from pupal cocoon to adult was also noted.

(b) Five shelled and five unshelled groundnuts were placed opposite 10 *P.farcta* fruits in a round covered dish with a diameter of 30 cm.

(i) Three pairs of *C. s. palaestinicus* which had developed on *P. farcta* were placed in the dish and allowed to disperse. Every day until death of the females, the number of eggs laid on each substrate was recorded. The experiment was repeated 4 times.

(ii) To see if the development on groundnuts does not alter the host preference, the experiment was repeated using *C. s. palaestinicus* adults which had developed on groundnuts in the preceding generation.

RESULTS AND DISCUSSION

1. Distribution and phenology of *Prosopis farcta*

Our findings are in accordance with the data on the distribution and phenology of *P. farcta* as given by Dafni (1975).

P. farcta is a deciduous spiny shrub, usually ½ to 1 metre high. A population of tree-like plants, up to 4 metres high was also found at Hatzeva in the Arava Valley. The shrub inhabits alluvial and saline soils and river banks. According to Zohary (1972), its general distribution is the West Irano-Turanian Zone, with extensions into the Mediterranean and Saharo-Arabian territories. In Israel it is known from the Coastal Plain, Galilee, Valley of Yezreel, Samaria, the Foothills of Judea, the Jordan Valley, Northern Negev and the Dead Sea area. The phenology of the plant varies in different localities, and even within the same locations there exist differences between clones, e.g. in some places plants are found on one side of the road, with only buds and a few flowers, while on the other side, there are plants with ripening fruit. Flowering starts in May and is usually completed by August, although in some cases it is renewed in September. The fruits are usually round or vaguely oval and range from 10 × 10 mm to 60 × 15 mm. They are green at first, then become reddish-brown and later black and hard. The number of seeds varies from none to 18 per fruit. The pods are indehiscent and crumble only under external influences.

2. Life History of *C. s. palaestinicus*

By examining infested fruit samples, the following picture of the life history of *C. s. palaestinicus* on *P. farcta* in Israel was obtained:

There are at least three generations during the year. The insects pass the winter as dormant larvae or prepupae. Toward spring, pupation begins and adults start emerging already in March. These lay eggs on fruit from the previous year, which usually remain on the plants in large numbers until July or August. The adults developing from eggs laid in March may emerge in June or July, together with some of the over-wintering generation. The second generation lays eggs on the green fruits of the new season that are just ripening, and development of the larvae continues over the next few months, being completed by October or November. The emerging adults lay eggs on ripe fruits, in which the overwintering generation develops.

The eggs, which are semi-ovoid, about 1 × 0.7 mm, are usually laid singly on the fruits of *P. farcta*, but occasionally three or four eggs are found overlapping one another. At first they are whitish, but after a day or two they become yellow-brown. Under laboratory conditions, the time from egg laying to larval hatching is five days at 30°C and 70% RH, and 9 days at 25°C and 50% RH. Emergence of the larva is usually through the flat surface of the egg directly into the fruit. Prevett (1967) has described in detail the morphological adaptations of the larvae of *C. s. serratus* for hatching. He concludes that the sclerotized X-shaped prothoracic plate (Fig. 2) plays an important part in egg-bursting. The first instar larva is white, about 0.8 mm long when it hatches, and has well developed legs.

The first instar larva bores through the fruit and into a seed. Although several eggs may be laid on the exterior of the *P. farcta* pod, not every penetrating larva will indeed find a seed. In our experiment on the seedfinding ability of the larva, it was found that from 440 hatching larvae which entered the fruits, only 165 (37.5%) reached and penetrated the seeds.

Inside the seed, the larva feeds, moults and usually remains until the end of the fourth instar, when it leaves to pupate.

A full description of the four larval instars of *C. serratus* from West Africa is given by Prevett (1967, 1971). In the second and third larval instars, the legs are degenerate, but redevelop in the fourth instar and may help it to leave the seed. Some larvae feed on one or two additional seeds before forming the pupal cocoon. In fruits collected from the field, pupal cocoons were observed within the pod near its surface (in some cases adult beetles were found trapped within the fruit). In the laboratory, some of the mature larvae left the pod to pupate. Possibly in the field these larvae penetrate the ground to pupate, as observed by Donahaye *et al.* (1966) for the *Caryedon* larvae that feed on *Acacia* seeds in the Arava. Searches in the ground around *P. farcta* plants did not yield any pupae. In the summer, pupation may occur one or two days after cocoon construction, while in winter the prepupa will enter a diapause, the length of which depends on temperature and humidity. In the laboratory, at 25°C and 50% RH, a diapause of two to three months was recorded. The adults emerge 19-20 days after pupation.

3. The Structure of the Prothoracic Plate of the First Instar Larva

The prothoracic plate is well developed only in the first instar larva. According to Prevett (1971), who described and figured the prothoracic plate of different species of *Caryedon,* the arrangement of the teeth on each of the two parts of the plate of *C. s. serratus* is 1+1+(4-6). We found that the variation in the teeth arrangements of the first instar larvae of *C. s. palaestincus* reared in Israel from *P. farcta* and *Acacia radianna* was greater than in *C. s. serratus*. In larvae from *P. farcta,* prothoracic plates of 1+1+(1-3)+(0-3) were found and in larvae from *A. radianna*, the arrangement was 1+1+(1-4)+(0-4) (Fig. 2).

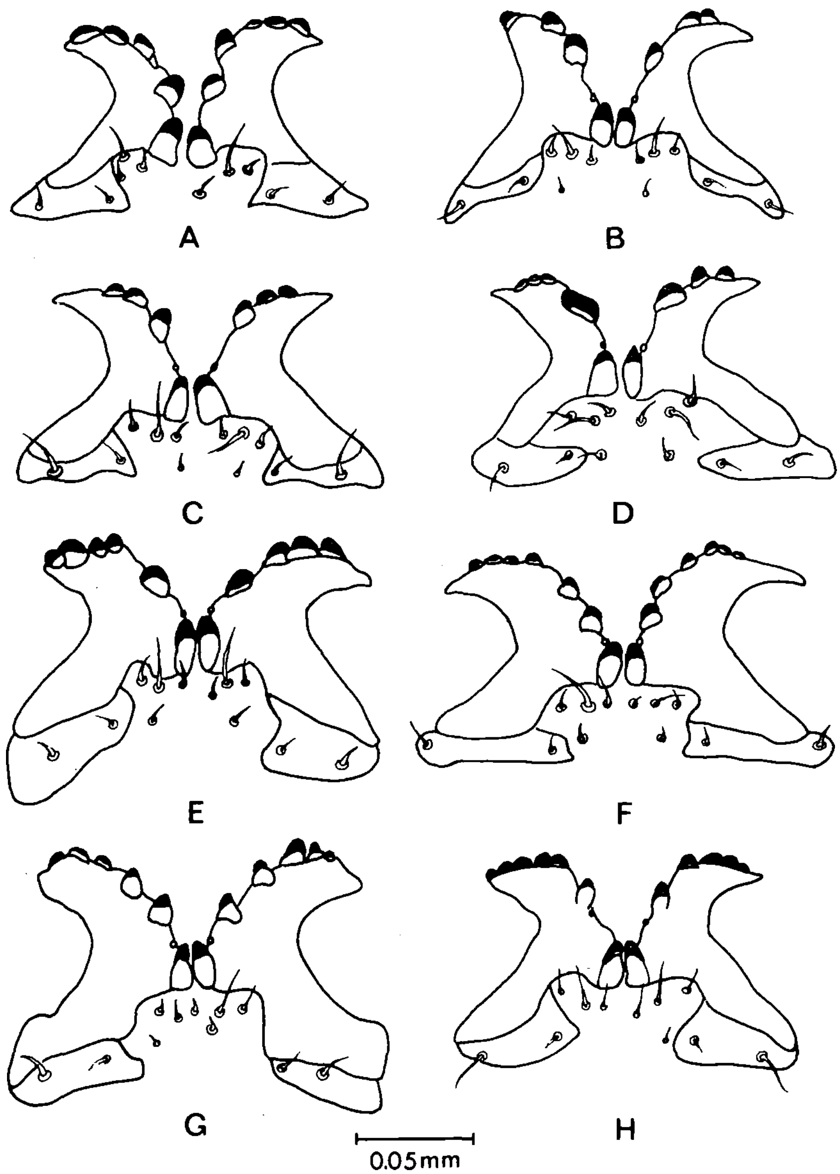

Fig. 2. Prothoracic plate of first instar larvae of *Caryedon*.

A-D *Caryedon serratus palaestinicus* Southgate from *Prosopis farcta*.

E-G *Caryedon serratus palaestinicus* Southgate from *Acacia radianna*.

H *Caryedon serratus serratus* (Olivier) (after Prevett, 1971).

4. Fecundity, Rate of Ovipostion, Longevity and Sex Ratio of *C. s. palaestinicus*

(a) At 25°C and 50% RH:

Of a total of 32 pairs, only 21 females oviposited. They laid an average of 41.9 ± 0.9 eggs (range 10-63) per female. Oviposition commenced almost immediately. The rate of oviposition gradually increased over a period of 6 days and then decreased from the 9th day (Fig. 3a). Ovipositing females lived for an average of 16.1 ± 0.8 days and males for 12.8 ± 0.8 days. An analysis of variance shows that females lived significantly longer than males. Those pairs that apparently did not mate lived for a significantly longer period than those that did (Females 21.8 ± 2.6 days; males 16.1 ± 1.0 days).

(b) At 30°C and 70% RH:

Twenty-five females out of 32 laid eggs. The average number of eggs laid per female was 31.4 ± 1.0 (range 16-63). Most eggs were laid during the first 6 days (Fig. 3b). Females lived for an average of 15.4 ± 1.0 days and males for 10.9 ± 0.8 days. The longevity of females was significantly longer than that of males. Females that did not mate lived 15.3 ± 2.0 days and the males that did not mate lived 14.3 ± 0.2 days.

When reared at 25°C and 50% RH, the females laid significantly more eggs ($P < 0.001$) than at 30°C and 70% RH. There is no significant difference in the longevity of ovipositing females at 25°C and 50% RH, and 30°C and 70% RH. The same female length of life was found by Calderon *et al* (1967) for females from *Acacia spirocarpa* at 26°C and 70% RH (16.0 days). Males at 25°C and 50% RH had a life span similar to that recorded by Calderon for males from *A. spirocarpa* at 26°C and 70% RH (12.8 days). However, males reared at 30°C and 70% RH had a shorter life span.

Cancela da Fonseca (1965), studying *C. s. serratus*, found a general tendency of females to live longer than males, though with no significant difference between them. He found that length of life increased with decreasing temperature, increasing relative humidity, absence of nuts and absence of mating.

We found a sex ratio of 132 females to 124 males i.e. close to 1:1.

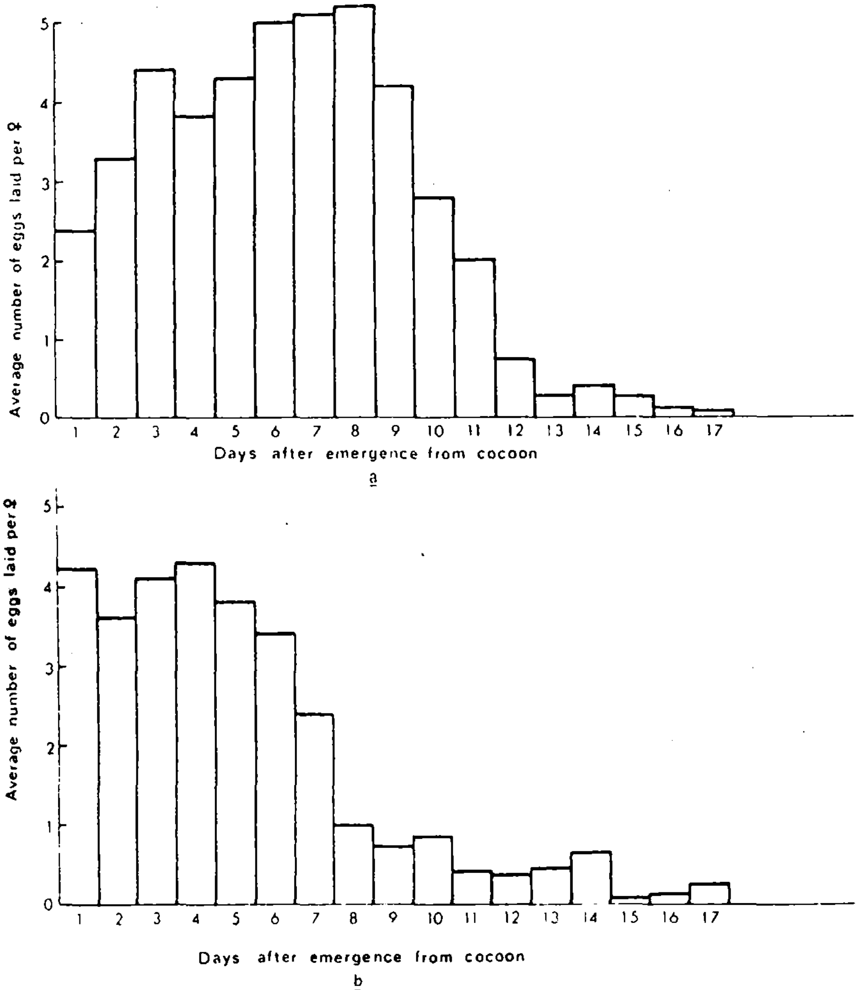

Fig. 3. Rate of oviposition of *C.s. palaestinicus*

a) 25°C, 50% RH b) 30°C, 70% RH.

5. Egg viability

Our observations showed that the nonviable eggs were distinguished either by a mass of tiny bubbles within the yolk, or by a round blank area which excludes a third or more of the egg yolk.

It was found that only 77% of the 300 eggs laid hatched. Part of the brood laid by the same female hatched, and part did not (range 50-100% viability per female). Nonviable eggs were often found on samples of fruit of *P. farcta* from the field as well.

Both Prevett (1953) and Cancela da Fonseca (1965) recorded that unmated females of *C. s. serratus* are capable of laying a few nonviable eggs. Amaro *et al.* (1958) found that at 30°C and 55-75% RH, only 22-35% of the eggs of *C. s. serratus* were viable.

6. Host Preference and Development of *C. s. palaestinicus* on *P. farcta* and on *Arachis hypogea* L. (groundnuts)

(a) Oviposition and development of *C. s. palaestinicus* on *P. farcta* and on groundnuts.

TABLE 1. Number of eggs laid by *C.s. palaestinicus* on *P. farcta* and *A. hypogea*.

Oviposition substrate	No. of ovipositing females	No. of eggs per female Mean ± S.E.
P. farcta	25	31.4 ± 0.81
A. hypogea	17	16.5 ± 0.79

From Table 1, it is seen that when provided only groundnuts, *C. s. palaestinicus* lays eggs on them, but significantly fewer ($P < 0.0035$) than on *P. farcta*. Two hundred and eighty-one eggs were laid in the containers with groundnuts. Of these, only 152 were deposited on 43 seeds of groundnuts and the rest were deposited on the container walls. In comparison, when given *P. farcta* seeds, almost all the eggs were deposited on the seeds. Thus, in the given conditions groundnuts are less attractive as an oviposition site than *P. farcta*. This is indicated both by the lower number of eggs laid on the groundnuts and by the fact that many eggs were laid on the walls of the container. Since fewer females laid eggs on groundnuts than of *P. farcta*, there may be a certain repulsion towards groundnuts.

Calderon *et al.* (1967) also recorded a low average number of eggs (13.7) laid on groundnuts by *C. s. palaestinicus* from *Acacia* at 26°C and 70% RH. In comparison, Cancela da Fonseca (1965) obtained an average of 114.5 eggs per female of *C. s. serratus* on groundnuts (from West Africa) at 30°C and 70% RH, and Prevett (1953) recorded a mean of 32.42 (range 6-99) eggs by *C. s. serratus* on groundnuts at 26°C and 70% RH.

The beetles developed much more successfully on *P. farcta* seeds than on groundnuts. From the 43 groundnuts, 32 adults developed, i.e. 16% of the eggs deposited. From 100 seeds of *P. farcta* (each with 1 egg on it), 75 adults developed. Development was much slower on groundnuts than on *P. farcta* (Table 2).

TABLE 2. Length of development (days) of *C.s. palaestinicus* on *P. farcta* and *A. hypogea*.

Substrate	Egg to Pupal Cocoon		Pupal Cocoon to Adult		Average from egg to adult
	No. of eggs	Mean ± S.E.	No. of cocoons	Mean ± S.E.	
P. farcta	80	18.95±0.67	75	20.02±0.25	39
A. hypogea	41	41.95±1.61	25	20.5 ±1.09	62

(b) Oviposition preference tests:

We found no difference in host preference whether the beetles were bred one generation previously on *P. farcta* or on groundnuts. In all cases (Table 3) eggs were laid only on *P. farcta*.

TABLE 3. The number of eggs laid by *Caryedon s. palaestinicus* (reared from *P. farcta* and *A. hypogea*) on *P. farcta* and *A. hypogea* when offered together.

	C.s. palaestinicus ex *P. farcta*		*C.s. palaestinicus* ex *A. hypogea*	
Fruit offered for oviposition	*P. farcta*	*A. hypogea*	*P. farcta*	*A. hypogea*
Replicate No.	No. of eggs laid in each replicate			
1	31	0	44	0
2	63	0	25	0
3	57	0	34	0
4	22	0	36	0
Total eggs laid	171	0	159	0

A different behavior by *C. s. serratus* from West Africa was observed by Dr. Southgate (personal communication). Adults of *C. s. serratus*, given the choice of laying eggs on *P. farcta* or on groundnuts (Israeli variety Virginia), oviposited on both, and far more individuals developed to adulthood on groundnuts than on *P. farcta*.

Specimens of *C. s. palaestinicus* from *P. farcta* were sent to Dr. Southgate in England. Crosses were made there with *C. s. serratus* from West Africa. Out of 15 crosses, only 6 produced an F_1 generation, and from these only an average of 4 adults emerged. From these emerging adults an attempt was made to set up a culture, but no second generation was obtained. The experiment was repeated, and again a second generation failed to emerge.

Dr. Southgate concludes that the two subspecies "... are so closely allied that despite the slight differences in genitalia, there is sufficient compatibility for a fertile hybrid generation to exist for a short while. This hybrid, however, is, as proved above, unstable and eventually breaks down". (Personal communication).

The fact that, when given the choice, *C. s. palaestinicus* oviposits only on *P. farcta,* indicates that although *C. s. palaestinicus* can develop on groundnuts, it will not become a pest of groundnuts in Israel in places where *P. farcta* grows.

ACKNOWLEDGEMENTS

The authors would like to thank: the members of the Entomology Section of the Department of Zoology of Tel Aviv University for their help in collecting the material; Professor D. Gerling for his comments; Dr. P.L. Prevett, Plant Infestation Control Laboratory, Slough, England, for his comments on the larval prothoracic plate; and especially Dr. B.J. Southgate for the identification of the material and the information on preference and cross-breeding tests.

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