ENTOMOPHAGA 29 (1), 1984, 87-93

THE BIOLOGY OF *HYPERASPIS JUCUNDA* [*COL. : COCCINELLIDAE*] AN EXOTIC PREDATOR OF THE CASSAVA MEALYBUG *PHENACOCCUS MANIHOTI* [*HOM. : PSEUDOCOCCIDAE*] IN SOUTHERN NIGERIA.

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The biology of *Hyperaspis jucunda* (Muls.) was studied at 27 °C and the incubation period averaged 5.1 days. The 1st, 2nd, 3rd and 4th larval instar averaged 2.5 ; 2.8 ; 3.4 and 5.0 days respectively. Larval development was completed in about 13.8 days while it took 7.1 days for the pupae. The total developmental time averaged 26.4 days. Mean longevity was 100 and 101 days for males and females respectively. The premating period was 19-24 h while the preoviposition period averaged 6.3 days. The generation cycle (egg to egg) averaged 32.8 days. The oviposition period was about 93 days during which an average female laid 456 eggs.

The cassava mealybug (CMB) *Phenacoccus manihoti* Mat.-Ferr., was accidentaly introduced from Latin America into Africa (Herren, 1981). In Nigeria, several attempts are being made to control it through the importation of natural enemies from Latin America by the International Institute of Tropical Agriculture through the CMB Biocontrol Project of the Root and Tuber Improvement Programme. To this end various studies are being carried out on the bionomics, ecology and feeding behaviour of these natural enemies. In this paper we report on the life cycle and some other aspects of the biology of *H. jucunda*, an imported predator of the CMB in Nigeria. In Latin America, it is a natural enemy of *Phenacoccus herreni* (Cox & Williams, 1981), a related species to the CMB.

MATERIALS AND METHODS

REARING UNITS

A mealybug-infested cassava leaf was placed on filter paper in a Petri-dish 9.5 x 9.5 x 1.5 cm. A 6 cm and 1.5 cm holes 1.2 cm apart were made on the top section of the Petri dish. The larger of the holes was covered with fine mesh for aeration. Through the smaller one glass vial containing tap water and plugged with cotton wool was placed downwards on the paper. Water continuously moistened the filter paper and kept fresh the infested cassava leaf, which was replaced

every other day. All experiments were conducted in a growth chamber Conviron E 15 at 27 °C and 75° % RH and at 12 L: 12 D at the International Institute of Tropical Agriculture.

LIFE CYCLE

Twenty five eggs of *H. jucunda* of about 12-h old were individually placed in rearing units. Each egg was surrounded with CMB ovisacs. Observation was made on moulting and the developmental period of each stage.

MATING AND OVIPOSITION BEHAVIOUR

Fifteen pairs of adult beetles were provided with mealybugs in separate rearing units and their selection of oviposition site was recorded for a 48-h period. To determine the premating and preoviposition periods, freshly emerged virgin ♀♀ were paired with ♂♂ for 6, 12, 18, 24, 48 and 72 h while possibility of parthenogenesis was studied using 5 virgin ♀♀ confined singly with mealybugs for 10 days.

FECUNDITY AND LONGEVITY

Adults resulting from the life cycle study were set up in pairs for fecundity and longevity studies and followed until the death. They were provided with sufficient CMB ovisacs and the eggs laid were recorded and removed daily.

RESULTS AND DISCUSSION

LIFE CYCLE

The total life cycle (egg to adult) of *H. jucunda* was 26.4 days. The incubation period was 5.1 days and there were 4 larval instars lasting on average 2.5 ; 2.8 ; 3.4 and 5.0 days respectively. Larval developmental period was 13.8 days. The pupal stage lasted 7.1 days.

THE EGG

Egg measurements are given in table 1. The egg appears milky white and glossy. It is oblong, the largest width is about 2/5 of the long axis. As embryonic development continued, the egg

TABLE 1

Measurements (mm) of the immature stages (a) *of* H. jucunda *at 27 °C*

Stage	No. of observations	Length		Width	
		Range	X ± SD	Range	X ± SD
Egg	22	0.54 - 0.60	0.56 ± 0.07	0.26 - 0.32	0.30 ± 0.02
1st instar	12	0.88 - 1.18	1.03 ± 0.08	0.36 - 0.48	0.42 ± 0.04
2nd instar	12	1.66 - 2.98	2.74 ± 0.49	1.10 - 1.84	1.53 ± 0.24
3nd instar	12	3.60 - 3.96	3.77 ± 0.14	1.72 - 2.38	2.06 ± 0.19
4th instar	10	4.04 - 4.48	4.35 ± 0.14	1.96 - 2.78	2.40 ± 0.24
Pupa	10	4.56 - 5.12	4.83 ± 0.23	2.70 3.54	3.00 ± 0.27

(a) All stages measured 24-h old.

becomes somewhat creamy-yellow and oftentimes appears slightly depressed at one side. **Coles** (1964) reported similar phenomenon in the eggs of *Hyperaspis trilineata* (Muls). Within few hours before and after eclosion the chorion appeared whitish and a very thin superficial white ring can be observed along the edge, giving the egg the appearance of young whitefly larva. The incubation period ranged from 4 to 7 days (table 2). A 24 % mortality was observed during this stage (table 2).

TABLE 2

Developmental period, mortality and longevity of the life stages of H. jucunda *with range in parenthesis*

	Cumulative mortality		Developmental period (days)		Longevity (days)	
Stage	n	%	n	$\bar{X} \pm SE$	n	$\bar{X}$
Egg	25	24	19	5.11 ± 0.99 (4-7)		–
1st instar	19	32	17	2.53 ± 0.51 (2-3)		–
2nd instar	17	36	16	2.81 ± 0.40 (2-3)		–
3rd instar	16	36	16	3.38 ± 0.50 (3-4)		–
4th instar	16	40	15	5.07 ± 0.88 (4-6)		–
Pupa	15	40	15	7.13 ± 1.46 (6-9)		–
Egg-adult			15	26.4 ± 1.18 (22-28)		–
Adult	–	–				
	–	Male			4	100 ± 3.92 (95-104)
	–	Female			4	101.15 ± 6.85 (96-111)

THE LARVAL STAGE

Based on the number of exuviae deposited, 4 larval instars were distinguished.

The 1st instar larva - It hatches through an almost complete opening with a flap which hingers on the long axis of the egg. Eggs of *H. trilineata* have also been observed to hatch in this way (**Coles**, 1964). Newly-hatched 1st instar larva appears creamy-white, but as time elapses, the body tends more and more to creamy yellow. White and fragile setae are present on all body parts, but the density of the setae is higher on the dorsal and pleural regions. Only a few are found on the sternal side. **Simanton** (1916) and **Paterson** (1957) reported such distribution of setae in other *Hyperaspis* larvae. Some of the lateral hairs are believed to be specialized and defensive, either in a merely mechanical way or possibly contain a poison (**Böving**, 1917). The head is hypognatous. The antenna and labial palps are not well visible. The maxillae and mandibles, though relatively small, are conspicuous. There are 2 brown spots, one on each side of the thoracic segments. In this instar, the legs project beyond the body while on all others, they are hidden within the white wooly coating. The body is quite narrow and tapers posteriorily. The

1st instar larvae of *Hyperaspis binotata* (Mulsant) and *Hyperaspis lateralis* (Mulsant) larvae are similar in appearance (**Simanton**, 1916 ; **McKenzie**, 1932). The body measurements of 1st instar larva are shown in table 1. The development of the 1st instar lasted from 2 to 3 days (table 2) and a 10.5 % mortality occurred during this stage (table 2).

Moulting - In the 1st, 2nd and 3rd instar, the larva fastens itself by the caudal end to a surface by means of a sticky secretion released from the anus. The skin splits open along both the cervical and ecdysial lines. The attachment of the old skin to the substratum enables the new larva to get rid of the exuviae easily.

Second, 3rd and 4th instars - The newly-hatched larva appears creamy white but becomes more and more yellowish as time elapses. The setae are arranged as in the first instar larvae. As the old exuviae is being dropped off, a thin and granular-like white waxy covering appears on the dorsum and pleurum so that by the end of the 1st day of life, these parts of the body are entirely covered by relatively long threads of this materials which extend beyond the body sides thus covering the legs. The rate at which the white waxy coat is deposited seems to depend mainly upon the age of the larva, food availability and rate of consumption and the temperature (**Nsiama & Odebiyi**, unpubl.). The white waxy coat which is present only in the last 3 instars ♂ them resemble giant mealybugs. The covering is said to play a protective role in related species of *Hyperaspis* (**Simanton**, 1916 ; **Boving**, 1917 ; **McKenzie**, 1932, **Coles**, 1964). All instar larvae emitted whitish or yellowish drops when slightly pressed. Such drops are said to be emitted by large repugnatorial glands placed dorsally in the intersegmental skin on each side of the 1st 8 abdominal segments (**Boving**, 1917). The antennae and the labial palps become more conspicuous as the larvae become older. In the 4th instar larvae, 3 antennal segments are evident and mandibles and maxillae are very well developed. Tables 1 and 2 give respectively the size and the duration of each of the 3 last instars. A 5.9 and 6.3 % mortality occurred respectively in the 2nd and 4th instars while there was no mortality in the 3rd instar (table 2). The total larval period ranged from 12 to 16 days.

The pupal stage - One to 2 days before entering the pupal stage the 4th instar larva becomes less active, less mobile and less sensitive to disturbance. Before moulting to pupa the larva fastens itself to the substratum and either shrivels up in a protective way or simply lays flat on the substratum. When the white waxy coat was removed from the pupae, the dorsum and pleurum appeared greyish yellow with brownish, spiny, hard hairs. The body measurements of one-day old pupae are given in table 1. The pupal period was completed in 5 to 10 days (table 2). No mortality was recorded in this stage (table 2).

The total life cycle (egg-adult emergence) ranged from 22 to 28 days (table 2) with a total mortality of 40 % (table 2).

ADULT STAGE

The emergence - Before emergence, the old case of the pupae split open along the long axis on the sternum and the cervical line. The emerging adult remained under the pupal case for sometime before moving around apparently to allow the wings to harden.

Mating - Only ♀♀ paired with ♂♂ for 24-h period or more oviposited. Thus premating period in newly emerged adults is presumed to be at least 19 h (table 4) but in *H. lateralis*, **McKenzie** (1932) found pairing occurring immediately after emergence.

The preoviposition period and oviposition sites - The preoviposition period ranged from 5 to 8 days (table 3). There appeared to be 3 possible sites of oviposition in relation to the prey : inside the ovisacs, at the edge of the ovisacs and away from the ovisacs (table 4). The number of eggs laid inside the ovisacs was 4 and 15 times greater than in the other 2 places (table 4).

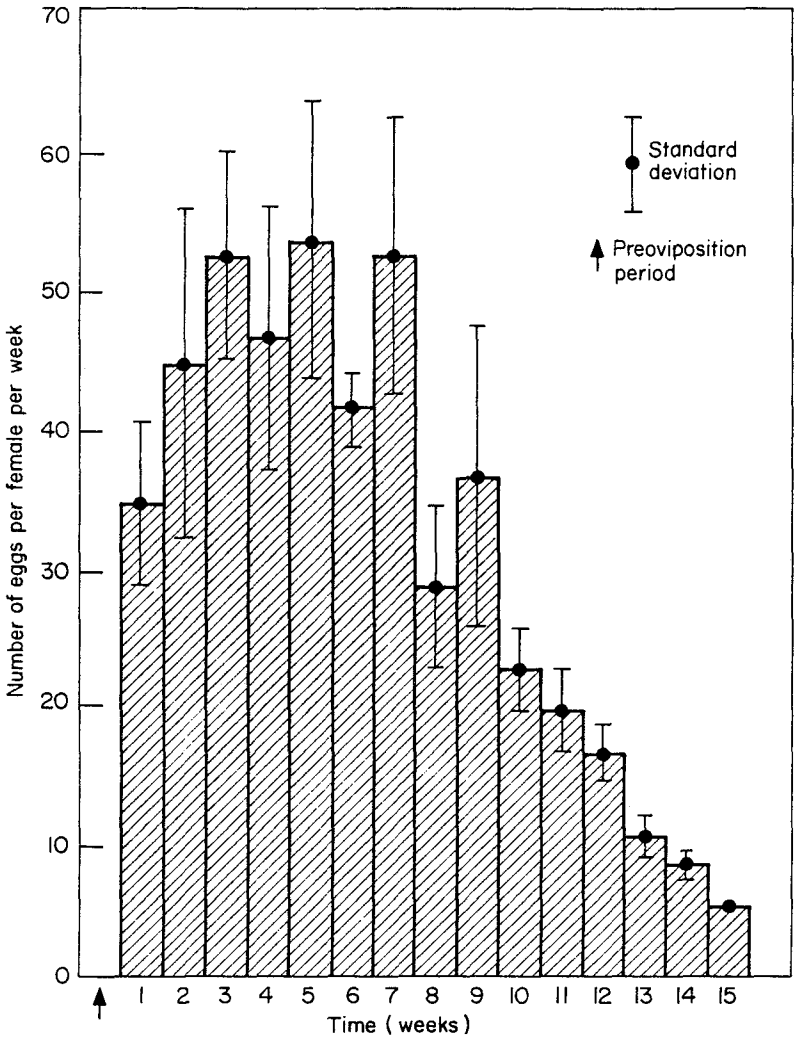

Fig. 1. Weekly oviposition pattern of *H. jucunda.*

In the fecundity studies, eggs were mostly found not only inside the ovisacs, but also under dead or living cassava mealybugs. The deposition of eggs by this predator in the immediate vicinity of the prey is an important factor for the survival of the newly hatched larvae which feed more voraciously on eggs than on other mealybug stages. Unmated ♀♀ did not oviposit.

Fecundity and longevity - The number of ♀♀ involved in these studies was relatively small because of accidental loss during the experiments. There was also considerable variation in the egg laying pattern apparently due to the variation in the longevity of individual ♀♀. The total number of eggs per ♀ varied from 331 to 556 (table 3). Figure 1 shows the weekly oviposition

TABLE 3

Fecundity and time-related oviposition parameters of H. jucunda *at 27 °C*

Fecundity parameters	Range	$\bar{X} \pm$ SD
Premating period (hours)	19 - 24	–
Preoviposition period (days)	5 - 8	6.33 ± 1.22
Generation cycle (days) (egg to egg period)	31 - 34	32.75 ± 1.25
No. of eggs/female/day	1 - 18	5 ± 1
No. of eggs/female/week	5 - 65	33.2 ± 19.9
Total no. of eggs/female/ during the oviposition period	331 - 556	456 ± 106
Oviposition period (days)	87 - 102	93 ± 7
Interoviposition period (a)	1 - 2	1 ± 1

(a) Days during the oviposition period when eggs are not laid.

trend. Fifty percent of the total eggs were deposited in about 6 weeks. The daily oviposition rate varied from 1 to 18 eggs (table 3) which were laid in batches of 1 to 7. The oviposition period varied from 87 to 102 days (avg. 93 days) and was occasionally interrupted by 1 to 2 days without egg laying (table 3). The average longevity of ♂ and ♀ was from 95 to 104 (avg. 100) and from 96 to 111 days (avg. 101.1 days). This long life span as well as the long oviposition period may constitute desirable characteristics in the predator-prey interaction. The ♂ and ♀ sex-ratio was 1.5:1.

TABLE 4

Sites of oviposition of H. jucunda *in relation to the mealybug ovisacs at 27 °C*

Oviposition sites	Number of eggs laid/site/day (a) Range	$\bar{X} \pm$ SD	Means in % of total eggs laid
IOM	38 - 49	43.5 ± 7.7	74
EOM	12 - 13	12.5 ± 0.70	21
AOM	3 - 3	3.0 ± 0.00	5
Total eggs laid over 2 days	–	118	100

(a) = by 15 ♀♀

IOM = inside the ovisacs of the mealybug ; EOM = at the edge of the ovisacs of the mealybug ; AOM = away from the ovisacs of the mealybug.

ACKNOWLEDGMENTS

The authors wish to thank the Commonwealth Institute of Entomology for identifying *Hyperaspis jucunda*. The work was carried out at the International Institute of Tropical Agriculture.

RÉSUMÉ

La biologie de *Hyperaspis jucunda* [*Col. Coccinellidae*]
un prédateur exotique de la cochenille blanche du manioc *Phenacoccus manihotti*
[*Hom. : Pseudococcidae*] dans le sud Nigeria

La biologie de *Hyperaspis jucunda* (Muls.) a été étudiée à 27 °C. La période moyenne d'incubation fut de 5,1 j. Les 1er, 2e, 3e et 4e stades larvaires ont duré en moyenne 2,5 ; 2,8 ; 3,4 et 5,0 j, respectivement. L'état larvaire a demandé 13,8 j et l'état nymphal 7,7 j. La moyenne du temps total de développement fut de 26,4 j. La longévité a été de 100 et 101 j en moyenne pour les adultes mâles et femelles respectivement. Une période de 19-24 h précède l'accouplement chez les femelles fraîchement écloses. La période de préoviposition a duré 6,3 j. Le cycle d'une génération (période de l'œuf à l'œuf) fut de 32,8 j en moyenne et la période moyenne d'oviposition de 93 j durant laquelle une femelle pond 456 œufs.

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