ENTOMOPHAGA 32 (3), 1987, 281-289

THE BIOLOGY AND BEHAVIOUR OF *IPHIAULAX VARIPALPIS* [*HYMENOPTERA : BRACONIDAE*] AS A PARASITE OF *DIRPHYA NIGRICORNIS* [*COLEOPTERA : CERAMBYCIDAE*]

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The ability of the braconid parasite, *Iphiaulax varipalpis* Cary to control the beetle *Dyrphya nigricornis* Olivier was evaluated. Field collected samples and specimens reared in polyethylene paper tubes under laboratory conditions (23.0°C ± 1.0 at 70 % r.h) were used. Field parasitism was low (10.72 %) while laboratory parasitism was high (57.66 %). The parasite detected the hosts very easily in the laboratory. This ability is minimised in thick canopies of *Coffea arabica* L. Host colonization was brisk (90 seconds) and confined to a near absolute area of discovery, measuring 4.18 ± 0.41 cm. The parasite reproduces gregariously with female lifespan being approximately double the male period. The parasites are very active at the age of 10 days. As they age their potential fecundity (232 oocytes) reduces drastically with oviposition.

KEY-WORDS : *Iphiaulax varipalpis*, ovipositor, probe, parasitism, durations.

The feasibility of controlling the yellow headed borer - *Dirphya nigricornis* Olivier - by the braconid parasite *Iphiaulax varipalpis* Cary has not been amply demonstrated in Kenya. Wood borers have not been solely controlled by braconids for a long time. For example, the braconid *Iphiaulax eurygaster* Brulle is not a reliable method for beetle control in America and Canada (**Grimble**, 1969 ; **Grimble** *et al.*, 1970 ; **Grimble & Knight**, 1969). No explanation has been provided for this failure. A good understanding of the biology and behaviour of *I. varipalpis* would help to ultimately understand its role and potentiality as a native control agent for the pest. Such an evaluation should necessarily precede attempts to introduce natural enemies of any pest which is a target of classical biological control (**Huffaker & Messenger**, 1976). It also helps to understand host discrimination if any (**Van Lenteren** *et al.*, 1978).

The prospects of relying upon *I. varipalpis* in Kenya as a biological control measure against *D. nigricornis* larvae, has not been elucidated. If this locally occurring parasite were able to control the borer on its own steps would be formulated to augment and enhance its action in coffee. This paper considers in some details some aspects of the biology of *I. varipalpis* as a parasite of *D. nigricornis*. The target pest has long development periods in the field (**Crowe**, 1962). Infestations start when female beetles deposit light brown elongate-oval shaped eggs singly under a flap of bark 10 cm from the tip of the coffee shoot. It was originally thought that larvae and pupae durations were 10 and 2 months, respectively (**Crowe**, 1962).

Recent studies have recorded longer periods of upto 18 months as a result of 2 brood generations from beetle eggs laid during the same infestation (**Wanjala**, 1985). In Kenya, *D. nigricornis* attacks *Coffea arabica* L, a single wild plant, *Vangueria rotundata* Robyns (**Crowe**, 1962) and probably other wild rubiaceae (**Crowe**, 1962). The parasite *I. varipalpis* is uniformly active on the host throughout the long developmental period of the *D. nigricornis* larvae in the field.

MATERIALS AND METHODS

D. nigricornis infested branches were collected from 6 sites : Jacaranda, Rukera, Muri, Kiaora, Azania and Matungulu. At each site, 1-2 hectares of mature coffee aged about 20 years old and above were selected for sampling. The samples were collected from individual rows and all infestations found in the 5th plant of each row taken. They were collected at monthly intervals. Sampling was maintained throughout the period, April 1982 to April 1985.

Branches were severed 20-30 cm below the basally visible frass bore-hole and transferred to the laboratory. In the laboratory the entire bored length of the shoot was examined under a microscope for evidence of any cocoons made by *I. varipalpis* after it had been stripped of leaves. Whenever cocoons were found, shoots were placed in rearing tubes measuring 30-60 cm long and 2.50 cm diameter made from polyethylene paper. The ends of the tubes were sealed loosely by cotton wool to facilitate aeration. The rearing laboratory conditions were 23.0°C ± 1.0 at 70 % r.h. The tubes were examined daily for the emergence. *I. varipalpis* females were killed and dissected under a microscope (x 10) and the number of oocytes in their ovaries established. The purpose of this was to determine the potential fecundity of the braconid. Additionnaly, the length (mm) of their ovipositor was measured and recorded. These data would be used to establish whether the length of the ovipositior played any role in the accessibility of *D. nigricornis* to the parasite.

Experiments were also designed to study how the *I. varipalpis* parasitized *D. nigricornis*. To investigate this aspect, newly emerged adult parasites were introduced into perspex cages (30 x 25 x 25 cm) in single pairs (sex ratio 1 : 1). They were fed on diluted honey on cotton wool. Live and active larvae of the pest within their tunnels were presented to adults of *I. varipalpis*. The parasites were then observed closely to record ovipositor probing into frass boreholes made by the borers presented. The frequency and interval of ovipositor insertions were timed and recorded. The period of observation lasted the entire lifespan of the pair of parasites from day 1 to day 28.

The duration of the pre-oviposition, oviposition and post-oviposition periods (days) were monitored from the same specimens throughout. Durations of the development from the start of the parasitization through to emergence of adults was established.

RESULTS

Data obtained from field samples are shown in table 1. The Jacaranda, Kiaora and Azania samples yielded no braconids during this study. Field parasitization was dismally low in nature. It ranged from 5.56 % to 14.29 % for samples obtained from 3 sites : Muri, Rukera and Matungulu. This meant that on average the level of parasitism was 10.72 % ± 1.47 only. Throughout the sites the parasites were found early in the season of host attack, which coincided with onset of rainy seasons. As the pest larvae developed parasitism was scanty on its later instars.

About 3.43 ± 0.69 parasitoids emerged per *D. nigricornis* larva during 15.43 ± 4.57 days after sampling. It was therefore concluded from the data obtained that *I. varipalpis* was either gregarious or it superparasitized its host. Upto 6 individuals of the braconid pupated in a white cocoon of approximately 4.18 ± 0.41 cm long. The cocoons consisted of chambers with each of them being occupied by an individual pupa.

TABLE I

Emergence times and number of I. varipalpis *attacking larvae of* D. nigricornis *at Muri, Rukera and Matungulu Coffee Estates*

Site	Duration (days) of emergence after host collection	Adult parasitoid emerging per branch	Larval parasitism (%)
Muri (n = 13)	14	6	7.69
(n = 18)	7	3	5.56
(n = 7)	7	2	14.29
Rukera			
(n = 10)	14	6	10.0
(n = 7)	42	3	14.29
Matungulu			
(n = 8)	12	2	12.50
(n = 2)	12	2	12.50
Range	7-42	2-6	5.56-14.29
Means	15.43	3.43	10.72
± s.e.	4.57	0.69	1.47

Bracketed values represent the number of individual larvae in the samples.

The number of oocytes in each female of *I. varipalpis* was high (fig. 1). The braconid had a high potential fecundity of approximately 323 oocytes. The ovipositor measured about 5.07 ± s.e. mm long. It was concluded from these observations that the braconid had an ovipositor which ensures accessibility of *D. nigricornis* larvae boring within tunnels.

Data obtained on the duration of various developmental stages are shown in table 2. Eggs laid by *I. varipalpis* invariably hatched into larvae after 7.0 ± 0.25 days. The larval stage lasted 6.60 ± 0.24 days. Pupation took another 12.0 ± 1.0 days. It was evident that although this braconid was capable of initiating several generations on a single generation of the larval stage of the beetle, the pest stage that is susceptible to attack by *I. varipalpis*, this did not occur in the field.

The estimated periods for pre-oviposition, oviposition, post-oviposition and lifespan (days) for *I. varipalpis* are shown in table 3. Females of *I. varipalpis* attained oviposition (Pre-oviposition period) after 11.0 days following emergence). Thereafter they had potential to parasitize *D. nigricornis* larvae for 15.0 days (oviposition period). Following this they survived for 3.0 more days (post-oviposition period). The overall lifespan was 28.01 ± 1.0 days for ♀ and 14.0 ± 2.0 days for ♂.

Under laboratory conditions, the percentage parasitism of *D. nigricornis* by ♀ of the braconid was impressively high (table 4). *I. varipalpis* accounted for the death of 57.66 ± 5.16 % of *D. nigricornis* presented, leaving as survivors only 42.34 ± 5.16 %.

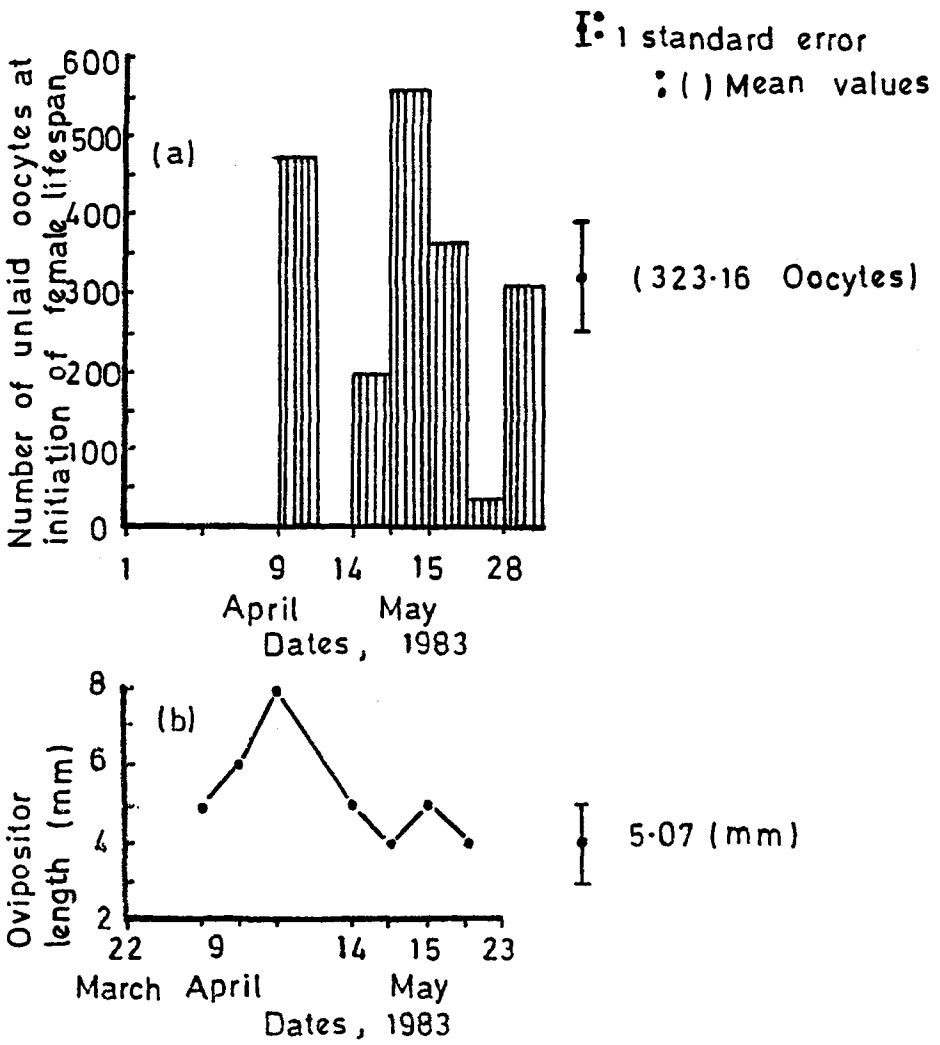
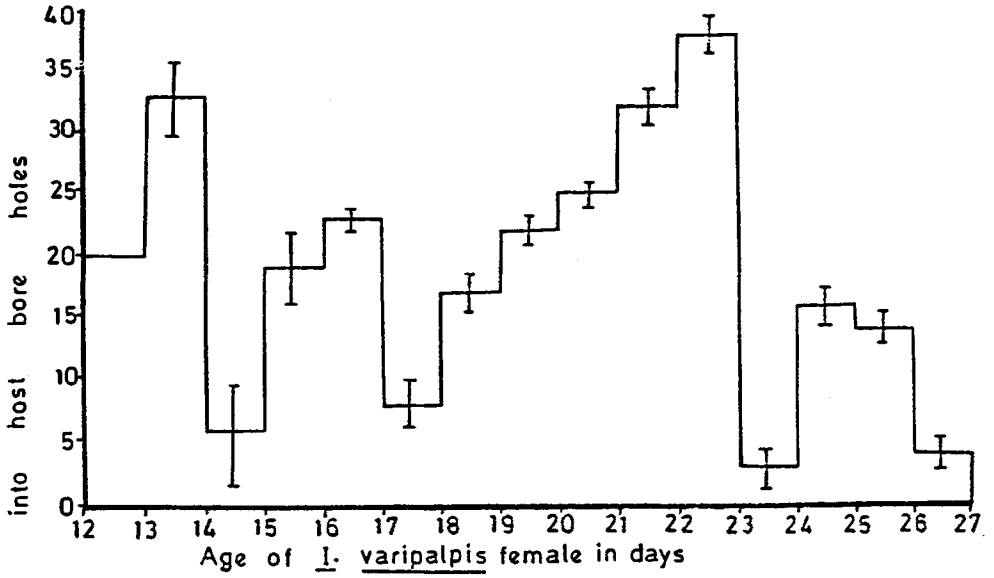


Fig. 1. Fecundity of *Iphiaulax varipalpis* estimated from oocyte number and ovipositor length.

TABLE 2

Development periods from egg to adults of I. varipalpis

Stage	Duration (days) ± s.e.
Egg	7.0 ± 0.25
Larva	6.60 ± 0.24
Pupa	12.0 ± 1.0
Adult	18.0 ± 0.50



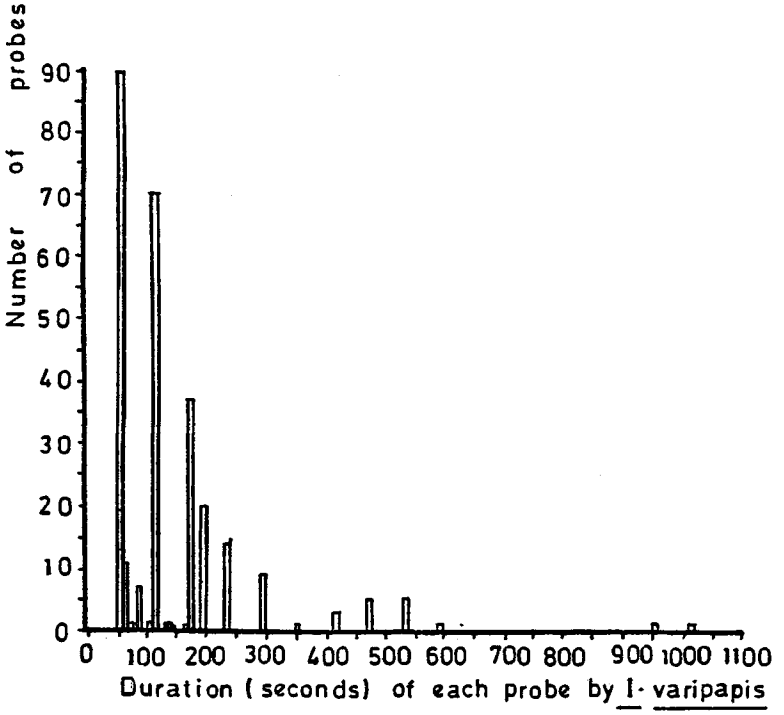


Fig. 2a. Effects of age of *Iphiaulax varipalpis* on its parasitization, n = 10.

Fig. 2b. Duration of *I. varipalpis* during parasitization of *D. nigricornis* larvae, n = 10.

TABLE 3

Duration (days) of I. varipalpis *survival in the cages*

Period	Duration ± s.e.
Pre-oviposition	0.0-11.0 ± 0.56
Oviposition	16.0-24.0 ± 4.0
Post oviposition	25.0-28.0 ± 1.50
Lifespan (♀)	28.0 ± 1.0
Lifespan (♂)	14.0 ± 2.0

The disparity between field and laboratory levels of parasitism was mainly explained by the behaviour of the braconid.

TABLE 4

Colonization potential by I. varipalpis *adult female on* D. nigricornis *larvae in several coffee portions under laboratory conditions*

Parasitization period (days)	Live larvae presented	Number of larvae attacked	Real percent mortality	Survival per experiment
5	14	6	42.86	57.14
8	18	12	66.67	33.33
8	13	8	61.53	38.47
6	14	8	59.59	40.41
Range 5-8	13-18	6-12	42.86-66.67	33.33-57.44
Mean 6.75	14.75	8.50	57.66	43.34
± l.s.e. 0.75	1.11	1.26	5.16	5.16

The parasitization of *D. nigricornis* larvae was found to be achieved following a series of ovipositor probes into bores of the pest, that continued over the adult oviposition period as shown in fig. 2a. The process lasted on average 90.0 s each time. It could extend upto 1020 s (fig. 2b). *I. varipalpis* thus does parasitize larvae of *D. nigricornis* rather briskly each time. Perhaps short probing periods do not result in oviposition. Prior to the 10th day of oviposition when the parasites attained the highest rate of probing, the process is punctuated by 3 phases of oviposition activity spread over 2-6 days.

When adults of *I. varipalpis* were about 12 days old, they spent accumulatedly about 200 mn probing (fig. 3). This rose to 380 mn, daily when they attained the age of 14 days. At advanced ages when little or no parasitization occurred, the period taken was approximately 30 mn per day. The reduction in the parasitic activity probably represented the exhaustion of eggs from the ovaries as braconids aged. It was apparent that when the braconids were 21 days old, the period of parasitization upsurged to about 600 mn daily and ceased 2-5 days thereafter, meaning that by that age the ability to continue as a parasite was limited both physically and reproductively. It was also possible that the longer periods may be associated with successful oviposition, the cycles representing time required to develop eggs.

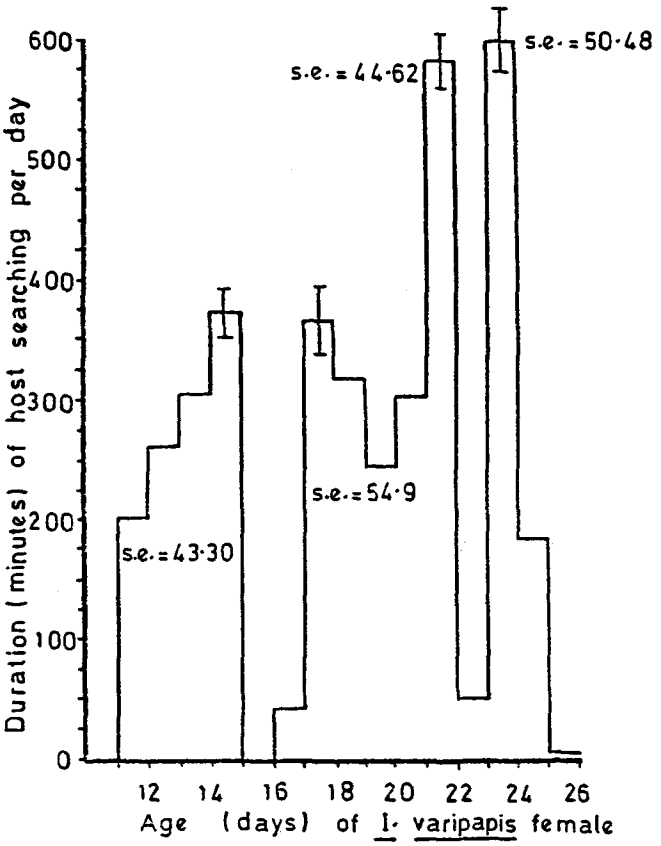


Fig. 3. The duration of host searching by *I. varipalpis* in relation to age of the parasite.

DISCUSSION

There was no evidence to suggest that the *D. nigricornis* population experienced the same level of parasitization under laboratory conditions and in coffee fields from *I. varipalpis*. This is to say that a slow reduction in the population of the pest does occur in the field well below the levels attainable when conditions are ideal as in the laboratory. Success in laboratory breeding (**Van Lenteren** *et al.*, 1978), variable abundance in all localities, lack of information on its occurrence by previous workers (**Crowe**, 1962) and undetectable occurrence or absence in 50.0 % of the sites used during this study suggested that the braconid required specific environmental requirements for its survival.

The data of this study were generated from laboratory evaluations of *I. varipalpis* obtained near optimal conditions for food (*D. nigricornis*), space, shelter and the absence of competition. Obviously, in nature, parasitic searching prior to detecting the hosts is variable in result especially when the host becomes scarce (**Tanigoshi & McMurtry**, 1977). The data gathered indicated, however, the potential ability of *I. varipalpis* to overtake low popula-

tions of *D. nigricornis* larvae. The reason then why *I. varipalpis* does not strongly repress the field populations of *D. nigricornis* today could be purely its inability to search, detect and colonize the hidden larvae of the pest within canopies and cavities of the coffee plant. The coffee plant, although serving as a host to *D. nigricornis*, often contains single attacks only on any of the categories of shoots of the plant (**Wanjala**, 1985). The attacks occur least at canopy peripheries.

The braconid as an important biological control agent for the pest parasitized gregariously but reproduced abruptly. Presumably this is an adaption to some peculiarity of its ecology. It is unproven but quite possible that *I. varipalpis* takes advantages of a single *D. nigricornis* once found in nature to place a great amount of its progeny in that host (*loc. cit.*). This is a regularly occurring phenomenon among parasitic insects (**Hassell**, 1966, 1968, 1969 a, b ; **Hassel & Varley**, 1969 ; **Huffaker & Kenneth**, 1969 ; **Varley & Gradwell**, 1970).

Apparently *I. varipalpis* did not fully discriminate the hosts it had already parasitized. It therefore qualified as a super parasite. This behaviour is a common feature with many parasitic insects (**Smith & DeBach**, 1942 ; **Van Lenteren** *et al.*, 1978). These authors were of the opinion that the inability to discriminate parasitized hosts from unparasitized ones was a serious disadvantage to the species concerned in spreading their progenies. They also considered that at species level, the habit indicated specialisation to aggregate their progenies which therefore ultimately enhanced survival.

Natural enemies, such as *I. varipalpis*, if they were to control populations of *D. nigricornis*, would require certain characteristics. They would have to keep pace with the immense coffee canopy and the long range dispersal of their host specific (**Miller**, 1980 ; **Ehler & Miller**, 1978). It is not certain whether the parasite investigated was host specific. The likelihood is that it was monophagous as it only attacked *D. nigricornis* larvae while the egg, pupal and adult beetle stages were not susceptible.

ACKNOWLEDGMENTS

This paper is part of a study on population dynamics of *Dyrphya nigricornis* on *Coffea arabica* submitted as a Ph.D thesis to the University of Nairobi by the 1st author. It was funded by the Coffee Research Foundation (CRF), Kenya. We are grateful to staff of the Entomology Section for assistance, in collecting data. This paper is published with permission of the Director of Research, CRF.

RÉSUMÉ

Biologie et comportement d'*Iphiaulax varipalpis* [*Hym. : Braconidae*]
parasite de *Dyrphya nigricornis* [*Col. : Cerambycidae*]

On a évalué la capacité que possède le braconide parasite, *Iphiaulax varipalpis* Cary à lutter contre le Coléoptère Cérambycide *Dirphya nigricornis* Olivier. On a utilisé des échantillons récoltés dans les plantations et des spécimens élevés dans des tubes de polyéthylène maintenus dans les conditions du laboratoire (23°C + 1,0 à 70 p. 100 H.R.). Le parasitisme à l'extérieur était faible (10,72 p. 100) tandis qu'il était fort en laboratoire (57,66 P. 100). Le parasite détectait très facilement les hôtes au laboratoire. Cette capacité était réduite dans les frondaisons épaisses de *Coffea arabica* L. La colonisation de l'hôte s'effectuait très rapidement (90 secondes) se confinant à une aire presque absolue de découverte mesurant 4,18 + 0,41 cm. Le parasite se reproduit d'une façon grégaire, la durée de vie de la ♀ étant approximativement le double de celle du ♂. Les parasites sont très actifs à l'âge de 10 jours. Comme ils vieillissent, leur fécondité potentielle (323 ovocytes) se réduit d'une façon draconienne avec l'oviposition.

MOTS CLEFS : *Iphiaulax varipalpis*, tarière, enquête, parasitisme, durée.

Received : 16 June 1986 ; Accepted : 7 October 1986.

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