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Studies in West Pakistan on the biology of one Nitidulid species and two Coccinellid species (Coleoptera) that attack scale insects (Hom., Coccoidea)

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Introduction

Three species of Coleoptera, namely *Cybocephalus semiflavus* Champ. (Nitidulidae), and *Simmondsius pakistanensis* Rafiq Ahmad & Ghani and *Chilocorus nigritus* (F.) (Coccinellidae), commonly prey on scale insects, especially Diaspididae, in West Pakistan. Apart from prey and locality records, little has been published concerning these species, and in this paper an account, based on field and laboratory observations, is given of their biology.

Cybocephalus semiflavus

Distribution and prey species

Cybocephalus semiflavus is known to prey on *Aonidiella orientalis* (Newst.) (Ramachandra Rao, 1929), *Raoiella indica* Hirst (Channa Basavanna & Puttarudriah, 1957), *Diaspis* sp., *Chionaspis* sp. and *Aleyrodes* sp. (Vinson, 1959) in India; *Aspidiotus destructor* Sign. and *Aulacaspis tegalensis* (Zhnt.) in Mauritius (Moutia, 1944*b*); and *Stenaleyrodes vinsoni* Tak. in Réunion (Vinson, 1959).

In West Pakistan this species preyed upon *Aonidiella aurantii* (Mask.), *A. citrina* (Coq.), *A. orientalis, Aspidiotus destructor, Aulacaspis tubercularis* Newst., *Chrysomphalus aonidum* (L.), *Cryptoparlatoreopsis* spp., *Diaspis echinocacti* (Bch.), *Diaspidiotus caucasicus* (Borkhs.), *Fiorinia hederae* Hall & Williams, *Hemiberlesia lataniae* (Sign.), *Lepidosaphes* sp., *Insulaspis pallida* (Green), *Leucaspis coniferarum* (Hall & Williams), *Odonaspis penicillata* (Green), *Parlatoria blanchardii* (Targ.), *P. crypta* McKenzie, *P. ghanii* Hall & Williams, *P. oleae* (Colv.), *Parlatoreopsis longispinus* (Newst.), *Pinnaspis buxi* (Bch.), *P. strachani* (Cooley), *Quadraspidiotus perniciosus* (Comst.), *Rugaspidiotus tamaricicola* Malen., *Tecaspis* sp. and *Temnaspidiotus excisus* (Green). It was distributed throughout West Pakistan except in the high hills.

Description of immature stages

Egg (Fig. 1).—Length 0·37–0·40 mm, breadth 0·17–0·19 mm; dull white; elongate, somewhat cylindrical with both ends rounded, micropylar end roughened by the presence of numerous minute granular papillae in a circular area; black ocelli of the larva visible 24–36 h before hatching. At the time of eclosion a rupture occurs in the chorion at the apical end of the egg and extends to about one-third of its length.

Larva (Fig. 2).—Orthosomatic, subcylindrical, metathoracic and first to seventh abdominal segments subequal in length. Head prognathous, broad, a little wider than long. Pro-, meso- and meta-thorax each with one long and three clavate setae on each side and 10–14 clavate setae on dorsum. Abdominal segments 1–8 each with one long and one clavate seta on each side and 14–16 clavate setae on dorsum; segments 8–9 each with two lateral conical protuberances each bearing a terminal seta.

There were four larval instars; the dimensions of each instar are given in Table I.

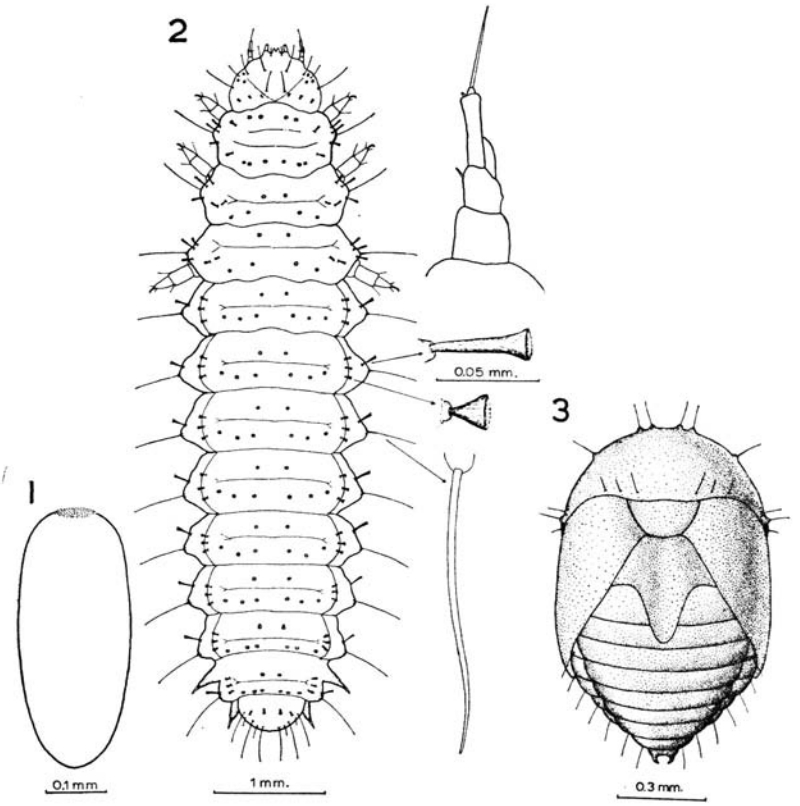

Fig. 1–3.—Egg, larva and pupa of *Cybocephalus semiflavus.*

TABLE I. *Width of head capsule and body length of* Cybocephalus semiflavus *in different larval instars*†

Stage/Instar	Width of head capsule (mm)	Body length (mm)
1	0·12–0·13	0·46–0·50
2	0·15–0·17	0·57–0·62
3	0·22–0·24	0·79–0·89
4	0·29–0·32	1·26–1·51
Before pupation	0·35–0·37	2·94–3·16

†Data from 3 individuals measured within 10 h of each moult and just prior to pupation.

Pupa (Fig. 3).—Length 1·12–1·26 mm, breadth 0·69–0·76 mm; roughly triangular but rounded anteriorly, dorsally convex. Head 0·51–0·55 mm broad, closely appressed to the body; eyes dark brown to black, partly covered by cephalolateral portions of prothorax. Pronotum with 6 chalazae on anterior margin, 3 on each lateral margin and 6 on posterior margin. Wing pads meeting on ventral side. Abdominal segments 1–8 each with one pair of lateral chalazae; caudal segment recurved on to venter and provided with organs of attachment.

Life-history

Copulation and oviposition were studied in one field-collected and four laboratory-bred pairs during September–October (at 25 ± 1·7° C and 55 ± 4% r.h.). Mating occurred 3–5 (average 4·3) days after emergence and lasted for 9–28 (average 17) min. Oviposition commenced 3–6 (average 4·8) days after copulation. The eggs were laid singly or in groups of 2–3 under the scale coverings, mostly of the ovipositing females, a total of 15–69 (average 34) eggs being laid during the entire oviposition period of 10–53 (average 23·8) days. The highest number of eggs, 69, was laid by the field-collected female. The post-oviposition period was 1–8 (average 3·6) days.

TABLE II. *Duration (days) of the developmental and adult stages of* Cybocephalus semiflavus †

Stage/Instar	Min.	Max.	Average
Egg	7	8	7·4
Larva: instar 1	3	4	3·4
instar 2	2	3	2·8
instar 3	6	8	6·5
instar 4	8	10	9·4
instars 1–4	20	24	22·3
Pupa	9	11	9·8
Egg to adult	37	41	39·4
Adult longevity: male	7	30	16·6
female	17	58	33·2

†Data from 8 individuals.

In the laboratory during September–November (at 25·6 ±2·2°C and 54 ± 5% r.h.) development of *Cybocephalus semiflavus* from egg to adult took 39·4 days when fed on eggs of *Aspidiotus destructor*. The durations of the various stages are given in Table II.

Larvae and adults feeding on the scales alternately sucked and regurgitated the body fluids. The fluids of *Tecaspis* sp. eggs were regurgitated 10–12 times by first-instar larvae, 7–8 times by second-instar, 4–5 times by third-instar and 2–4 times by fourth-instar larvae. When fed on eggs of *A. destructor*, which are smaller than those of *Tecaspis* sp., regurgitation occurred 1–4 times in different instars.

Since most eggs were laid under the coverings of the ovipositing female scales, the newly hatched larvae fed on newly hatched nymphs for 2–4 days. When food was no longer available in the scale, the young larvae crawled out and searched for newly settled nymphs or ovipositing females with the scales loosened by crawlers. In the second instar and thereafter the larva fed on body fluids of all stages of the scale. Individual larvae and adults could consume up to 47 eggs daily (Table III).

TABLE III. *Average daily rate of feeding of* Cybocephalus semiflavus †

	No. eggs consumed		
Instar	*P. strachani*	*Tecaspis* sp.	*Lepidosaphes* sp.
1	8	5	7
2	16	11	12
3	31	17	24
4	46	24	38
Adult	47	26	41

†Data from 3 individuals for each prey species, the same individuals through each instar.

Seasonal incidence

On *Aonidiella orientalis* infesting *Dalbergia sissoo* the Nititulid was more abundant during December–February (predator/prey ratio 1 : 8) than during May–September (ratio 1:70–124). Its relative abundance on different prey (*A. citrina* infesting *Citrus sinensis, A. orientalis* infesting *D. sissoo, Aspidiotus destructor* infesting *Mangifera indica* and *Parlatoria blanchardii* infesting *Phoenix dactylifera*) was studied at Multan during March–November (Fig. 4–7). The average number of predators per 1 000 scales (post-embryonic stages) was 2·9 on *Aonidiella citrina,* 12·4 on *A. orientalis,* 3·2 on *Aspidiotus destructor* and 4·6 on *Parlatoria blanchardii,* indicating that of these scales *Aonidiella orientalis* is the preferred prey. The population of *Cybocephalus*

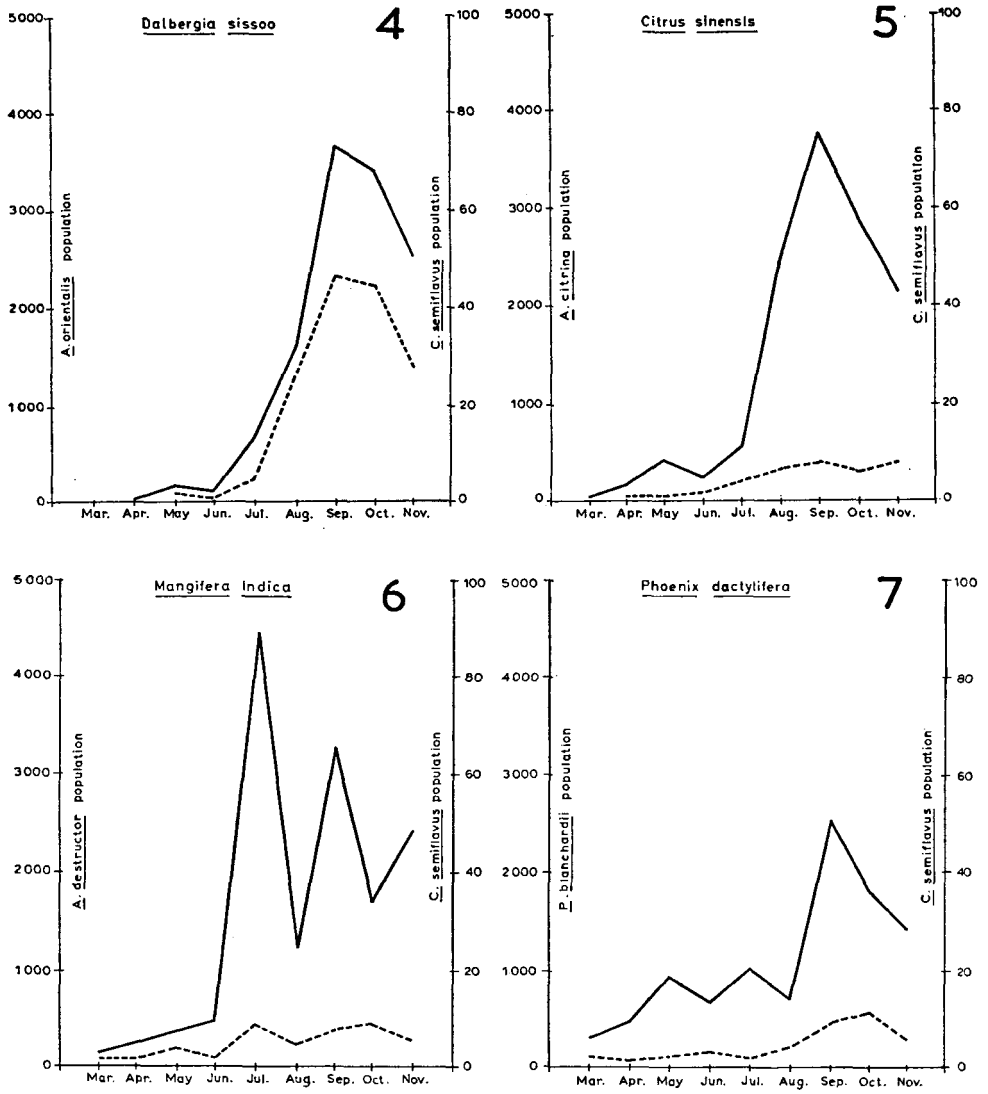

Fig. 4–7.—Abundance of *Cybocephalus semiflavus* relative to four species of scale insects on different host-plants. (Populations of predators and prey given as numbers per 105–in^2 leaf area.)

semiflavus increases proportionately with that of *A. orientalis* (Fig. 4–7), and may therefore limit the populations of this scale.

At Wah up to 5% of the larvae were parasitised by *Zeteticontus* sp. (Encyrtidae).

Conclusions

This predator has several qualities of value from the point of view of biological control, namely, the remarkable power of dispersion, long adult life, high reproductive potential and persistence at low prey densities, but without the aid of other natural enemies it does not in West Pakistan appear to reduce the population of its prey to a non-economic level. It can, however, be considered as a supplementary predator and may prove a useful introduction against some Diaspidids in other parts of the world.

Simmondsius pakistanensis

Distribution and prey species

Simmondsius pakistanensis was first recorded in 1964 feeding on *P. oleae* from the Kaghan Valley, West Pakistan (Ahmad & Ghani, 1966*a*). It has since been observed feeding on *Leucaspis coniferarum* infesting *Pinus roxburghii* and *P. wallichiana* in the Murree Hills, Azad Kashmir, Kaghan Valley and Swat State on *Parlatoria* sp. and *Eriococcus* sp. infesting *Berberis ceratophylla* and on *Q. perniciosus* infesting *Malus pumila* in the Murree Hills. It was abundant on *L. coniferarum* (heavy infestations) infesting *Pinus roxburghii*, but was rarely found on the other scales.

Description of immature stages

Egg (Fig. 8).—Length 1·08–1·13 mm, breadth 0·46–0·50 mm; somewhat cylindrical, slightly punctate; mallow pink, turning darker near hatching. About one day before

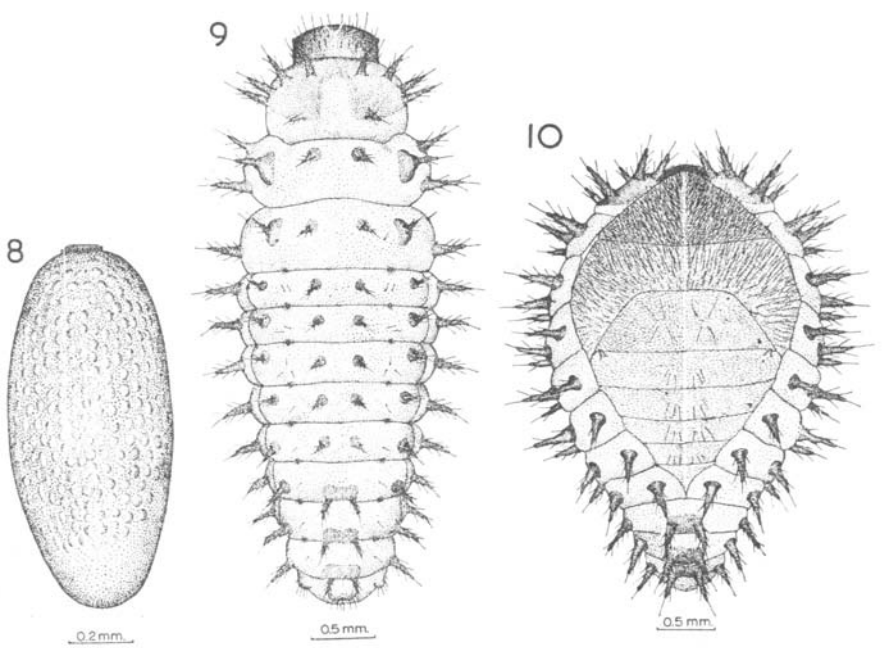

Fig. 8–10.—Egg, larva and pupa of *Simmondsius pakistanensis*.

hatching the larva is visible as a coiled mass through the translucent egg-shell; at the time of eclosion a rupture occurs at the apical end of the egg and extends to about two-thirds of its length.

Larva (Fig. 9).—Somewhat fusiform with greatest width in the region of metathorax and first abdominal segment. Head black bearing several setae. Thorax and abdomen dorsally armed with six rows of yellow-brown to black senti; pinnacula of senti deep brown to black. Prothoracic shield deep brown to black, semicircular with 10 senti at its margin. Mesonotum with 8 senti. Metanotum with 6 senti and 2–4 cephalolateral chalazae. Abdominal segments 1–7 each with 6 senti, length of lateral senti gradually decreasing posteriorly; segment 8 with 4 dorsal senti. Eight pairs of conspicuous, circular gland openings, one pair on each coria between metathorax and eighth abdominal segment. Terminal seta of each sentus longer than its stem in first instar, but about one-half of the length of stem in fourth instar. Pinnacula of dorsal senti on abdominal segments 1–5 separated and on segments 6–8 contiguous. White mealy substance appears on dorsum after first moulting, gradually increases in third and fourth instars and covers thoracic and abdominal tergites at the end of larval stage.

There are four larval instars, the dimensions of each being given in Table IV.

TABLE IV. *Body length and width of head capsule of* Simmondsius pakistanensis *in different larval instars*†

Instar/Stage	Width of head capsule (mm)	Body length (mm)
1	0·44–0·46	1·11–1·16
2	0·56–0·59	1·85–1·97
3	0·74–0·76	2·54–2·64
4	0·86–0·88	3·82–3·95
Before pupation	0·96–0·98	4·81–5·81

†Data from 2 individuals measured within 8 h of each moult and just prior to pupation.

Pupa (Fig. 10).—Length 3·21–4·82 mm, breadth 1·95–2·17 mm; broadly ovoid; dorsal surface moderately convex; light brown when newly formed, gradually changing to dark brown. Head 1·11–1·16 mm broad, retracted beneath pronotum and closely appressed to the body. Pronotum prolonged medially on the anterior margins for reception of head, lateral margins rounded, extreme posterior parts visible from above. Mesonotum with two brown markings; wing pads joining each other ventrally. Abdomen roughly triangular, eight distinct segments visible dorsally; first abdominal segment with two cephalolateral conical protuberances; last segment with forked tail.

The pupa is formed within the shed larval skin which splits lengthwise at the mid-dorsal line from the posterior margin of the head to the posterior portion of the fifth, or the anterior margin of the sixth, abdominal tergite. The exuvia enclosing the pupa is covered with a white mealy substance.

Life-history

Copulation and oviposition were investigated in four pairs of *S. pakistanensis* in the laboratory (at 24 ±2·2°C and 53 ± 4% r.h.). Mating occurred 8–11 (average 9·5) days after emergence, and oviposition started 6–11 (average 9·0) days later. Females laid 153–242 (average 186) eggs during their entire oviposition period of 51–71 (average 63·0) days, the eggs being laid singly or in groups of 2–7 on pine needles and under the scale coverings. The post-oviposition period was 4–44 (average 24) days.

In the laboratory during July–October (at 23·6 ± 2·5°C and 53 ± 5% r.h.) development of *S. pakistanensis* from egg to adult took 38·5 days when larvae and adults were fed on *A. orientalis* and *Q. perniciosus*. The durations of the various stages are given in Table V.

TABLE V. *Duration (days) of the developmental and adult stages of* Simmondsius pakistanensis †

Stage/Instar	Min.	Max.	Average
Egg	7	9	7·7
Larva: instar 1	5	7	6·0
instar 2	3	4	3·5
instar 3	3	5	3·8
instar 4	6	8	6·9
instars 1–4	18	23	20·3
Pupa	6	9	7·9
Egg to adult	32	41	35·8
Adult longevity: female	78	128	105·0
male	73	117	100·8

†Data from 8 individuals

The feeding habits of this predator are similar to those of *Chilocorus infernalis* Muls. (Ahmad & Ghani, 1966*b*). On *A. orientalis* daily consumption was 14–18 (average 15) eggs. Second-instar larvae destroyed 2–6 (average 4·2) second-instar or 2–4 (average 3·1) adult scales. Third- and fourth-instar larvae and adults (Table VI) could each consume up to 35 scales daily.

TABLE VI. *Average daily rate of feeding of* Simmondsius pakistanensis †

Instar	No. female scales consumed		
	A. orientalis	*L. coniferarum*	*Q. perniciosus*
3	13	19	16
4	28	35	29
Adult	25	32	27

†Data from 11 individual predators, three or four on each prey species and the same individuals through each instar.

Seasonal incidence

In the Murree Hills adult *S. pakistanensis* spent the winter (November–January) in cracks and crevices of the bark of pines. Oviposition started in February, and hatching of the eggs at the beginning of March. Larvae (all instars) and adults were abundant during April–May and destroyed many scales. In June and July, when the scale was multiplying rapidly, the predator population declined owing to heavy parasitism by the larval/pupal parasite *Tetrastichus epilachnae* (Giard) which reached 42% at Phaghwari (Murree Hills). Second-generation larvae appeared in July and August, but only in small numbers. The predator population remained very small during August–October when the scale population was large. It completed two generations in a year.

Conclusions

S. pakistanensis appears to be important in the control of *Leucaspis coniferarum* until its effect is limited by the parasite *T. epilachnae*. In the absence of this parasite, *S. pakistanensis* might prove a useful introduction to other countries in view of the complete synchrony of predator-prey activities and the predator's voracious feeding habit, long adult life and high reproductive capacity.

Chilocorus nigritus

Distribution and prey species

Chilocorus nigritus is known to prey upon *Coccus colemani* Kannan (Coleman & Kannan, 1918), nymphs of *Diaphorina citri* Kuway. (Husain & Nath, 1927), *Aonidiella*

orientalis (Glover, 1933), various stages of *Aleurolobus barodensis* (Mask.) (Kapur, 1940), aphids (Rahman, 1940), *Coccus viridis* (Green) and *Aspidiotus* spp. (Puttarudriah & Channa Basavanna, 1953) in India, *Aspidiotus destructor* in Ceylon (Hutson, 1933) and in Diego Garcia (Orian, 1959), *A. destructor* and *Aulacaspis tegalensis* in Mauritius (Moutia, 1942, 1944*a*), *Ischnaspis longirostris* (Sign.), *Pinnaspis buxi*, *Chrysomphalus aonidum* and *Eucalymnatus tessellatus* (Sign.) in the Seychelles (Vesey-Fitzgerald, 1941), and *Aspidiotus rigidus* Reyne in North Celebes (Reyne, 1948).

During the present investigations in West Pakistan *Chilocorus nigritus* was found attacking several species of Diaspidids, and was abundant on *Aonidiella orientalis*, *Aspidiotus destructor*, *P. strachani*, *Q. perniciosus* and *Lepidosaphes* sp. It is distributed throughout West Pakistan except in the high hills.

Description of immature stages

Egg (Fig. 11).—Length 0·96–1·01 mm, breadth 0·46–0·49 mm; elongate, somewhat fusiform with both ends evenly rounded; micropylar end roughened by the presence of numerous minute granular papillae in a circular area; ivory yellow when freshly laid, turning to dull yellow with black hue and finally darkening near hatching. Larva visible through the egg-shell as a coiled mass a few hours before hatching; at the time of eclosion a rupture occurs at the apical end of the chorion and extends to three-quarters the length of the egg.

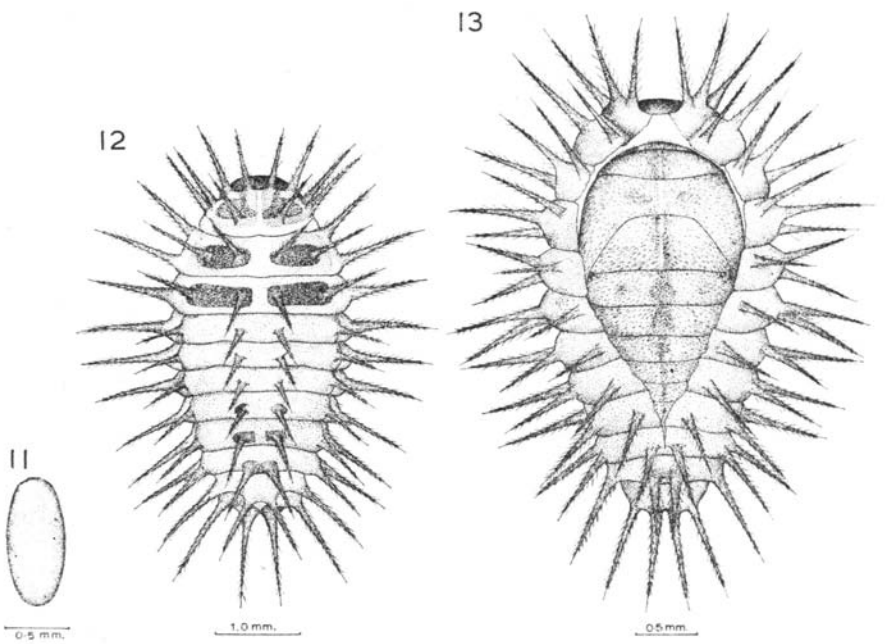

Fig. 11–13.—Egg, larva and pupa of *Chilocorus nigritus*.

Larva (Fig. 12).—Somewhat fusiform with greatest width in the region of mesothorax to first abdominal segment. Head small, a little longer than wide, fairly smooth, slightly dark to black with a few scattered white setae; ocelli three on either side of head near antero-lateral angles just near the antennae; maxillary palp long and three-segmented; labial palp small and three-segmented; antenna short with a terminal seta. Protergum with 5 senti on either side of mid-dorsal line at the margin of brown to dark brown semicircular areas; pinnacula of cephalolateral senti somewhat

contiguous. Mesotergum with 8 and metatergum with 6 senti; on meso- and meta-tergum pinnacula of two dorsal senti on each side of mid-dorsal line contiguous. In first instar one sentus in the central row on either side of mid-dorsal line on pro-, meso- and meta-tergum with cephalad seta; in second instar several setae appear on all senti. Abdominal segments 1–6 each with 6 senti; length of lateral senti gradually decreasing posteriorly; segments 7–8 each with four senti; pinnacula of dorsal senti on abdominal segments 1–5 separate and on segments 6–8 contiguous. In the full-grown larva, meso- and meta-tergum dark to black; abdominal segments 1–3 light yellow; pinnacula of senti on prothorax, abdominal segments 1–3, 7 light yellow, on meso- and meta-thorax and abdominal segments 4–6 dull yellow to black; length of dorsal senti 0·9–1·1 mm.

Vesey-Fitzgerald (1941) recorded five larval instars, whereas Puttarudriah & Channa Basavanna (1953) recognised only four. In this study four larval instars were recognised, the dimensions of each being given in Table VII.

TABLE VII. *Body length and width of head capsule of* Chilocorus nigritus *in different larval instars* †

Instar/Stage	Width of head capsule (mm)	Body length (mm)
1	0·34–0·37	1·02–1·06
2	0·44–0·47	1·73–1·88
3	0·56–0·59	2·05–2·19
4	0·79–0·83	3·16–3·41
Before pupation	0·89–0·94	5·55–5·83

†Data from 3 individuals measured within 12h of each moult and just prior to pupation.

Pupa (Fig. 13).—Length 3·33–3·60 mm, maximum body breadth 2·39–2·59 mm, bright yellow just after pupation, turning yellow with dull yellow to black markings afterwards. Head 1·03–1·08 mm broad, yellow with conspicuous black eyes, retracted beneath pronotum, not visible on dorsum. Pronotum yellow with ten stripes along the margins of prothoracic shield and mid-dorsal line; laterally prolonged for reception of head. Mesonotum yellow with dull yellow markings. Wing pads and metanotum dark yellow. Abdomen yellow with dull yellow markings; first segment with a pair of cephalolateral protuberances; last segment with a pair of forked feet or organs of attachment. Body tergites setigerous.

The pupa is formed within the shed larval skin which is split lengthwise at the mid-dorsal line from the lateral arms of the epicranial suture to the anterior margin of sixth abdominal tergite.

Life-history

Copulation and oviposition were studied in five pairs of *C. nigritus* at 23·3 ± 1·7°C. The adults mated 4–7 (average 5·4) days after emergence. Copulation lasted for 15–56 (average 28) min. Oviposition began 8–13 (average 10) days later, the eggs being laid singly or in groups of 2–4 under scale coverings, under spiders' webs or occasionally exposed on leaves. A total of 228–351 (average 292) eggs was deposited by a single female within the oviposition period of 74–118 (average 94) days. The female died 2–43 (average 15) days after the last deposition of eggs. Beetles collected from congregation sites (see pp. 14–15) did not oviposit during December–April in the laboratory, so confirming the findings of Tirumala Rao *et al.* (1954). However, adults collected from the field before assemblage and those reared from pupae bred in the laboratory did oviposit during December–April.

The larva emerges by a series of movements in which the body is bent and extended. In the laboratory during September–March (at 24 ± 2·2°C and 53 ± 5% r.h.) development of *C. nigritus* from egg to adult took 37·6 days when larvae and

TABLE VIII. *Duration (days) of the developmental and adult stages of* Chilocorus nigritus †

Stage/Instar	Min.	Max.	Average
Egg	8	9	8·4
Larva: instar 1	3	4	3·1
instar 2	3	4	3·5
instar 3	4	6	5·4
instar 4	7	9	8·6
instars 1–4	17	22	20·6
Pupa	8	10	8·6
Egg to adult	33	40	37·6
Adult longevity: female	90	147	123·4
male	44	163	103·7

†Data from 10 individuals.

adults were fed on *Aonidiella orientalis*. The durations of the various stages are given in Table VIII.

The feeding habits of the larvae and adults of *C. nigritus* are similar to those described by Geyer (1947) for *Exochomus flavipes* (Thnb.). On *A. orientalis* the daily consumption of the first-instar larva was 15–35 (average 21) eggs, and of the second-instar larva 5–12 (average 8) first-instar nymphs or 2–8 (average 5) second-instar nymphs. Third- and fourth-instar larvae could consume up to 41 scales daily (Table IX).

TABLE IX. *Average daily rate of feeding of* Chilocorus nigritus†

Instar	No. female scales consumed			
	A. orientalis	*Q. perniciosus*	*Lepidosaphes* sp.	*P. strachani*
3	12	10	16	19
4	27	29	32	41
Adult	19	17	24	32

†Data from 4 individuals for each prey species, the same individuals through each instar.

The larvae were sometimes cannibalistic: all instars fed on eggs; second-, third- and fourth-instar larvae completely devoured first-instar larvae; and third- and fourth-instar larvae fed on the ventral side of second-instar larvae, leaving the legs, head and dorsal skin.

Seasonal incidence

Tirumala Rao *et al.* (1954) stated that in early summer the adults assembled on banyan trees (*Ficus bengalensis*) at Coimbatore and dispersed after the south-west monsoon in July, whereas Ketkar (1959) reported congregations of adults on banyan from November to January and from March to May near Poona. During the present investigations congregating beetles were observed on the leaves, fruit and branches of banyan at Rawalpindi and Karachi during September–June and November–March, respectively. At Rawalpindi the groups were larger and the adults concealed themselves in clusters of inner, particularly the overlapping, leaves during December–February. During March, as the weather became warmer, the adults scattered all over the tree, but during May–June most settled on the lower parts of the tree facing north, so avoiding the sun. Dispersal began during March–April at Karachi and in June at Rawalpindi, and the adults migrated to scale-infested plants where they continued to destroy the scales, until the end of September at the former locality and until November at the latter. Adults were seen feeding during August–October at Abbottabad and during July–October at Okara and thereafter migrated, presumably

to congregation sites which were not traced. Light infestations of scales and cold winters appear to shorten the period of activity of the beetle at Abbottabad, Rawalpindi and Okara, whereas fairly heavy scale infestations and hot, humid and mostly equable climate throughout the year seem to prolong its period of activity at Karachi.

Conclusions

The value of *C. nigritus* as a controlling factor has not always been clear. According to Hutson (1933), *Aspidiotus destructor* rarely caused serious damage in Ceylon owing to the activities of its natural enemies, particularly *C. nigritus*. In Mauritius, this scale was widespread owing to drought and shortage of *C. nigritus* (Jepson, 1935), and on coconut palms infestations were markedly reduced due to *C. nigritus* together with *C. politus* Muls. (Moutia, 1942). There was a marked reduction in the number of *I. longirostris*, *P. buxi*, *Chrysomphalus aonidum* and *Eucalymnatus tesselatus* on coconut palms following the introduction of this beetle into the Seychelles (Vesey-Fitzgerald, 1941); complete control was obtained and any outbreaks were only temporary (Vesey-Fitzgerald, 1953). On the other hand, *Chilocorus nigritus* did not control *A. rigidus* on coconut palms in North Celebes (Reyne, 1948); it was established against *A. destructor* in Diego Garcia, but proved ineffective (Orian, 1959).

In West Pakistan *C. nigritus* was fairly effective against *A. destructor* and *Aonidiella orientalis* in the coastal and sub-coastal areas, *P. strachani* in the hills and foot-hills and *Q. perniciosus* in the hills, particularly in the vicinity of congregation sites. It was more abundant at Karachi (coastal area) than elsewhere. However, it was unable to persist on light scale infestations; this and its highly specialised habits prevent it from maintaining full control of the scales without the aid of other natural enemies.

Summary

One Nitidulid species, *Cybocephalus semiflavus* Champ. and two Coccinellid species, *Chilocorus nigritus* (F.) and *Simmondsius pakistanensis* Rafiq Ahmad & Ghani, commonly attack Diaspididae in West Pakistan. The known distribution and prey of each species are reviewed, and new records from West Pakistan given. The immature stages are described.

The development of *Cybocephalus semiflavus* from egg to adult was completed in 37–41 days at *c.* 26°C. Mating occurred 3–5 days after emergence and oviposition began 3–6 days later, 15–69 eggs being laid. An individual adult could consume up to 47 Diaspidid eggs daily, but all Diaspidid stages were attacked. In the field the predator persisted at low prey densities, but on *Aonidiella orientalis* (Newst.), the preferred prey, its population rose in proportion to that of its prey.

The development of *S. pakistanensis* took 32–41 days from egg to adult at *c.* 24°C when fed on *A. orientalis* and *Quadraspidiotus perniciosus* (Comst.). Mating was 8–11 days after emergence and oviposition began 6–11 days later, 153–242 eggs being laid. An individual could consume up to 35 *Leucaspis coniferarum* (Hall & Williams) daily. The predator was abundant during April–May, but later its effect was limited by *Tetrastichus epilachnae* (Giard).

At *c.* 24°C *Chilocorus nigritus* completed development from egg to adult in 33–40 days. Mating was 4–7 days after emergence, and oviposition began 8–13 days later, 228–351 eggs being laid. *C. nigritus* attacked several species of Diaspidids, an individual consuming up to 41 scales daily. The adults congregated on banyan trees during November–March in the coastal area and during September–June in the foot-hills, but dispersed to scale-infested plants at other times of year.

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