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BIOLOGY AND CONTROL OF THE INSECT PESTS OF CUCURBITS OF THE INDO-PAKISTAN SUBCONTINENT

MOHAMMAD ABDULLAH

P.C.S.I.R. Laboratories, Karachi 32

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Vine crops of the gourd family Cucurbitaceae are of economic, agricultural,industrial and medical importance. The cucurbit vegetables serve as alkali reserves of the blood, as source of minerals, as source of roughage, and as source of vitamins A, B, C and G. Some of them have such alkaloids as colocynthin, colocynthetin, bryonin, myriocarpin, momordicin, etc., and are used as a remedy for various diseases. Their seeds usually contain fats with linoleic, oleic, linolenic or conjugated polythenoid acids as major components. These plants are attacked by adult or immature stages of a number of insect pests, which are, alphabetically and order wise, followed by their known natural enemies in parentheses, as follows: I. Coleoptera or beetles and weevils: (1) *Acythopeus citrulli*—a curculionid; (2) *Apomecyna histrio*—a cerambycid; (3) *A. pertigera*—a cerambycid; (4) *Aulacophora atripennis* or black pumpkin beetle—a chrysomelid; (5) *A. foveicollis* or red pumpkin beetle—a chrysomelid (crows, mynas and a reduviid bug, *Rhinocoris fuscipes*); (6) *Epilachna* species or spotted lady bird beetles—a coccinellid, namely *E. chrysomelina*, *E. dodecastigma* (reduviid *Rhinocoris fuscipes*), *E. vigintioctopunctata* (*R. fuscipes*, *Pleurotropis foveolatus* and *Tetranychus ovularum*); and *Juliodis atkinsoni*—a buprestid. II. Diptera or true flies: (B) *Dacus brevistylus*—a trypetid (*Opius incisi*); (9) *D. cucurbitae* or melon fly—a trypetid (*O. fletcheri*, *Syntomus phyrum* and *Ipobracon* sp.); (10) *Myiopardalis paradalina*—a trypetid. III. Hemiptera or plant bugs, etc.: (11) *Aspongopus brunneus*—a pentatomid; (12) *A. janus*—a pentatomid (*Eupelmus aspongoni*); (13) *Frankliniella sulphurea*—an aphid; (14) *Gallobellicus crassicornis*—a mirid; (15) *Leptoglossus membranceus* or paddle legged bug—a pentatomid; (16) *Megymenom brevicorne*—a pentatomid; (17) *Metacanthus pulchellus*—a berytid; and (18) *Nezara viridula*—a pentatomid (*Telenomus* sp., *Microphanurus* sp., *Sarcophaga sternodontis* and *Trichopoda pennipes*). IV. Lepidoptera or butterflies and moths: (19) *Agrotis ypsilon* or greasy surface caterpillar—a noctuid (*Microgaster* sp., *Amblyteles* sp. and *Fileanta rufocauda* (20) *Laphygma exigua* or indigo caterpillar—a noctuid (*Sturmia inconspicuoides*, *Actia monticola*, *Euplectrus gopimohni*, *E. plecoptrae*, *Bracon hebetor*, myna bird, *Canthecona furcellata*, rereduviid *Rhinocoris fuscipes* and *Ammophila* sp.); (21) *Margaronia indica*—a pyralid (*Apanteles taragammae*); (22) *Pericallia ricini*—an arctiid (*Apanteles ricini*); (23) *Plusia peponis*—a noctuid (*Ceraphron athanassi*, *Apanteles plusia* and *A. taragammae*); (24) *Sphenarches caffer*—a pterophorid (*Apanteles paludicolae* and *A. rangii*). V. Orthoptera or grassshoppers, locusts, crickets, etc.: (25) *Brachytrypes achatinus*—a gryllid (lizards and digger wasp *Sphex lobatus*); and (26) *Poecilocerus pictus*—an acridid. Their biology and control measures are described in this monograph.

Vine crops of the gourd family, Cucurbitaceae are of considerable economic, agricultural and medical importance (see Table A). Common examples of the cucurbits are: bush pumpkin or summer squash (*Cucurbita pepo* var. *condensa*, cantaloupes (*Cucumis melo* var. *cantalupensis*), cassaba melon (*Cucumis melo* var. *inodorus*), chayote (*Sechium edule*), citron melon, cucumber (*Cucumis sativus*), gherkin (*Cucumis anguria*), mango melon or lemon cucumber (*Cucumis melo* var. *chito*), muskmelon (*Cucumis melo*), netted melons (*Cucumis melo* var. *reticulatus*), pumpkin (*Cucurbita pepo*), pumpkin-cushaw and large cheese (*Cucurbita moschata*), squash (*Cucurbita maxima*), water melon (*Citrullus vulgaris*), etc.[51] Vernacular names of the important cucurbits of Pakistan and India are arranged alphabetically with their scientific names in parenthesis: agumak (*Mukia madraspatana*), akashgaddah (*Corallocarpus epigeus*), bhimb or kundru (*Coccinia cordifolia*), bilari (*Mukia scabrella*), bindaal (*Luffa echinata*), bislambhi (*Cucumis callosus* or *trigonus*), chachinda (*Trichosanthes anguina*), choti-indrayan (*Cucumis prophetarum*), gargunaru or mala (*Bryonopsis laciniosa*), ghia-taroi (*Luffa racemosa*), gol-kaddu (*Benincasa cerifera*), gol-kakra (*Momordica cochinchinensis*), gulur (*Hodgsonia heteroclita*), indrayan (*Citrullus colocynthis*), jangli chachinda (*Trichosanthes cucumerina*), jangli karela (*Memordica balsamina*), kaddu (*Lagenaria vulgaris*), kakri (or Kharbuza) (*Cucumis melo*), kanchan-arak (*Momordica dioica*), karela (*Momordica charantia*), Khira (*Cucumis sativus*), karni-taroi (*Luffa amara*), lal indrayan (*Trichosanthes palmata*), mitha-kaddu (*Cucurbita maxima*), the muskmelon (*Cucurbita moschata*), palwal (*Trichosanthes dioica*), safed-Kaddu (*Cucurbita pepo*), tarali (*Zehneria umbellata*), taroi (*Luffa acutangula*), tarbuz (*Citrullus vulgaris*), etc. Prain,[40] Baquar and Tasnif.[4]

From the above examples it should be obvious that many of our common vegetables are cucurbits, Vegetable growing or gardening is an important subject of *agriculture* and *horticulture*. Vegetable production for local markets and their canning and manufacture is an important *industry*, which shall develop more and more in the Indo-Pak subcontinent in the years to come. In the U.S.A., for example, the gross income from farm production and Government benefit payments by groups of commodities of vegetable crops amounted to $ 880,000,000 in 1936 Thompson.[51] Vegetable growing includes home gardening, market

TABLE A.—CHEMICAL COMPOSITION, FUEL VALUE, VITAMINS AND MEDICINAL PROPERTIES OF THE CUCURBITS.

Name of the plant	Water per cent	Protein per-cent	Fat per-cent	Ash per-cent	Carbohydrates			Fuel value per pound, Calories	Vita-min A	Vita-min B	Vita-min C	Vita-min G	Medicinal properties		
					Fibre per cent	Sugar per cent	Starch per cent						Parts used	Active principle	Remedy or use
1. Cucumbers	96.1	0.7	0.1	0.44	0.5	2.60	—	65	fair	fair	good	—	roots & seeds	—	diuretic
2. Muskmelons	—	0.6	0.2	0.6	0.5	5.4	—	—	good	good	good	—	pulp & seeds	—	eczema
3. Pumpkin	90.5	1.2	0.2	0.82	1.3	2.50	2.6	160	good	fair	fair	fair	—	—	—
4. Squash summer	95.0	0.6	0.1	0.44	0.5	1.00	0.2	85	—	—	—	—	fruit pulp	—	poultice
5. Squash, winter	88.6	1.5	0.3	0.83	1.4	3.90	1.0	200	—	—	—	—	—	—	—
6. Squash, Hubbard	—	—	—	—	—	—	—	—	excellent	fair	—	fair	—	—	—
7. *Bryonopsis laciniosa*	—	—	—	—	—	—	—	—	—	—	—	—	whole plant	?	fever, inflammation biliousness.
8. *Citrullus colocynthis*	—	—	—	—	—	—	—	—	—	—	—	—	root & fruit	colocynthin & colocynthetin	fever, intestinal disorder, ascites, jaundice, etc.
9. *Coccinia cordifolia* or *indica*	93.1	1.2	0.1	—	1.6	3.5	—	—	good	—	good	—	root, leaves & fruit	alkaloid & amylase	reducing sugar from urine.
10. *Corallocarpus epigeus*	—	—	—	—	—	—	—	—	—	—	—	—	root	bryonin	mucous enteritis, dysentery & rheumatism.
11. *Cucumis callosus*	—	—	—	—	—	—	—	—	—	—	—	—	whole plant	?	biliousness, purgative.
12. *Cucumis prophetarum*	—	—	—	—	—	—	—	—	—	—	—	—	fruit	myriocarpin	emetic & purgative.
13. *Momordica balsamina*	—	—	—	—	—	—	—	—	—	—	—	—	whole plant	momordicin	stomachic & tonic.
14. *Momordica dioica*	84.1	3.1	—	2.97	7.7	—	—	—	good	—	good	—	fruit	?	antiseptic & antitubercular.
15. *Mukia* or *Malothria maderaspatana*	—	—	—	—	—	—	—	—	—	—	—	—	whole plant	?	biliousness, vertigo, toothache & gases in stomach.

gardening, truck growing or truck gardening, production for canning, manufacture and freezing crop production and vegetable forcing out of their normal season by artificial heat, etc., usually in greenhouses. Vegetables are an important source of human diet, particularly for the so-called 'vegetarians'. Vegetables are: base formers and serve as alkali reserves of the blood, source of minerals such as calcium and iron, source of roughage by their succulence or high water content aiding in the digestion of the more concentrated foods and avoiding constipation, source of vitamins which are essential for human growth, reproduction and health, etc. The chemical composition, fuel value in calories, *medicinal properties* etc., of some of our cucurbits are mentioned below.4,51

In addition, it may be mentioned that seeds of the following cucurbits contain fats with linoleic, oleic, linolenic or conjugated polythenoid acids as major compounds: *Cayaponia* spp., *Citrullus colocynthis*, *C. fistulosis*, *C. vulgaris*, *Cucurbita maxima*, *C. pepo*, *Echinocystis fabacea*, *E. oregana*, *Luffa acutangula*, *L. graveolens*, *Marah gilensis*, *M. macrocarpa* *Memordica balsamina*, *M. dioica* and *Trichosanthes cucumerina* (*vide* Swain, 1963).[50]

Having realized the importance of the cucurbits (*vide supra*) the reader can now better appreciate the following account of the insect pests which destroy our crops, their parasites, predators and control measures, etc. The insect enemies of our cucurbits are adults or immature stages of beetles and weevils (Coleoptera), trueflies (Diptera), plant bugs, etc. (Hemiptera), butterflies and moths (Lepidoptera), and grasshoppers, crickets, etc. (Orthoptera). These are arranged alphabetically, order wise, in the appropriate section below.

A more detailed investigation on the biology (and control) of several individual insect pests of economic importance in this country is now in progress in my lab. For the benefit of every entomologist interested in similar problems, and especially for the guidance of those who are interested in abstracting information on bionomics of insect pests or in carrying out original research in this and other developing countries were proper guidance is not available to every research student, it seems useful to give an *outline of the topics* covering the *biology of insects* in general (Table B). The programme (*vide infra*) could be easily modified according to one's problem or circumstances.

TABLE B

I. GENERAL

A. Nomenclature (common, Latin and synonymical names)
B. Distribution (geographical, seasonal, geological).
C. Generations.
D. Hybridization.
E. Evolution.
F. Techniques (rearing, mounting, *et al.*)

II. EGG

A. Description (individual and *in situ*)
B. Local distribution
C. Formation (in female).
D. Fertilization
E. Incubation
F. Hatching
G. Latency
H. Toxinosis
I. Antagonists (parasites, predators, competitors)
J. Resistance (to antagonists, chemicals, climate)

III. LARVA (or NYPH)

A. Appearance (taxomomic and ecologic)
B. Local distribution
C. Dispersal (includes all movements)
D. Feeding (mechanics, hosts, orientation)
E. Utilization of food (digestion, absorption, circulation, storage) (mechanics and chemistry)
F. Respiration
G. Development (rate, tissue differentiation, moulting, pupation) (time and number of instars)
H. Excretion
I. Secretion
J. Latency
K. Toxinosis
L. Antagonists (see II-I)
M. Resistance (to antagonists, chemicals, climate)

IV. PUPA (if present)

A. Appearance (taxonomic and ecologic)
B. Local distribution
C. Dispersal (any movements in media)
D. Respiration
E. Development (rate, tissue differentiation, moulting)
G. Latency
H. Toxinosis
I. Antagonists (see II-I)
J. Resistance (antagonists, chemicals, climate)

V. ADULT

A. Appearance (taxonomic and ecologic)
B. Local distribution
C. Dispersal (includes effective ranges)
D. Feeding (mechanics, hosts, orientation, site)

E. Utilization of food (digestion, absorption, circulation, storage)
F. Respiration
G. Copulation (orientation, mechanics)
H. Oviposition (including placement)
I. Excretion
J. Secretion
K. Aggregation (swarms, *et al.*)
L. Longevity
M. Toxinosis
N. Antagonists (see II-I)
O. Resistance (invaders, chemicals, climate)

I. Coleoptera or Beetles and Weevils

(1) *Acythopeus citrulli*

Order Coleoptera
Family Curculinoidae

It occurs regularly in Bellary as a pest of water melon, and is also known from Tinneverlly.

It is a serious pest of water melon.[21] The grubs bore into the sides in contact with ground, and tunnel in the fruits, filling its passage with excrements, and cause decomposition.

Life history and control measures are still to be worked out.

(2) *Apomecyna histrio F.*

Order Coleoptera
Family Cerambycidae

It is found in North Bihar, particularly Chapra, Laheria Serai and Pusa. It is less abundant than the following species.

The adult beetle may crush young shoots. The larvae occur late in the season at Pusa, and feed on the tissues of the stem, making irregular burrows in the course of its feeding. The grubs normally kill the plants which they attack.[21]

The beetle is found to be a pest on the stem of pumpkin, *Tinospora cordifolia* or gilo of Menispermaceae *Luffa* sp. and *Cephalandra* sp.

Life history is not yet worked out.

The pest is of minor importance.

(3) *Apomecyna pertigera*

Order Coleoptera
Family Cerambycidae

The beetle has been recorded at Pusa from larvae in *Luffa* stem, bottle gourd, snake gourd, and pumpkin stem, and the adults have also been found on cucumber fruit. It has been found at Chapra, Jarhat and Coimbatore.[19]

The adult eats the young fruits. The grub on hatching bores into the stem and tunnels along it extending to the central pith.[33] The trailing stems of curcurbit grow luxuriantly, since the damage is less, and the life of the insect is long enough to check rapid multiplication.

Egg.—Creamy white eggs with a temporary reddish tinge are laid singly on the epidermis of the stem, usually at or near one node. Each egg is 1.5 mm long, elongate, oval in shape with rounded apices. The egg dehisces at the thicker end, splits longitudinally almost from end to end in 2 or 3 places, allowing the young grub to emerge out.

Larva.—The egg splits in 5 or 6 days, the young grub grows about the size of the egg. It is cylindrical, with the thorax slightly larger than the abdomen, tapering to the hind end, the head is flattened, segmentation is distinct, and there are minute hairs on each segment. Little change is apparent during the larval life, and it is impossible to ascertain the moults as the larvae are extremely sensitive to disturbance and are not easy to rear. The body segments are soft, distinctly separated, with distinct fleshy protuberances, which can be extended to exert pressure against the wall of the burrow, thus pushing the grub forwards. Legs are absent. The full grown larva measures about 20 mm when fully grown, a cavity is formed, which is closed behind with fibres and pieces of tissue. In some cases an incomplete fibrous cocoon is prepared, as a lining to the cavity. No special provision is made for the exit of the imago. The pupa lies in the cavity with the cast larval skin behind it.

Pupa.—It is about 12 mm long. It moves by the rhythmic contraction and relaxation of the abdominal segments which have lateral projections and hairs.

Adult.—The beetle emerges by eating its way out of the stem. Soon after emergence the beetles mate, during mating the female walk about carrying the male. When distrubed the beetles fall to the ground, with the limbs folded tightly against the body, and feign death. The duration of the life cycle is affected by atmospheric conditions of temperature and humidity.

Control.—The affected stem should be destroyed and burnt down. The adult beetles should be mechanically caught by hand nets, and put in kerosinised water.

It is a minor pest of cucurbitaceous plants, and as such comparatively less work has been done on its control. Sometimes it does considerable damage in North India.

(4) *Aulacophora atripennis* (*Black pumpkin beetle*)

Order Coleoptera
Family Chrysomelidae

It has been recorded from Godavari, Kistna, Coimbatore,[21] and Lyallpur.[25]

It has been found attacking snake gourd, bottle gourd, bitter gourd,[19] *Cucurbita* sp. *Cucumis* sp. and *Citrullus* sp., *Luffa aegyptiaca* or ghia-taroi and *Luffa acutangula* or taroi.[25]

The life history and habits are nearly identical with that of *A. foveicollis* (*vide infra*).

With our present knowledge of the pest, it can be said that the pest is neither as injurious nor as widely distributed as *Aulacophora foveicollis.*

(5) *Aulacophora foveicollis* (*Red pumpkin beetle*)

Order Coleoptera
Family Chrysomelidae

It attacks cucumber,[12] melons, and gourds in fact, all the cucurbitaceous plants with the exception of bitter gourd. This may be due to some unpalatable juice in this plant.[25]

The adult beetles feed on the leaves of curcurbits, (preferably the soft ones, making holes in the leaves or in severe attacks completely defoliate the plant), and also attack flowers, thereby lowering the yield. The grubs have also been recorded to bore into the fruits. In the case of melons the damage is upto 35%, particularly in the fields where water stands for a longer time.[25]

The larvae bore into the roots and stems, and destroy a number of seedlings, when present in large number. The grubs living under ground do more damage than the adults, since they destroy the roots and thus kill the entire plant.[1]

As a matter of fact the adult beetles coming out from hibernation in February after overwintering nip the developing seedling in the bud, and cause more damage. Not less than 20 beetles have been observed attacking a seedling with 3 or 4 leaves.

Copulation occurs several times, the females laying a batch of eggs after each mating. The duration of mating varies from 5 to 75 hr.

Egg.—The eggs are mostly laid in night, usually in batches or singly as well on the moist shady soil or in cracks near the food plants. The maximum record in the lab. of the number of eggs laid by a female is 295, and at one laying 60.[25]

The eggs are spherical, 0.612 mm in dia, yellow in colour, and with sculptures on the shell. In groups they are pressed against each other and become more or less polyhedral in outline. Depending on the ecological factors, mainly temperature and humidity, the eggs hatch in 6 to 15 days. The egg becomes orange in colour.

Larva.—The newly hatched larva is very active and voracious feeder, 1.2 mm long and 0.28 mm across the body. There are four instars for 2 to 5 days each, depending on the food supply and temperature. It enters the prepupal stage within a fortnight after hatching, but the grub may last for 23 days. A full grown larva measures about 12 mm in length and 1.6 mm across the body.

Pupa.—After 13 to 23 days the larva tunnels into the soil, and prepares an oval waterproof pupal chamber. The grub lies motionless in the pupal chamber, decreases in length and increases in thickness and within 2 to 5 days, it moults and changes into the pupa. Pupa is 6.5 to 7.5 mm long and about 3.5 mm across the mesothorax. The pupae are found at a depth of 1/3″ to 10″ near the roots of the food plants. The pupal stage lasts from 7 to 17 days, after which the adult emerges out.

Adult.—The adult as it emerges is pale in colour, but it soon develops a light orange tinge. It begins to feed. Moulting occurs now, and egg laying commences in about a week's time. The adult lives for a month, but during hibernation they live for more than 5 or 6 months.

Hibernation.—This species hibernates in the adult stage from October to November. They hibernate on twigs of dried cucurbit creepers, *Cana indica*, mulberry bushes, lucern, brinjal, catton, cabbage, etc. for four months. Both the sexes hibernate almost in equal numbers, but the mortality in males is higher than in females.[25]

Time of Appearance.—The beetles come out of hibernation from March to April, deposit their eggs and tend to disappear. The eggs develop into larvae and pupae, which are abundant during April and May.

Number of Generations.—There are 5 to 6 generations in a year from the end of March to the end of October. Later on, the insects hibernate.

Natural Enemies.—(1) These are crows, mynas, and some other birds, which pick up the grubs and pupae when they are exposed by ploughing.

(2) The reduviid bug, *Rhinacoris fuscipes* feeds on the pumpkin beetles in the field.

Control Measures.—It has been already mentioned that the beetles coming out of hibernation cause the greatest damage by destroying the young spring crop of cucurbits. They are the parents of the future breeds, and as such some of the successful methods of control of the adults are first mentioned.

(1) *Repellants.*—Our farmers throw ashes with or without kerosene over the germinating cucurbits to repel the pest. The author suggests the use of dry slaked lime and tobacco dust for the same, to be diluted with ashes or road dust. Tobacco dust is in addition a good manure.

(2) *Dusting Stomach Poison.*—Repellents, however, effective are not very efficient, and as such, Paris green mixed with ashes or fine road dust in the proportion of 1:8 by weight or lead arsenate 1:32 dust gives satisfactory results, preferably through a dusting machine. The precautionary measures adopted while dusting are:—

(1) Dusting is operated on moist leaves, early in the morning. (2) For adhering to the leaves, fine powder is used. (3) A thorough dusting of the entire creeper is performed. (4) The operation is repeated after rains. (5) It is rather risky to dust on windy days.

(3) *Spraying.*—Below are mentioned some of the successful stomach poisons which have been sprayed:

1. Naphthalene emulsion: Kerosene oil 2 gallons; naphthalene 10 lb; hot water 1 gallon; soft soap 1 lb.

2. Lead arsenate mixture: Lead arsenate 1 parts by weight; lime 8 parts by weight; mollases 600 parts by weight.

3. Tobacco decoction: Tobacco (Refuse) 6 parts by weight; soap 1½ parts by weight; water 600 parts by weight.

Spraying is done before the attack of the pest, and is repeated every 6 days for the first brood (Husain et al., 1926).[25]

(4) *Mechanical Method.*—Hand-picking or collecting with hand nets is not a successful approach here.

(5) *Trap crop.*—The treatment of early grown cucurbits with stomach poison to destroy the early beetles has a low mortality percentage.

Control Measures against Grubs and pupae.—(1) soil fumigation. It is accomplished most cheaply by pouring strong tobacco decotion yound the roots of the food plants.

(2) *Ploughing the field after the Crop.*—Soon after harvesting, this procedure has been found successful to destroy grubs and pupae.

Suggestions.—(1) It is advisable to sow early varieties or to sow ordinary varities at an early season so that the crop develops ample foliage to resist the onslaught better. (2) It appears to be safe to grow excess of seed-lings during four successive weeks to get at least one of the four seedling safe. If the crop is much conjusted it can be thinned later on.

(6) *Epilachna Species* (*Spotted ladybird beetles*)

Order Coleoptera
Family Coccinellidae

Vernacular Names.—It is commonly known as Seedehula, Gulaganjihula in Mysore and Hadda in Punjab.

Historical.—Of all the genera of the family Coccinellidae, *Epilachna* is the only genus, the species of which are phytophagus. *E. vigintiocto punctata* is distributed all over Asia, while in India *E. dodecastigma* is also a pest of crops.

It is reported as a pest as early as 1918 by Ayyar (1927),3 and *E. dodecastigma*, was found as pest of brinjal seedling in North India. Later on the genus gained importance in Travancore and Mysore. It was found attacking potato, brinjal, cucumber, melon, pumpkin, and bitter gourd. A few weeds like *Datura*, *Solanum nigrum* and *Lycopersicum esculentum* are also attacked.

Of all the pests of valuable crops, *Epilachna* beetles rank very high in importance. The beetle entirely

removes the epidermis of the leaves by mandibles which act like sheers (Krishnamurthy, 1932)29, a habit, quite peculiar to them. Young larvae feed on the epidermis only, but as they grow they eat away the green matter of the leaves from the underside. The adults injure the upper epidermis eating up regular areas, leaving parallel bands of unattacked tissue, forming a lace like structure.44

In cases of severe attack, the entire plant becomes skeletonized with all its leaves appearing as a sieve like structure, the plant becomes brownish yellow and soon perishes.29

General.—There are 3 species of the lady bird beetles, of which the first two are pests on cucurbits and solanaceous both, and the third one is a pest of cucurbits only: (1) *Epilachna dodecastigma* is a deep copper coloured beetle which bears six black dots on each elytron. (2) *E. vigintioctopunctata* is deep red in colour, and each elytron bears seven to fourteen dots. (3) *E. dumerili* is of light copper colour with a shining appearance and six black dots which are encircled with yellowish ring on each elytron.

It is widely distributed in Pusa, Nilgiri, Jorhat, Chapra, Coimbatore,21 Travancore, Banglore and Hokote etc. It occurs on leaves of *Luffa aegyptica*, potato, brinjal, tomato, cucumber, *Solanum*, cowpea bitter gourd, *Momordica*, pumpkin and other plants.

Copulation.—From March to April, the beetle usually mate in the early hours of the day for nearly two hours. Two to three days after copulation, the female begins to lay eggs.

Egg.—The yellow and elliptical eggs are laid in clusters of 45 each, attached to the undersurface of leaves by short stalks. The beetle can lay 120 to 150 eggs at a time and about 450 eggs in her life time.29

The egg hatches in 3 to 5 days. The larva coming out of the egg through an opening made on one side of the apical end. The maximum number of eggs of *E. vigintioctopunctata* & *E. dodecastigma* hatch in three days at $80 \pm 3°$F.38

Larval Stages.—There are 4 larval instars:29

FIRST INSTAR: Length, 2 mm; width 8 mm.

Here, the prothorax is provided with two groups of short conical pointed chitinous teeth, each group with 4 to 5 teeth. Thoracic and abdominal segments have long, sharp spines, each segment having 4 to 5 spines. After 12 to 24 hr it changes into the 2nd. instar larva.

SECOND INSTAR: Length 4.5 mm; width 1.5 mm.

The body spines are larger and darker in shade, and the prothorax becomes devoid of teeth. After 7 days it moults into the 3rd. instar.

THIRD INSTAR: Length 7.5 to 10 mm; width 3.5 to 4.5 mm.

The larva increases in size. It moults into the:-

FOURTH INSTAR: which becomes sluggish for a couple of days. It fixes at the hind end and after nearly 24 hr, it transforms into a pupa.

Pupa.—The outer covering gets folded, and after 3 to 6 days the adult beetle emerges through an apical slit.

Adult.—It liberates itself from the pupal covering by a series of convolusive movements. It becomes a voracious feeder within 24 hr.

During winter, the adult beetles hibernate among heaps of dry plant parts, and in cracks in the soil. The over wintered beetles emerge from the last week of March to the middle of May. They lay eggs, and 4 to 6 generations are passed from April to October. The damage is severe during May and June and also in July by the first and second brood of the pest. The brood so overlap that all the stages are to be observed in the field till September.

Larval Predator.—The reduviid bug, *Rhinocoris fuscipes feeds* on the larvae of Epilachna beetle, *E. dodecastigma* and *E. vigintioctopunctata* in the field. Two to three caterpillars form the maximum feed per day.

Parasites.—The larval as well as pupal stages of *E. vigintioctopunctata* are attacked by the endophagous parasite *Pleurotropis foveolatus*,3,29 from Mysore and South India.

The parasite, *Tetranychus ovularum*, attacks freshly laid eggs, not more than 1 or 2 days old, to a percentage of 1.5 to 2.45.

Control Measures. Mechanical.—Catching the adults with hand and nets, and destroying the egg masses and larvae is much effective at a very early stage. The process is to be repeated for about 8 to 10 days.

Chemical.—Treatment with sodium fluosilicate, lead arsenate and the water extract of the bark of *Mundulea suberosa* (abundant in the forest area) has brought successful results. Lead arsenate is

quite economic to be used on a large scale in the field.[29]

Dusting.—(1) A pound of lead aresenate, mixed with 8 lb powdered lime mixed with fine road dust or silicate mixture, dusted with a machine or muslin bag yields 60 to 70% mortality in 2 to 3 days. (2) Adults and grubs may be destroyed within 1 to 2 days of *E. vigintioctopunctata* and *E. dumerili* by a mixture of D.D.T. 0.5%, 1%, 2%, 4% with cow dung ash as carrier.[49]

*Instructions for Dusting.*46—(1) Dusting operation may be performed in the early morning when the leaves are wet with dew. (2) The operation may be repeated twice in May, and once in June, if required, and should be repeated after every shower of rain. (3) Fine dust should be used to adhere the leaves better. (4) Dusting is rather risky on windy days.

Spraying.—When the crop is 2 to 3 weeks old, a thorough spraying of the infected as well as non infected areas is done to kill the present generation and reduce subsequent multiplication.

Some of the tried and successful formulae are:

1. Sodium fluosilicate: 1 lb; water 10–20 gallons.

After 4–5 days, the mortality is upto 40%.

2. Rosin compound solution: Common rosin 2 lb; hot washing soda 1 lb; water 1 gallon.

3. Lead Chromate Paste: Lead chromate 33%; powder 202; water 1 gallon.

4. Lead Arsenate: Arsenate 1 lb; water 50–60 gallons; lime 5 lbs; jaggery 10 lbs.

It is cheaper than Chromate and more voilent poison, the percentage of mortality being 90. (Krishnamurthy, 1932).[29]

5. *Mundulea* Bark Powder: Extract of fine powder 1 lb; water with soap 8–10 gallons.

A number of hairy spines present on the larval body, facilitate the insecticidal action by retaining it for a considerable time. Most of the adult beetles also die, when thoroughly sprayed. It is applied both as a powder and as a spray in the case of water extract.

Biological Control.—An important larval parasite, *Pleurotropis foveolatus* has been successfully tried in India by various workers. Lal30,31observed a heavy parasitization in the early September. During 2nd., 3rd. and 4th. week of September, a large number of adult parasites emerged from about 300 *Epilachna* grubs in the lab. Simultaneous field work gave the same result. At the end of September, every grub was parstized and the pest was brought under complete control at a temperature of 77.9°F. minimum, and 92.7°F. maximum, the average relative humidity being 89.7%.

Age of Host suitable for Parasitism.—Excepting the first instar larva and fully formed pupa, all other stages, the 2nd. and subsequent larval instars and early stages of the pupa are suitable for parsitization, the 4th. instar larva being preferred most.

Symptoms of Parasitism.—The parasitized larva is readily distinguished from the healthy yellow grubs by its brown appearance, sluggish nature, and scarce feeding. It fails to pupate, and dies in 5 or 6 days.

Field Observations.—The parasite is common in the field alround the year, but in adverse conditions from December to January and March to June it becomes scarce. The percentage of parasitism never exceeds 5 to 8 in Banglore,29 18 to 16.9 in Bihar in October.

Stinging and Egg Laying.—The female parasite perches on the back of the host and stings it by a sudden jerk, and lays from 24 to 50 eggs in groups below the larval skin at an interval of 15 to 20 min. The female may parasitize more than one host and lives for 10 days. The egg incubates from 24 to 28 hr and larva emerges out. After a week to two weeks the pupa emerges and after 3 to 4 days in summer and 10 to 12 days in winter the adult emerges through irregular punctures in the larval integument.

Suggestions.—(1) It is reasonable to assume that by destroying the wild host plants of *Epilachna* occurring nearby the crop and thereby starving out a part of survivors after the removal of the main crop from the field, and supplementing with lead arsenate spray, a good control will be obtained. (2) Wherever it is convinient, the seedling may be grown in covered nurseries till they are big enough to be transplanted, so as to avoid the attack at a juvenile stage.

Addendum.—In a recently published research monograph on the "Biology and morphology of the larva of bean beetle, *Epilachna chrysomelina* Fabricius" (1966–1968, Department of Publications, University of Karachi), Shahid Husain Ashrafi recorded this species from Lyallpur,

Muzaffarabad, Kashmir, Tandojam, Hyderabad and Karachi on the musk melon (*Cucumis melo*), pumpkin (*Cucurbita pepo*), water melon (*Cucurbita citrullus*), and cucumber (*Cucumis satuivus*) where the larvae cause much more damage to the crop than the adults. The bionomics and anatomy of the fourth instar larva are described in considerable detail. The control measures remain to be worked out.

(7) *Julodis atkinsoni*

Order Coleoptera
Family Buprestidae

Habit.—The buprestid beetle was first reported from Derae Ismail Khan (Punjab) causing considerable damage to cotton and melon crops in June 1895.

The female of this beetle was found feeding on 'joasa' leaves at Delhi. It also fed on leaves of cotton, hollyhock and *Zizyphus* in captivity. It laid 38 eggs in the soil singly as well as in small batches for 32 days. The eggs are creamy brown and cylindrical with rounded ends. The incubation period lasts for 35 days. The larva comes out by puncturing an aperture near the middle of the egg, and go into the soil, where they feed on the roots.[7]

Control measures are not yet worked out.

It is a minor pest of cucurbits.

II. Diptera or True Flies

(8) *Dacus brevistylus*

Order Diptera
Family Trypetidae

Habit of the Pest.—Just before laying eggs, the famale is very active. It goes about over the fruits a number of times and selects a convinient spot for egg laying which is very often near the stalk. This habit probably facilitates the dropping of the fruits at the time the maggots are full grown and ready for pupation, which under normal conditions takes place in the soil. The female after selecting the spot for oviposition, stretches out its ovipositor, with which it pricks the fruit and a liquid of dry white colour oozes out of the puncture. The female flies off for a while, comes back and licks up the fluid collected in the form of a globule. Again she thrusts her ovipositor in the same place moves it up and down a number of times. In one puncture as many as 8 eggs are laid. Three such punctures have been noticed in a single fruit containing a maximum of 22 eggs.[10]

Cephalandra indica is the main food plant. The fly has been noticed to breed in captivity on snake gourd, bitter gourd, cucumber and melons. From field collections of the fruits also adults have been reared out.[10]

Two days after egg laying a small hole is seen on the fruit at the place of oviposition and the adjoining areas begin to turn soft and brown. In about 4 or 5 days the entire fruit turns brown by which time the maggots have completely devoured its contents, leaving only the shrivelled up skin and seeds. If the maggots are only a few in number a portion of the fruit still remains fresh, but the fruit in either case drops down.

Egg.—Generally three to four eggs are laid in each puncture, the egg being found adhering to the seeds. The egg is about 2.5 mm in length, shiny white, slightly curved, cylindrical in shape and narrow at one end. The incubation period varied in the laboratory from a little less than 2 days to 4 days.[10]

Maggot.—The freshly hatched larvae are of the same size as the egg. When full grown it is 8 mm long and 1.4 mm broad. The maggots when full grown drop either with the fruit or by themselves in the soil. In the field through the maggots drop in one place from a fruit, they disperse slightly before they enter the soil for pupation. The depth of the soil at which they pupate varies from 1/2 to 2 in. depending upon the hardness or looseness of the soil. The larval period in the laboratory was 4 to 6 days in October, 1935.[10]

Pupa.—The pupal period varies from 8 to 10 days. The puparium is elliptical and brownish in colour and about $4\frac{1}{2}$ to $5\frac{1}{2}$ mm long and 2 to $2\frac{1}{2}$ mm broad.

Longevity of Flies.—The average longevity of the fly of both sexes is generally 28 to 30 days.[10]

Total Life Cycle.—Total life cycle ranges from 15 to 17 days depending upon ecological factors. There are 5 to 6 broods in a year.

Natural Enemy.—The only hymenopterous parasite recorded is *Opius incisi* by Cherian and Sundarum.[10]

Control Measures.—The attacked fruits should be hand picked and destroyed completely or rather burnt.

(9) *Dacus cucurbitae* (Melon fly)

Order Diptera
Family Trypetidae

It has been described from Hawaiian Islands, tropical regions on cucurbit fruits,33 South Africa on young cucurbits (Munro, 1925)37, Formosa on beans and tomatoes,27 South India and Java on cucurbits, tomato and papaya.52 Ponce39 noticed *D. cucurbitae* on seven species of cucurbits, brinjal, tomato, guava, mango, peach and karela.

It is found throughout India and Pakistan. It is common in Coimbatore on melon, cucumber, pumpkin, water melon, *Luffa aegyptica*, *Trichosanthes dioica* fruits, *Cephalandra indica* stem, making galls in wild small fruits and cultivated large fruits of *Cucumis trigonis*, *Momordica charantia* fruits, and *Trichosanthes anguina* fruit.[21] It was found to be a pest on peas, *Nux vomica* and cucumber in Madras *Lagenaria vulgaris* at Delhi, peach and mango in Punjab,44 *Luffa aegyptica*, bottle gourd, bitter gourd, *Cephalandra indica*, tinda in Kanpur,[8] and brinjal and tomatoe at Naini, Allahabad.

It has been recorded from Peshawar,[47] Charsada, Hiarpur, Kohat, Bannu and all over the N.W.F.P. (Pakistan) irrespective of climatic conditions.

The fruit fly is a serious pest of cucurbit plants, the larvae being the sole cause of the damage. It has been recorded causing great havoc in the North West Frontier State;44 the average damage being 20 to 50%. In 1946, there occurred another epidemic of fruit flies in South Hills, causing thereby a damage of 20 to 50%.54

The maggots bore into the pulp and nibble the fruit into galleries. They nibble out the pulp of the fruit which is afterwards attacked by fungus thereby causing it to rot. Karela (*Momordica charantia*) and *Luffa acutangula* usually get distorted in shape, showing one or two holes from which the maggots desert the fruit for pupation.47 If a ripe pumpkin is infected with a large number of maggots a rapid decay changes the pulp into a semi-liquid mass possessing sickening odour. The fruits which have been infected and the point where infestation has occured become curved or a depression occurs on them. The maggots are also found attacking tender shoot and thus in the long run damaging the entire plant.

Economic Status of Fruit Flies.—Among insect pests of fruits, fruit flies occupy a very important position. Nature has endowed these creatures with some special facilities which make their depradations far more serious and comparatively difficult to check, for these maggots bore into and remain inside fruits, and as such, they are protected from outside and are beyond the reach of any measure like spraying, dusting etc. Their habits also make them comparatively immune to attacks of natural enemies like parasites and predators once they are inside a fruit. In addition, they are also carried from place to place safely harboured in fruit both by human and other agencies. Their rapid multiplication and the capacity under ordinary circumstances to pass through numerous generations in the year help them to maintain their major status as fruit pests.[3]

The flies generally copulate in the field in the evening time for a period of 45 to 90 min. The pre-oviposition period varies from 14-24 days depending on the season. It increases from 23–24 days in November and December. After copulation, the female becomes very active. It punctures the fruit by means of its pointed ovipositor and a white coloured liquid oozes out of the *Luffa* plant, which solidifies in due course to form a protective covering over the puncture. In the case of *Luffa* and pumpkin the punctures are more numerous in young fruits, but in the case of brijnal only ripened fruits which become somewhat pulpy are attacked. Long white eggs are laid in the receptacle made by the ovipositor.

The eggs hatch out in 2 to 3 days and the young maggot begins to tunnel into the fruit. The maggots are cylindrical, pale yellow, tapering towards the head and with dark mouth parts.

The larval stadium consists of 3 instars which occupy a period of nearly a fortnight. The first instar larva has an average length of 3 mm and a breadth of 0.75 mm, the respiratory system at this stage is of metapneustic type *i.e.*, the last pair of abdominal spiracle is open.

The second instar larva is 5 mm long and 1 mm broad and the length of the third larval instar increases to 7 mm and the breadth to 1.5 mm and the respiratory system is of amphineustic type, *i.e.*, the prothoracic and post abdominal spiracles are open.

The last instar larva is 10 to 13 mm long and 2.5 mm broad. The respiratory system becomes complex due to tracheal anastomosis.

Pupation.—The rotting of the fruit and its falling down on the ground as a result of the damage caused by the maggots, helps in reaching them to the soil in order to pupate there. Rarely, however, they pupate while still in the fruit. The pupa is incapable of movement. It varies from 4 to 7 mm in length and from 2.5 to 3.5 mm in breadth. The body of the pupa is marked by a number of transverse bands.

The colour of the pupa varies with development. In the begining it is yellowish white but turns yellow at the end of the second day. As the development proceeds the colour becomes brown and by the time the fly emerges, the pupa is completely dark brown in colour.

The pupal stage lasts for almost a week in normal season. The adult flies can live for a period varying from 2–3 months, the whole life being completed in 3 to 4 weeks.

Seasonal History.—The adult flies are active throughout the year and continue breeding except for a short period in the winter. Summer is passed on cucurbit vegetables, which are in plenty. In winter, the duration of the egg, larval and pupal period is prolonged and the fly mostly breeds in tomatoes (*Lycopersicum esculentum*), brinjal (*Solanum melongena*) and wild cucurbits depending upon their availability, otherwise the flies live on the nector of flowers, on the juices of the fruit and on honey dew.

Natural Enemies.—Probably due to numerous complexities and varying climatic and other conditions, which govern biological principles, the biological control is not satisfactory. *Opius fletcheri*, *Synt mos phyrum*, *Ipobracon* sp. and other parasites have given good results. The method requires further experimentation and elucidation.

Control measures.—A number of control measures have been put forward, but none of them make a complete control or check of the fruit fly. It appears to be proper to destroy earlier stages to prevent further multiplication.

The larvae in the attacked fruit should be destroyed promptly and completely by boiling, burning, or deeply burrowing under ground, because experiments have shown that a proportion of flies will emerge from puparia situated as much as 2 to 3 feet below the ground. The affected fruits, therefore, be burried deeply or rotten in water where the larvae cannot escape, say to a depth of 4 feet.3 stresses on keeping fields and plains clean and sanitary. Deep summer ploughing, followed by flooding to kill the pupae by direct sun heat and exposing the fallen larvae to birds which feed on them, has also been suggested Raking up of the soil under infested trees and fields during winter to destroy hibernating pupae has also been suggested.

Chemical.—The flies require ten days after their emergence to begin reproduction and during this feeding period the flies subsist on nectars and other sweet juices. This period is made use of in control of the insect.

Rahman44 suggested a poisonous bait spray consisting of lead arsenate 1 chattak; mollasses 2 chattaks; and water ½ lb.30,31 mentions spraying the plants with a bait spray containing lead arsenate 20 oz., mollasses 4 oz. and water 8 oz. to attract the flies and cause their death when they feed on poisoned leaves and fruits. Verma54 suggested spraying nicotine sulphate to be used at the rate of one part in hundred parts of aqueous solution containing 5 per cent mollasses.

The fruit flies53 show chemotropic responses to citronella oil, ammonia, vanilla and clensel. They investigated the efficiency of bait traps for the control of fruit flies. Clensel, however, had slight advantage over others. Clensel when tried in 1:30 dilutions gave higher percentage of attraction as compared with other dilutions. For economy, trap bottles should be kept at 15 ft distance.

(10) *Myiopardalis paradalina*

Order Diptera
Family Trypetidae

This species has been recorded as a pest of melons in the Punjab and North West Frontier Province26 and.47 It is a very serious pest in Baluchistan wherever melons are grown.

This fly lays eggs under the rind of a developing fruit. The maggots on hatching bore into and feed on the pulp which soon gets rotten. When present in large number, the growth of the fruit is arrested. Sometimes more than 90% of the fruit is damaged by the maggots of this fly.26 Due to the serious infestation of this species, melon cultivation in Baluchistan has received a severe set back.

The overwintered pupae are found at a depth of about 2 inches in the soil in field, where melons were cultivated in the previous year. At the begining of May, when the early varieties of melons begin to flower, the adults emerge and soon after pairing, the female selects the young fruit for oviposition. She cannot succeed in puncturing the rind of a healthy melon of over four days growth. Early morning is the time when flies are found busy depositing their eggs in the very young swelling fruit, even selecting those which have the flowers still attached to them. It is deposited below the rind in a hole made at right angles to the rind by a pointed implement attached to the ovipositor of the fly. The position of the puncture on the rind is shown by a small projection of gum,

of reddish appearance, which dries and falls off in a few hours after which it is impossible to tell by outward appearance, if a melon is punctured or not.

The eggs are long, pointed at both ends, opaque white in colour and visible to the naked eye. Five eggs are generally deposited in a hole. They hatch in four days and the young grubs make their way to the seed pulp, leaving the remains of the egg shell behind.

During the time the grub is feeding on the seed and the pulp surrounding the seed, it constructs tunnels to protect itself from the fruit juice; accumulating by gravitation at its posterior end, but if the fruit is turned over, the grub has to leave feeding, and commences new protective tunnels in other directions that will drain by gravitation at its posterior end, and so keep the tunnel clear for obtaining its supply of air, but if the fruit has not been disturbed the grub after about 15 days of laying of the eggs commences leisurely to eat its way through the edible pulp towards the rind which it takes about 20 days to reach, when it cuts its way out, head foremost, and goes to earth under the fruit and in some cases if the soil is loose buries itself about an inch below the surface, when its larval skin gradually hardens so as to form a case, it remains in the pupal stage, until its period of transformation comes for development into the perfect insect. It remains in the pupal stage for about a fort-night. The life cycle is completed in about 5 weeks.

Seasonal History.—From May to August, 2 to 3 broods are produced depending upon climatic conditions. The maggots of the second brood attack the newly set melon, the sowing of the crop being done by the end of June. The maggots of the last brood pupate in September in which stage winter is passed, the flies emerging in the following May.

Control measures. (1) *Mechanical.*—Very young fruits with flowers attached to it, can be buried inside the heap of a dry earth and so kept out of reach of the fly. The cultivators for this purpose should examine some fruits for the external signs of gum drop showing the presence of flies eggs beneath the rim. The fruit that shows least number of these signs or that which shows no signs of being punctured is selected for being covered over. The selected fruit is then placed on the ground in a slightly raised portion and a basket full of dry lose earth is kept over it. This practice is successful against the fly pest, and it causes no harm to the development of the fruit, but it bleaches the rind of the fruit to almost pure white. After 15 days the earth covering is removed and the fruit is now daily turned over during the next six days, when it rapidly assumes its natural colour.

The practice of turning over the fruit at certain intervals is remarkable as it is to prevent the chance of cutting out of any grubs in case the fruit should have been attacked before being covered over with dry earth.

(2) In the case of musk melons which cannot be burried each selected fruit should be placed in a light muslin bag six inches broad x 8 inches long, the mouth of the bag being drawn close round the stem, supporting the fruit by a thread. When the fruit so protected attains the age of 6 days, the bag could be removed and placed over some other selected fruit. In this way, one bag can be used for the protection of about 20 young melons against the fly during the season.

(3) As the plants of the melon family bear bisexual flowers and the difference between the sexes is apparent, it would be an easy matter to fertilize the flower as they open, and put them into the bags at once, so as to shorten the time they would be open to the attacks of the flies. Owing to the size and formation the operation is simple and can be performed very expeditiously.

It is a fairly common pest of much importance.

III. Hemiptera or Plant Bugs, Etc.

(11) *Aspongopus brunneus*

Order Hemiptera
Family Pentatomidae

It is a brown, ochraceous bug, found in Bengal, Ranchi, Assam, Naga, Khasi Hills, Siripur and Pusa, and other places. In Pusa it is found on pumpkins. It is most common in rainy season.

These bugs suck the sap of the food plants, and in cases of serious attack by nymphs and imagines, the leaves turn brown and ultimately die, the whole area presents a sickly appearance. It happened so in Pusa in July, 1916.

Adults are sluggish in habit. The eggs are laid in clusters on leaves as well as on the leaf stalks. The nymph emerges out by puncturing a hole in the egg shell. In the early stages nymphs are gregarious and are seen clustering in numbers round the leaf stalks and stems. They emit a characteristic punjent odour.

Hand picking of adults and nymphs is recommended.

It is a minor pest of cucurbits, but sometimes becomes a serious sporadic pest.21

(12) *Aspongopus janus*

Order Hemiptera
Family Pentatomidae

It is 16 to 20 mm. long, and is found in Hardwar, Khasi Hills, Calcutta, Bombay, Khandala, Madras, Trivandrum, Bangalore, Ceylon, plains of South India Chakwal (Punjab), Poona, Muzaffarangar (on cucurbits), Pusa (on pumpkin and bottle gourd), Adoni and Salem (on pumpkin), Travancore (on bottle gourd, brinjal, lababs, and pumpkin)21 and Lyallpur.

These pests are seen in cucurbit fields from May to September. Both adults and nymphs suck juices from the branches, leaves, buds etc. of the creeper by inserting their beak (proboscis).

Eggs of a dark brown colour are laid on the leaves in a single row, from which emerge nymphs of orange red colour. The antennae and legs are black, and black spots are present on the back.

(1) Hand picking of the adults and nymphs is recommended. (2) Bugs are mechanically shaken into pails of water containing little kerosene oil on the surface.

Natural Enemies.—Eupelmus aspongoni is an egg parasite of this bug, found at Kanpur. Parasitized egg masses were collected from the fields at Kanpur, and identified.

It is a minor pest of cucurbits, but sometimes becomes a serious sporadic pest.21

(13) *Frankliniella sulphurea*

Order Hemiptera
Family Aphididae

Description.—It is found on leaves of ash gourd, water melon, halwa kaddu and in the flowers of torai. These food plants have been recorded from Lyallpur.

Life History and Control Measures are not yet worked out.

It is a pest of minor importance.

(14) *Gallobellicus crassicornis*

Order Hemiptera
Family Miridae (Capsidae)

It is a common pest, found on gourds, sucking the young leaves, on tobacco leaves, seed capsules and weeds in great numbers at Pusa.

It sucks the plant sap from tender portions of food plants like leaf and young shoot.

These are fragile, but active light green insects, found in all stages of development on the food plants, especially the top shoots and young leaves. The adults as well as the mymphs become torpid with cold, they are most active during the hottest parts of the day, flying about, stimulated by even very slight disturbance. The male is smaller than the female and are commonly observed in crops, on tender tobacco plants as well as gourd.

Eggs are laid singly in the tissue of the leaves along the midrib and are somewhat curved in the middle and rounded posteriorly. Each egg has a pair of fine threads attached to it at its free end, which is not distinct to naked eyes. The nymphs come out through an anterior slit, and lie motionless for sometimes near the egg shell. The nymph develops into the adult. The females are more common than males.

Control.—Mechanical methods of hand picking, and shaking the plants over pans of water and oil or over oily clothes are efficient control measures. (Fletcher, 1914.)19

It is a pest of minor importance.

(15) *Leptoglossus membranaceus* (Paddle legged bug)

Order Hemiptera
Family Pentatomidae

It has been found on *Trichosanthes cucumerina*, orange trees, passion fruit, pear, plumb, cape gooseberry, beans, peas,21 tomato and cabbage, but the damage is not serious.

It is distributed in various parts of Pakistan, India, Ceylon, Andaman Islands and Burma, etc.

The bug sucks fruit juices by thrusting its beak, with the result that the punctured fruit drops off before it is mature. In the case of peas and beans, the young parts are seen to shrivel and wither.

Life history is not completely worked out. The eggs are deposited in clusters on the twigs and leaves of plants. The young insects resemble the adult, but are smaller and wingless.

Control Measures.—Insects with piercing and sucking mouth parts are not to be treated with stomach poison, but with contact poisons, and as such kerosene emulsions, vermisapan, Mac Dougall's solution etc. are to be employed which kill the early stages of the insect, when the body is soft and unprotected by wing cases.

Mechanical Method.—Insects are caught through hand nets and thoroughly destroyed. Every female that is killed may prevent a brood of perhaps 50 young ones. They are easily collected by shaking the plants in the early morning, when they are comparatively sluggish. They may be caught on bamboo winnoying trays smered with tar or some other sticky substance, a method commonly employed by the rice cultivators to catch the paddy bug. A thorough control is essential to destroy the bulk of brood before the insect has deposited their eggs.

It is a pest of minor importance.

(16) *Megymenom brevicorne*

Order Hemiptera
Family Pentatomidae

It has been recorded from Khasi Hills, Calcutta, Burma (Rangoon), China and Malaya.

This brassy black bug and its nymphs have been noticed as feeding on *Passiflora quadrangularis* (Passifloreae), pumpkin, and snake gourd.36

Upto 18 cylindrical eggs, covered with whitish silky or waxy substance are laid in a chain end to end on the upper and lower sides of the leaves, or the stems of the food plant.36 The eggs are pale whitish when freshly laid and turn to a reddish tinge before the eclosion of the nymph.

The nymph emerges by forcing up the circular operculum present at the upper end of the egg. A few hours before hatching the embryo nymph may be seen through the chorion of the egg. At the time of hatching nymph is pink in colour, which darkens in later instars, and spots and markings become more dense. Five instars are passed on, the average duration of which is:—

First Instar 10.10 days; second Instar 8.50 days; third Instar 9.75 days; fourth Instar 15.30 days; fifth Instar 30.25 days; adult stage 11.75 days (Miller, 1929).36

The adult insect of both sexes is entirely black or coppery black, but owing to the presence of a white wax like substance, it appears greyish. The membranous portion of the hemelytra is pale ochraceous with an irregular dark brown shading, which is most pronounced along the veins.

There is observed a tendency towards gregariousness when several mymphs and adults are kept close. Both nymphs and adults have the curious habit of vibrating their antennae when disturbed. The total life cycle from the deposition of egg to the life of the adults is about 94 days.

Control.—The eggs, although, inconspicuous, may be discovered and destroyed by crushing. For adults, best results are obtained by mechanically dropping the bugs in a tin of water containing a film of kerosene oil on the surface. This can be achieved by shaking the plants in the early morning.

It is a pest of minor importance.

(17) *Metacanthus pulchellus*

Order Hemiptera
Family Berytidae (Neididae)

It is widely distributed chiefly in North India, on cucurbits, but it is seldom a serious pest. It has been found to damage bottle gourd by puncturing the young fruit. It has been collected from Pusa on pumpkin bottle gourd and the solanaceous tobacco,19 while a record on tea at Duars is also known.

It has been found damaging seed capsules of tobacco by sucking up the sap through its beak. Cucurbit plants, often laden with nymphs and adults of this bug are seen to be least affected. It damages to a little extent the bottle gourd plant by puncturing the young fruits; the sites of punctures exude a sticky secretion.

Life history not completely worked out. The eggs are inserted into the tissue of the leaves of bottle ground. The nymphs and adults are seen on the under surface of leaves.

Control Measures not yet worked out.

It is a pest of minor importance.

(18) *Nezara viridula*

Order Hemiptera
Family Pentatomidae

It is commonly distributed throughout Pakistan, India, Burma and Ceylon.

The chief food plants are cowpeas, cucurbits, coriander, cotton, cocao, potato, tomato, tobacco, maize, rice and wheat. Citrus orchards are also attacked when the latter is in vicinity of the former.

The injury is both direct and indirect. The food plant is directly injured by loss of plant sap, and it prepares a ground for the attack of fungi and bacteria, thus injuring indirectly. The fruit turns brown or black and bitter in taste.

Oviposition takes place between February and April, and eggs are laid in masses of about 40 each on the under surface of the leaves. The incubation period varies between 4 to 7 days depending upon the atmospheric conditions of temperature and humidity.

The nymphal stage lasts for about a month, during which about 5 moults occur. The nymphs and adults destroy citrus orchards, and with onset of rains multiply rapidly and attack the young crop of cucurbits.

Natural Enemies.—The eggs are parasitised by *Telenomus* sp. and *Microphanurus* sp.; while the adults are attacked by *Sarcophaga sternodontis* and *Trichopoda pennipes.*

Control Measures.—Brushing the bugs into pans of kerosinated water42 is the most satisfactory method. In case of bad infection, spraying with nicotine sulphate soap is recommended. Further in India, a weed plant, *Gynandroposis pentaphylla*, a tracts the bugs in large number, and as such these alternate host plants are to be totally eradicated from the neighbourhood of the food plants.

It is a pest of minor importance.

IV. Lepidoptera or Butterflies and Moths

(19) Agrotis ypsilon

Order Lepidoptera
Family Noctuidae

Common Name.—Greasy surface caterpillar, Gram Cut worm, etc.

Vernacular Names.—Chaua ki Sundhi in U.P., Kirauna, Bhulla, Kumta, Godheta.

Introduction.—The caterpillars of this cosmopoliton moth have a peculiar habit of hiding in the soil during the day time, and coming out in night to eat vegetation or to cut off young plants.

Cutworms are major pests of gram30,31 potato tobacco, young wheat and cucurbit plants in U.P. and attack lentil, Khesari and pea amongst the pulses, opium, lucern, cabbage, ground nut, mustard, linseed, barley and oats in Bihar.

It is a palearctic species,44 and occurs throughout Northern India, mostly along a belt of 100 miles parallel to the Himalayas including Bihar (Dhanara, Sabour, Colgong and Pakur), North Bengal, Assam near Himalayas. Peculiarly, however, it is not found in Madras, Bombay, Central India and Madhya Pradesh.

The caterpillars are voracious leaf eater, and nocturnal in habit. Besides this, they cut out the plants either below or above the surface of ground in night, and carry their food underground during day time. As a matter of fact, the caterpillars destroy more plants than they can feed, and cause considerable damage. Lal30,31 states that at times new leaves of flower buds may also be cut off.

The duration of life cycle varies a great deal in summer and winter. The presence of moths in August, September and October shows that breeding occurs throughout the cold weather.

Oviposition.—The moths oviposit late in the night, preferably on poppy plants. The abdomen is curved downwards and thus eggs are laid on the underside of leaves or opposite side of the stem. A single moth can lay as many as 344 eggs33 or 2,000 eggs on weed grasses.16 The maximum and minimum number of eggs laid per day are 79 and 6 respectively. Usually 1 to 30 eggs are laid at a place.

Egg.—Dome shaped, creamy white eggs are laid in October in the plain, which hatch in 1½ day in summer to 8 days in winter30,31. The colour becomes dull after 12 hours to 3 days in summer and winter respectively.

Larva.—A yellowish grey bodied, 1½ mm long larva hatches by eating out a part or whole of the shell. It feeds on fallen leaves, under which it hides easily. Successive moults occur, and before each moult the larva rests for sometimes and takes no food. At the first moult the colour is yellowish green which earkens in successive moults.

The full grown larva is dark brown in colour and on being touched it coils in the form of a disc. In case of deficient food supply, the smaller and resting larvae and pupae are devoured by the bigger ones. When too much distrubed, they bite their own body. The larval stage lasts for 27 to 36 days, depending upon the weather.

Pupa.—Depending upon the weather, the larva pupates under ground after a rest of 1 to 3 days. The chrysalis is reddish brown and about 20 mm long. The abdominal segments are distinctly telescoped into each other. The anterior end is obtuse, and the posterior end is pointed. In advanced pupa the black eyes become prominent and the ventrally folded wings can be marked out. The pupal stage varies from 10 days in summer to 30 days in winter.

Imago.—The obtuse end of the pupa bursts open, and the moth creeps out of the case with soft and crumpled wings 2″ long usually at night, but a few cases are of day emergence as well.[33] During the day time the moths hide in cracks and corners, and fly about in night. They soon copulate, and the duration of life is from 4 to 12 days. Males are observed to die earlier than females.

Natural Enemies.—Of the braconids described to attack the pest, *Microgaster* sp. is more numerous and destructive to the second brood of the caterpillar.[17] The Ichneumon parasite, *Fileanta rufocauda* parasitizes *Agrotis* sp. in Punjab. *Amblyteles* sp. in also a parasite.

Control.—Mechanical: Hand-picking is recommended in small areas. After 8 years of research work at Bihar, Dutt[16] reported that the pest can be most satisfactorily collected by the use of Andres maire traps against the present moth.

Chemical.—Poison baits are successfully broadcasted or placed in small heaps in the infested field in the evening. The tried baits are:

1. Lal[30,31] suggests the use of sodium fluosilicate, bran, molasses, and water in the field.

2. Dutt16 has tried at Pusa the following formula: Bhusa 1 maund; water 6 gallons; white arsenic 1 seer; gur 2 seers.

This mixture is enough for 5 acres. The paste is to be put out in small heaps about 2 yards apart.

Biological.—The parasites (baconids, *Microgaster* sp. and tachinids) were used, but the mortality percentage was low and as such biological control is not accomplished.

Suggestions.—The caterpillar feeds on pea, gram, wheat, lentil, mustard etc. and as such the cultural method of crop rotation is not possible, and recourse should be taken to the chemical method of control.

It is a pest of major importance in India.

(20) *Laphygma exigua* (Indigo catterpillar)

Order Lepdoptera
Family Noctuidae

Vernacular Name.—Kathri in Bengal and Lurka at Patna.

It is distributed throughout India. It is a pale or ochraceous coloured insect.

A large number of food plants are on record, such as lucern indigo, onion chillies,21 Jute lentil turmeric, dhaniya maize, castor, ragi, *Cannabis sativa* and *Trichosanthes dioica* (parwal).[48]

The caterpillars feed on the green leaves of plants and remove the mesophyll tissue from the under surface and thus defoliate the plants.

The life history was worked out by Cherian and Kylasam.9 It is as follows:

Egg.—Eggs, both of fertile and sterile nature are laid in clusters of 200 to 240 on young leaves of food plants. The cluster is covered by a felt of grey hairs. It hatches in 2 to 3 days.

Larva.—Newly hatched larvae are buff coloured with black heads. Their coloration is dependant on the type of food taken. They feed on epidermis, and measure about an inch in fully developed stage. Like cutworms they get curled up when they drop on the ground. The larval period is about 15 days.

Pupa.—The mature larvae pupate on the naked surface, but some bury underground to a depth of 2 to 4 inches in cocoons made of silk and earth. The pupal period is about 6 to 7 days, and is not affected by temperature and humidity. There is no hibernating stage in the life cycle of the pest.

Adult.—Adults start egg laying on the 2nd. day of emergence. Moths come out only after dusk, and no host preference is manifested.

Enemies.—A number of parasites have been reported, such as *Sturmia inconspicuoides* and *Actia monticola*, belonging to the Tachinidae with a 3% parasitisation9 *Euplectus gopimohni* at Dacca *Euplectrus plecoptrae*, and *Bracon hebetor.*

A number of predators like the Myna bird, the long *Canthecona furcellata*, the *reduvid* bug *Rhinocoris fuscipes* are predaceous on young caterpillars. The latter devours 4 to 5 caterpillars per day.

A wasp, *Ammophila* sp. is particular in stinging the caterpillar to paralyze it and hen keeps it in a burrow, and deposits an egg on it. The egg hatches and the grub feeds on the caterpillar, which becomes in due course an adult.

Control.—(a) *Mechanical*: (1) Collection & destruction of egg masses. (2) The moths may be destroyed by means of light traps. (3) Bagging is also effective.

(b) *Cultural*: (1) Harvested field should be ploughed and the stubbles and trash collected be burnt away to destroy the exposed pupae. (2) Flooding the field is also effective.

(c) *Chemical*: (1) Stomach poisons like lead arsenate or calcium arsenate are used in the ratio of 4 lbs. in 100 gallons of water per acre in case of a bad infestation on a wide area. (2) Plant protection by dusting with sodium fluosilicate mixed with ashes or fine road dust in the ratio of 1:8 or spraying it, is also effective.

It has voracious swarming caterpillars, occurring principally on irrigated cucurbits in March and April.

(21) *Margaronia indica*

Order Lepidoptera
Family Pyralidae

It occurs abundantly every where in the plains of India, as a pest of cucurbitaceons plants.21 The Pusa collection contains examples from the following localities and food plants: Coimbatore—Snake gourd; Surat—Cucumber, pumpkin leaves; *Luffa aegyptica*; Pusa—Cucumber leaves, boring *Luffa*; fruit; Howral—*Cucurbita pepo*; Lyallpur—Kaddu.

The caterpillar is found on the lower surface of the leaves, and is about 25 mm long, slender and with the anterior portion flattened. It is bright green in colour. The pupa is dark brown in colour, lodged inside transparent white silken cocoons. Pupal period lasts from 8 to 10 days.

Control.—As a matter of fact, it is not found in sufficient number to require control measures. In case of serious attacks hand picking and operation of any stomach insecticide is suggested.

Natural Enemies.—At England, *Apanteles taragammae* was bred from the larva of the pyralid moth *M. indica*; in India same results were obtained at Agra.[5]

It is a pest of minor importance.

(22) *Pericallia ricini*

Order Lepidoptera
Family Archtiidae

It is a phytophagous species, and has been noticed on plaintain, pumpkin, gingalley, cotton, agathi, *Calotropis*, *Morinhga*, Oleander and *Colocasia* at Madras. The Pusa collection contains specimens from plaintain (Coimbatore), Tymampet (Madras), castor (Calcutta) sweet-potato (Howrah), *Cucurbita pepo*, castor and *Commelina* (Pusa).[21]

Life history is not completely studied. Larvae are dark brown or black, thickly covered with fine long reddish brown hairs, and are active in habits. Pupae are squat, red brown in colour and enclosed in a rather flimsy white cocoon affixed to an object above the ground level.19

Control.—The pest is not so abundant, and as such hand picking of larva and spraying of the plant is recommended.[19]

Natural Enemy.—*Apanteles ricini*, a parasite, was reared from the larva of this pest.[5]

It is a minor pest of castor and garden crops

(23) *Plusia peponis*

Order Lepidoptera
Family Noctuiidae

It is found in South India, Canara, Bombay, Sikkim, Bihar and Ceylon.

The moth larvae feed on cultivated cucurbits [33] and black and green gram.

The caterpillars feed on leaves and when abundant may defoliate the entire creeper.

Eggs are greenish white, globular, beautifully sculptured, or laid singly on the under surface of the leaves. The newly hatched larvae are 1.5 mm long. The caterpillar remains on the lower surface of the leaves and hides in it for shelter. The colour is usually green matching with the leaves. A series of moults occur and pupa and adult are formed.

Natural Enemies.—The larval stages are parasitised by *Ceraphron athanassi*3 at Coimbatore, by *Apanteles plusia* of the Braconidae family at Banglore The latter is now synonymised with *Apanteles taragammae.*[5]

Control.—Hand picking of larvae and pupae has been suggested by Fletcher.[19]

It is a pest of minor importance, but occassionally it becomes a serious pest of cultivated cucurbits.

(24) *Sphenarches caffer*

Order Lepidoptera
Family Pterophoridae

It is distributed throughout Pakistan and India; Gujrat, Madhya Pradesh, Plains & Hills of South India, Uttar Pradesh, etc. Fletcher21 reports it from the following localities and food plants: Coimbatore—lablab and bottle gourd; Surat—white gourd; Pusa—bottle gourd leaves, *Cajanus indicus*; pod, *Hibiscus mutabilis* petals; Allahabad—*Luffa* bud; Kanpur—kaddu; Lyallpur—kaddu.

The caterpillars eat holes in the leaves of bottle gourd, destroy the bud of *Luffa* species, and eat into the flower bud and pod of pigeon pea and other pulses, but never penetrate inside.

Egg.—The egg is oval, about 5 mm long, reticulate, and bluish green to yellow shining colour. They are laid singly on a flower bud or pod of pigeon pea or in clusters on a young leaf, in a concealed position below. Eggs hatch in 2 to 6 days depending upon temperature and humidity.

Larva.—A yellowish green, about 1 mm. long larva hatches from the egg by breaking through the shell. It exhibits mimicry with the substratum on which it feeds. It develops a green colour on pumpkin leaves, on the pea pod it has a lateral brown stripe and a green colour matching the food. The larva alters very slightly in the different instars. The body is hairy, and in full grown larva it is long, cylindrical, stout, pale green in colour and about 7 mm. long. There is a clothing of spines and hairs on the body, which probably serves a protective purpose, since the larva feeds on hairy leaves and pods.

Pupa.—The full grown larvae spin a silk chamber upon the leaf or pod over a surface about 10 mm by 8 mm and then rests upon it. Here it pupates, and gets fastened by two points, the anterior half remaining free and capable of being raised till it is almost at right angles to the fixed abdomen. The pupa is about 7 mm long and is attached to the underside of the midrib of a leaf. On the dorsal surface a system of highly specialised tubercles project.

Imago.—The moth in the resting condition has its wings stretched out at right angles to the body. The moths are to some extent diurnal and fly by the day. Copulation takes place by day or night and lasts for about 12 hours.

In winter the life cycle is longer than in the hot season or in rains. It takes nearly 2 months. The insect occurs throughout the year with no definite stage of hibernation. Broods succeed on from time to time irregularly. The pest is abundant in the early and late winter.

Natural Enemies.—(1) *Apanteles paludicolae* was bred from *Sphenarches caffer* at Pusa. The young affected caterpillars appear to be quite normal, but the full grown ones are sleepy, with their body bent in the form of an arc. The percentage of parasitization is maximum during November and December. It was 80.6% in December, 1934 and 1935. (2) Caterpillars feeding on *Lagenaria* leaves are said to be parasitized by *Apanteles rangi*

Control.—Is not worked out.

It is a pest of minor importance.

V. Orthoptera or Grasshoppers, Locusts, Crickets, Etc.

(25) *Brachytrypes achatinus*

Order Orthoptera
Family Gryllidae

Vernacular Names.—Jhilla in Lower Bengal. Jhingur in Bihar.

The distribution of this species appears to be rather restricted and the exact limit is not clearly known. It occurs abundantly throughout Bengal and Bihar, but in Madras only at Nellore. It is a serious pest of cauliflower, cotton, jute, tobacco, cabbage, potatoes, and chillies. It also attacks mulberry, *Acacia* species, camphor, orange, rice, melon, cucumber, egg plant, sweet potato, sugar cane and weeds.

These crickets work at night, therefore, their presence is not always detected and the damage they cause is in most cases attributed to wrong sources. They cause damage to the plants in nurseries and fields. They cut the young plants off level with the ground at night. They make burrows, 9 to 18 inches deep in the ground, specially in sandy soils and conceal themselves during the day time. They sit at the mouth of the hole in the evening and can be recognized by their shrill piping. In one village of India, out of 45 acres of indigo, 25 acres were utterly destroyed.

These insects are causing serious damage to young jute plants, whose fields have been destroyed and seeds have been resown for 2 or 3 times in some cases, but still without success. When the plants grow to a height of about 9 in they are more or less immune. They come out at night and cut down the plants eating some and dragging some into their underground nests. They are generally found on soil devoid of moisture.

The big brown cricket passes through one complete life cycle in the course of a year.

Egg.—For oviposition a hole is always made in the hard soil, each egg is thrust separately into the soil, so that the eggs do not touch each other. Eggs are laid in burrows under the ground about the month of September.

Each egg is about 4 to 6½ mm in length and about 1½ mm. in diameter. It is cylindrical in shape with rounded ends, a little curved on one side. The surface is smooth without ornamentation; colour is yellow at first, which turns creamy white later on. The two eyes of embryos being clearly seen as dark spots in advanced stage. Before hatching they turn greenish. The egg shell is thin, membranous and soft.

Nymph.—The nymphs hatch out by bursting the shell at the head end. The eggs hatch after about a month. After hatching the nymphs undergo five instars. In all these the cricket retains a remarkable similarity of appearance, general shape and also the colour. The two sexes are early distinguished, because the female possesses an ovipositor, which grows with the growth of the insect. At the fifth moult it attains the adult stage.

First Instar.—A newly hatched young nymphs measures about 4½ mm from head to hind end, 1½ mm across head and abdomen. The antennae are about as long as the body. The general colour is light brown, the abdomen being paler and showing dark tinge in the middle. In general appearance and shape the nymph resembles the adult, only it is small and possess no wings. The pronotum is big, the segments of the body are distinguishable.

Second Instar.—Length from head to hind end 14 mm; breadth across head and anterior part of prothorax 3 mm; breadth across abdomen 45 mm; antennae about 15 mm; cerci about 4.5 mm.

There is hardly any change in appearance and colour except that the abdomen is slightly darkened.

Third Instar.—Length from head to hind end 24 mm; breadth across head and anterior part of prothorax 8 mm; breadth across abdomen 7.5 mm; antennae about 25 mm; cerci about 8 mm.

In general appearance and colour the nymph hardly undergoes any change. Laterally the mesonotum and metanotum show a small elongation which is really the begining of the formation of the wing pad.

Fourth Instar.—Length from head to hind end 29 mm; breadth across head and anterior part of prothorax 9 mm; breadth across abdomen 8.5 mm; antennae about 30 mm; cerci about 9 mm; meomethoracic wing-lobe 3 mm; metathoracic wing-lobe 4.5 mm.

The wing-lobes lie lengthwise and flat on the body. There is hardly any change.

Fifth Instar.—Length from head to hind end 33 mm; breadth across head and anterior part of prothorax 9.5 mm; breadth across abdomen 9 mm; antennae about 32 mm; cerci about 9.5 mm; metathoracic wing-lobes (tegmina) 6 mm; metathoracic wing-lobes (hind wings) 9 mm.

The tegmina touch each other over the back. All the holes lie flat lengthwise along the body.

Sixth Instar.—The cricket assumes the adult stage. The actual duration of each moult cannot be ascertained, but Ghosh22 observed these periods in the case of several crickets out of which only one survived, and reach the adult stage. The data according to his observations are: Egg hatched 10th October; 1st moult 19th November; 2nd moult 27th January; 3rd moult 21st March; 4th moult 7th May; 5th moult 15th June.

In certain cases the growth is rapid and the fully winged adult stage is attained by April. The majority becomes adult by June, while yet a few may be found in the nymphal stage as late as August. The adult cricket dies after laying eggs.

Control Measures.—Mechanical: The crickets may be collected and destroyed, when they are driven out of their burrows by the first heavy showers of rain. A better method is to beat them with broom, one effective stroke of which is sufficient to kill them. During such timings, when they are driven out, they are picked up by the crows. The same results can be obtained if their resting places are artificially flooded.

Chemical.—The cricket may be killed by poison baits, which may be either green shoots or leaves

dipped in a strong poison. The poison bait com monly in use is prepared in the following way: Bhusa 1 maund; white arsenic 1 seer; gur 2 seers; water enough to make all these into paste.

Poison bait consisting of sweet potato, gingelly oil and lead arsenate has also been recommended.

Biological.—(i) A lizard is said to prey upon them. (22) A metallic green digger wasp, *Sphex lobatus* is frequently seen to prey upon this cricket, which stings it, and drags down into a burrow-There the wasp lays an egg over it. The phenomenon of a cricket being dragged out by the digger wasp is common especially in hot months before the break of monsoons.

(26) *Poekilocerus pictus*

Order Orthoptera
Family Acrididae (Pyrgomorphidae)

This beautifully coloured grasshopper is common throughout the plains, except in Bihar, Bengal and Assam. It is fairly common in Aligarh on *Calotropis* plant. Dry and hot climate favours this species.

It is very fond of oak and feeds on leaves, stem, pods, flowers and almost all parts of the plant. Often reducing the plants to naked stems, not even leaving the green bark behind. Experiments were performed to investigate the potentiality of this grasshopper as a pest of cultivated crops like brinjal, tomato, bhindi, potato, grourds, cabbage, radish, musk-melon, castor, oleander, maize, cotton, broad bean, holly hock, sorghum, cow pea, etc. The nymphs were fed on these plants in the summer, and it was found that they readily take leaves and fruits of brinjal and tomato, and leaves of bhindi, potato, gourds, cabbage, radish, musk-melons, castor, oleander and maize. They under went normal moulting and became adults. The author has collected them on madar (*Calotropis*) leaves at Aligarh. This insect may become a menace to cultivated crops if its population becomes very large during spring.

Copulation.—The pre-copulation period in male is from five to eight days, while the female is ready for copulation soon after it undergoes its final moult. The process of copulation lasts from 2 to 4 hours.

Oviposition.—Egg laying begins from 20—26 days after the emergence of the female as adults. The period intervening between the first copulation and first egg laying varies from 14 to 20 days.

The eggs are laid in the soil about 5 to 6 in below the surface. Generally the soil which is selected for this purpose is of loose texture, hence more easily penetrable.

The number of eggs in a mass varies between 60 and 140, the average being 116. It is likely that more than two eggs masses are laid in nature.

Egg.—The egg is elongated, curved, almost cylindrical, thick in the middle and tapering towards the ends, which are bluntly rounded. When freshly laid, the egg grows in thickness.

Nymph.—The newly emerged nymphs begin to feed about 24 hours after their emergence. There are usually six nymphal moults before the individual reaches the adult stage. The duration of various instars is variable. On an average they are as follows:

First Instar 9.7 days; second Instar 7.8 days; third Instar 7.8 days; fourth instar 8.4 days; fifth Instar 9.5 days; sixth Instar 9.9 days.

The total nymphal life lasts for 50 to 60 days during summer. In the case of eggs which hatch in autumn, the nymphal period is very long.

Different Nymphal Stages.—First Instar: The freshy emerged nymphs are orange coloured with white and faint black stripes. After the lapse of a day, the blackish patterns become dark and the hopper looks yellowish grey in appearance. They measure 9 to 12 mm in length and about 2.5 mm in breadth.

Second Instar.—It resembles in general appearance and colour to the first stage nymph, but is bigger in size, measuring 10 to 13.5 mm in length and 2.5 mm across pronotum.

Third Instar.—The general colour of he body becomes deeper in this stage. The median yellow spots on the dorsal side of the abdomen turn orange in colour. The length of the body is 15 to 17 mm and breadth across pronotum is 2.7 mm.

Fourth Instar.—The general coloration becomes still deeper in this stage. The body measures 20 to 24 mm in length and 3 to 4 mm in breadth. Rudiments of wing-pads appear in this stage.

Fifth Instar.—The general coloration of the body develops a shining yellow tinge in places where there were yellow and white patches in the previous stages. The orange coloured spots grow deeper in tinge. The size of the hopper is 25 to 27 mm in length and 5 mm in breadth. The wing-pads get upturned and develop numerous branched veins.

Sixth Instar.—The freshly moulted nymph of this stage is lemon yellow in general colour with black markings. All the white patches of the previous stage become yellow and the black patches grow deeper in tinge. It measures about 35 to 43 mm in length and 7.5 mm in breadth.

Just before the nymph is about to moult finally for obtaining the adult stage, its colour in different parts undergoes well marked changes. All the black patterns on the body begin to turn bluish and all the orange and yellow spots fade away and instead continuous yellow patches on the blue black ground begin to appear.

The hopper when about to moult, stops feeding and rests on a twig, it begins to contract and expand the anterior region of its body.

Control Measures.—With a view to find out some suitable insecticide for controlling this pest a number of stomach poisons were tried in the form of sprays, dusts and poison baits. Lead arsenate which is commonly used for such insects was not found effective either in the field or in the lab, when sprayed at the usual concentration of 2 lbs. per 100 gallons of water.41 In the control cage all hoppers were found living beyond 16 days. The lead arsenite spray was prepared by disolving 5 lbs. of stone lime in 100 gallons of water to which two pounds of powdered lead arsenate and hundred pounds of gur were added and the whole mixture shaken thoroughly.

Calotropis and castor plants were dusted in the field with sodium arsenite mixed with lime in the proportion of 1:4. From the treated plants 33% of the hoppers died in six days.

Calcium arsenite dusted in the same proportion showed slightly better result. The leaves were not injured and about 50% of hoppers died in five days.

Paris Green was mixed with fine wood ashes in the proportion of 1:8, and 1:16m and dusted over *Calotropis* and oleander plants. With a dose of 1:3, 60% hoppers died in ten days, the remaining living beyond 16 days. Bait of sodium flousilicate did not give good results.

Experiments described above show that the spraying of infested plants with calcium or sodium arsenite at the rate of 1 lb and 1/2 lb per 100 gallons of water respectively seems to be the most satisfactory method of control.

It is a pest of minor importance for cucurbits.

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