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ECO-FRIENDLY MANAGEMENT OF MAJOR INSECT PESTS OF SUGARCANE: A CASE STUDY OF *PYRILLA PERPUSILLA* WALKER WITH ITS ECTO-PARASITOID *EPIRICANIA MELANOLEUCA* FLETCHER

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ABSTRACT : The present compilation is aimed at to appraise environment friendly management of *Pyrilla perpusilla* and potential parasitism of *Epiricania melanoleuca* on *P. perpusilla* which is extensively infesting sugarcane. As *E. melanoleuca* is an effective bio-control driving force of sugarcane, a long duration crop, damaged by an array of insect-pests at its luxuriant vegetative growth. With an estimate, sugarcane production declines by 20.0% due to insect-pests infliction. Early shoot borer, *Chilo infuscatellus* Snellen, Sugarcane Leaf hopper, *Pyrilla perpusilla* Walker, Internode borer, *Chilo sacchariphagus indicus*,Top shoot borer *Scirpophaga excerptalis*, Stalk borer, *Chilo auricilius,* Sugarcane woolly aphid, *Ceratovacuna lanigera*, Whitefly, *Aleurolobus barodensis*, Mealy bug *Saccharicoccus sacchari* etc. are the widespread pests of sugarcane. Amongst, *Pyrilla perpusilla* is a noxious depredator is of regular occurrence damaging this crop, causing a heavy toll of crop losses. In this article, existing literature on biology, damage and employed management options of *P. perpusilla* are reviewed, exhaustively. This review encompasses, pest's systematic position, distribution and the ranges of alternative host plants are surveyed; life cycle and the extent of damage caused by the pest are considered in the facet. Potential biological control agents for the *Pyrilla* are evaluated with special reference to the most effective nymphal and adult 'parasitoid', the moth *Epiricania melanoleuca* (Fletcher). To increase the crop productivity, management of insect-pests is of greater significance. In this framework, suggestions have been made for an integrated approach towards the prospective research, incorporating at least host-plant resistance and predation. Several eco-friendly management strategies have been developed as a result of research and development work. In order to save environment from chemical pollution, use of bio-control has been given utmost importance. The management technologies have been integrated as per need for the strategic management of this dreaded sucking pest.

Key words : *Pyrilla perpusilla*, *Epiricania melanoleuca,* parasitoid, sugarcane, management.

INTRODUCTION

Sugarcane, *Saccharum offi cinarum* L., is a perennial grass in the family *Poaceae* grown for its stem (cane) which is primarily used to produce sucrose. Sugarcane may also be referred to as nobel cane and originates from New Guinea. A mature stalk is typically composed of 11–16% fiber, 12–16% soluble sugars, 2–3% non-sugars, and 63–73% water. Sugarcane is the world's largest crop by production quantity. Brazil was the largest producer of sugar cane in the world. The next five major producers, in decreasing amounts of production, were India, China, Thailand, Pakistan and Mexico. Maharashtra is the largest producer of sugar contributes about 34% of sugar in the country followed by Uttar Pradesh. It is a long term crop with a growing period as long as 12 -18 months but varies with location and variety. The crop needs plenty of sun and water (min. 600mm of rain per annum, 1200 to 1800mm without irrigation, though water logging is not tolerated), pH of 6 – 7.5 is deemed as suitable soil. Sugarcane is considered as one of the most efficient photo-synthesizer in the plant kingdom, classified as a C4 plant it converts 2% of incident solar energy into biomass. A sugarcane crop is sensitive to the climate, soil type, irrigation, fertilizers, insects, disease control, varieties, and the harvest period. Sugarcane is attacked by a number of insect pests and diseases. The Sugarcane Leaf hopper, *Pyrilla perpusilla* Walker (*Homoptera : Lophopidae*) is one of the most destructive pest, widely distributed, and feeds on sugarcane, wheat, barley, oats, maize, sorghum and number of grasses (Chaudhary *et al*, 1990). Up to 28% of potential yield has been lost due to this pest and poor growth of seed sets and difficulties in milling cane from affected plants have also been recorded (Butani, 1964). *Pyrilla* adults and nymphs, both suck sap from underside of the leaves but most of the damage is caused by the nymphs and excretes honeydew onto foliage, leading to fungal diseases. This direct and indirect damage affects sugar yield and quality (Butani, 1964; Bindra & Brar, 1978; Asre *et al*, 1983).

Pyrilla can be effectively managed through the parasitoids, *Epiricania melanoleuca* without the use of insecticides (Singh *et al*, 2000). *Epiricania melanoleuca* was first recorded in India as the most important adult and nymphal parasitoid of *P. perpusilla* (Ganehiarachchi *et al,* 2000). It's different life parameters such as short life cycle, higher reproductive potential and marvelous searching capability for host enhances its efficacy as a bio-control agent. It's larval body is covered by wax which protects it from insecticides allowing the chemicals to be used in IPM programmes of *Pyrilla* (Garg Sathi, 1982). The larva ruptures the host's cuticle with mandibles and parasitically sucks hemolymph. Smaller, younger larvae feed near the head and hind leg of *Pyrilla.* It does not kill its hosts but makes them so weak that they can't reproduce (Murawski, 2003).

Distribution and Taxonomy

P. perpusilla is a major pest of sugarcane in Punjab, Uttar Pradesh, Bihar and Maharashtra. Generally, it is a minor pest but sometimes assume a major form in different parts of India. It has been recorded from many parts of Asia since 1903. The species has occurred throughout India, sometimes at epidemic levels (Stebbing, 1903, Dhaliwal & Bains, 1985). *P. perpusilla* also occurs elsewhere in Asia such as Burma, Indo-China, Thailand (Fennah, 1963) and in Cambodia, Indonesia, Laos and Vietnam (Varma, 1986). *P. perpusilla* is the only pest species of any importance in the Lophopidae. Fennah (1963) reviewed all the species of the genus *Pyrilla* occurring in India and Sri Lanka and described the distinguishing characters of the various sub-species. He suggested that there were two polytypical species present, namely P. *perpusilla* (Walker), widespread in India, Sri Lankaand Thailand and *P. aberrans* (Kirby) occurring in Sri Lanka and South India. He described ten geographical sub-species of *P. perpusilla.*

Host range

A large number of plants including various types of grass species are recorded as alternate hosts of *P. perpusilla* and some of these are used by this pest for both feeding and reproduction. *Zea mays*, *Sorghum* sp. (Gupta and Avasthy, 1954) *Pennisetum americanum*, *Hordeum vulgare* (Brar, 1981), *Mormordica charantia*, *Abelmoschus esculentus*, *Luffa aegyptica*, *Citrulus vulgaris*, *Cucurbita pepo* (Rahman and Nath, 1940), *Oryza sativa* (Power, 1981), *Pisum sativum* and *Bambusa arundinacea* (Flether and Ghosh, 1919) serve as alternative host plants for *P. perpusilla*.

Biology of *Pyrilla perpusilla*

The biology and the behaviour of *P. perpusilla* were first described by Fletcher (1914) in Bihar, India. It also described by some entomologists in various parts of the India (Quadri and Aziz, 1950; Patel *et al*, 1993, Fletcher 1914). The adult life span varies from 14-200 days and females live for a slightly longer period than males. The female has a pre-copulation period of about 11 days, copulation takes place during the day and is complete within two hours. Generally, the female takes 45-60 minutes for a single oviposition after a pre-oviposition period of 3-47 days, depending on the season and climatic conditions. Between two and *25* days can occur between successive ovipositions. Eggs are laid during the day, on the abaxial surface of the leaves along the midrib. They are deposited in four to five rows and are covered with a waxy thread-like material secreted by the female. During the winter, eggs are laid on the inside of the base of the leaf sheath, giving some protection from adverse climatic conditions. The female usually uses a lower, shady, concealed site for oviposition.

In winter, females lay eggs between the stalks and the dried leaf sheaths. Twenty to fifty eggs are laid at a time, with a life-time fecundity of 37-880. Khan and Rahman (Plate VI) reported that the number of eggs laid by a female depends upon the season, the least number being laid when it is very cold, e.g., December-March (Table 1). The interval between each laying during April-October is 2-6 days, during November-December it is 7-25 days, and during November-January 57-126 days.

The incubation period varies with season and ranges from 6-30 days. Adult P. *perpusilla* is a pale tawny-yellow soft bodied insect with the head prominently drawn forward. Wingspan varies from 16-18 mm and 19-21 mm for males and females, respectively. Females lay white to greenish yellow eggs which are 0.9-1.0 mm long and 0.45-0.64 mm wide. Newly emerged nymphs are 0.8-1.0 mm long and milky white in colour and pass through five instars to reach maturity. Each nymphal instar bears characteristic anal filaments which are slightly longer than the body. The ideal temperature for nymphal development seems to be 30°C, with a RH of 80% (Gupta & Ahmad, 1983). There are three to four generations of the insect in India and Pakistan. *P. perpusilla* sucks phloem sap from leaves and excretes honeydew onto foliage. Its adults and nymphs, both suck sap from underside of the leaves but most of the damage is caused by the nymphs. Feeding spots turn yellow and with the loss of sap the leaves wilt, retarding plant growth. Sooty mould grows on honeydew produced by *Pyrilla* and this further reduces photosynthesis. Losses ranging from 2-34% in sucrose content of the cane and from 3-26% in the purity of the sugar.

Fig. 1 : Showing Parasitoids - *Epiricania melanoleuca.*

***Epiricania melanoleuca* (Fletcher)**

Epiricania melanoleuca (Fletcher) is a moth in the Epipyropidae family. It was described by Fletcher in 1939. It is found in India. It is a potential ectoparasitoid on nymphs and adults of sugarcane leafhopper, Pyrilla perpusilla (Walker) in our country (Mishra and Pawar, 1980) and it has been extensively used for the hiocontrol programs against this pest in the recent past (Mishra and Pawar, 1984). The caterpillars of the members of *Epipyropidae* commence to feed and complete their larval stage on the nymphs/adults of homopterans. They are, therefore, truly parasitic in nature. The hosts do not die instantaneously although they succumb on account of parasitic infection in due course of time. The newly hatched caterpillars of *E. melanoleuca* move quickly on sugarcane leaves in search of their hosts. As soon as a *pyrilla* nymph or adult becomes available, the parasitoid catches hold of the tarsi of the host and gradually proceeds to orientate on the dorsal surface of the abdomen of the former from where it continues to feed until maturity (Chandra and Tiwari, 1978; Mandan and Singh 1981). On completion of the larval period (which lasts between 10 and 12 days), the caterpillar leaves the host's body and migrates to the sugarcane leaf surface to spin a white, oval-shaped cocoon inside which pupation occurs. After a pupal period of 4-11 days, moths emerge. The female moth, upon emergence, remains near the cocoon. However, the male flies to the cocoon to mate with the female. Soon after termination of copulation, the female begins to lay eggs alongside the cocoon. Under favourable conditions, these eggs hatch after 9 days to give rise to a new generation of caterpillars. Younger larvae feed near the head and hind leg of *Pyrilla*. It does not kill its hosts but makes them so weak that they can't reproduce. *Pyrilla* can be effectively managed through the parasitoids, *Epiricania melanoleuca* and *Tetrastichus* sp. without the use of insecticides .

Nature of damage

Both nymphs and adults of *P. Perpusilla* suck sap from the leaves of sugarcane but most of the damage is caused by the nymphal stage. The feeding punctures turn pale yellow and the coalescence of such spots imparts a yellowish colour to the leaves (Butani, 1964). Furthermore, due to continuous feeding of sap by thousands of planthoppers, the leaves become wilted and growth of the plant is arrested. In addition to the direct physical injuries, *P. perpusilla* is also responsible for reduced photosynthesis due to the growth of powdery mildew on its honeydew secretions (Rahman, 1942 and Rahman and Singh, 1943) have assessed that the heavy *P. perpusilla* infestations reduce the sucrose content by 3-4% and purity by 3-26%. However, they found that the glucose ratio of the plant increases three fold after *P. perpusilla* infestations.

Approaches to control

Different eco-friendly methods can be used for management of *P. Perpusill* against sugarcane. Parasitoids, predators and pathogens that are effective biological control agents. They caused no heath hazards to human beings and non-target organisms and have no residual toxicity. Spaced out from this Agronomic control, mechanical control, host–plant resistance is successful techniques for controlling *P. Perpusilla.*

(a) Cultural control

Khan and Khan (1966) described the use of agronomic methods to control the pest. Changing sowing and harvesting dates could reduce the effects of the pest by exploiting its phenology, and the burning of trash also had a beneficial effect on pest control. Joshi and Sharma (1989) controlled the pest successfully by distributing sugarcane trash with cocoons of *E. melanoleuca* in the harvested fields. This 'seeded' the field with the natural enemy for the next season's crop. However, Khan and Khan (1966) showed that the practice of rationing (continuing with three or four generations of the crop) greatly increased the pest populations, as the crop became a more or less continuous host for the pest. Other cultural practices are *viz.,* avoid late application of nitrogenous fertilizers, Collect and put egg masses in cage to facilitate emergence of parasitoids, removal and destruction of lower dried leaves.

(b) Biological control - parasitoids

Epiricania melanoleuca (Fletcher) (Lepidoptera: Epipyropidae) appears to be the most successful

Table 1 : Showing montly oviposition of *P.perpusilla* on sugarcane.

Period of egg-laying	Minimum no. of eggs laid	Maximum no. of eggs laid	Average no. of eggs laid
January	12	29	16.50
February	18	42	28.65
March	1	7	11.71
April	64	192	130.0
May	92	444	219.
June	49	188	94.50
July	11	96	55.71
August	32	144	80.26
September	93	285	169.5
October	78	475	190.28
November	26	196	92.50
December	12	87	39.12

Source - Khan and Rahman (Plate VI) Bull. Ent. Research vol. 31.

Table 2 : List of Parasitoids, predators and pathogens of *Pyrilla perpusilla.*

	Parasitoids	Predators	Pathogens
Egg parasitoids	**Hymenoptera: Encyrtidae** *Cheiloneurus pyrillae* Mani *Ooencyrtus pyrillae* (Mani) *Proleuroceroides pyrillae* Shafee, Alam & Agarwal	**Coleoptera: Coccinellidae** *Anegleis cardoni* (Weise) *Brumoides suturalis* (Fabricius) *Cheilomenes sexmaculata* (Fabricius)	*Aspergillus flavus* Link *Fusarium* sp. *Hirsutelta* sp. *Isaria* sp. *Metarhizium anisopliae* Metschnikoff (Sorokin) *Mucor hiemalis* Wehmer
	Hymenoptera: Eulophidae *Parachrysocharis javensis* Girault *Tetrastichus gala* Gholap & Chandale	*Coccinella septempundata* Linnaeus *Coccinella undecimpundata* Linnaeus *Micraspis allardi* (Mulsant) *Propylea disseda* (Mulsant)	
	Hymenoptera: Platygasteridae *Platygaster* sp.	**Coleoptera: Staphylinidae** *Paederus fusdpes* Curtis Hymenoptera: Formicidae *Crematogasier walshi* Forel	
		Neuroptera: Chrysopidae *Brinckochrysa scelestes* (Banks) Neuroptera : Coniopterygidae *Coniopteryx pusana* Withycombe *Nimboa basipundata* Withycombe	
		Odonata: Gomphidae *Platygomphus dolobratus* Selys	
		Araneida: Araneidae *Cryrtophora* sp.	
		Araneida: Clubionidae *Clubiona drassodes* Cambridge	
		Araneida: Salticidae *Menemerus* sp. *Plexippus* sp.	
		Araneida: Tetragnathidae *Leucauge* sp. *Tetragnatha* sp.	
Nymphal parasitoids	Hymenoptera: Dryinidae *Agonatopoides pyrillae* (Mani) *Richardsidryinus pyrillae* (Kieffer)		
Nymphal and adult parasitoids	Lepidoptera: Epipyropidae *Epiricania melanoleuca* (Fletcher) Coleoptera: Stylophidae *Pyrilloxenos compadus* Pierce		

parasitoid1 used during the past two decades against P. *perpusilla* (Table 2). A large area of new research on this lepidopteran parasitoid was developed as researchers began to discover its usefulness in reducing pest populations by as much as 90-100%. *E. melanoleuca* belongs to the family *Epipyropidae* which has a distribution in tropical and warm temperate areas, mainly in Australia and in the Indian subcontinent. The larvae have been observed in an erect position, clinging to the margins of leaves by the pro-legs and waving the thorax back and forth ready to grasp a host when it passes. After catching a host the larva attaches itself by hooked claws with its head directed posteriorly. It is believed that the larva feeds through the host cuticle by penetrating it with sharp mandibles, allowing it to suck the host's body fluids. The larva passes through four or five instars on the body of the host and during this period it secrets a large amount of wax over its body, making it conspicuous. The host dies after the parasitoid reaches the pre-pupal stage or soon after it has been released by the parasitoid (Fig. 1). The larva pupates in a cocoon near the ground or on a leaf or a grass stem.

(c) Biological control -predators

The coccinellid *Anegleis cardoni* (Weise) is a predator of P. *perpusilla* eggs and nymphs. Another coccinellid, *Brumoides suturalis* (Fabricius) is reported to feed on the eggs and nymphs of *P. perpusilla* throughout India (Rajak *et al,* 1987 its life cycle lasting 25-30 days with activity throughout the year. *Menochilus sexmaculatus* (F.) has been recorded from India and Pakistan as a predator of *P. perpusilla* eggs and nymphs. The common Palaearctic coccinellids, *Coccinella septempunctata* Linnaeus, and C. *undecimpunctata* Linnaeus feed on *P. perpusilla* eggs all over India and. Their role as predators of *P. perpusilla* is not known, however. The coccinellid *Micraspis allardi* (Mulsant), recorded previously as *Verania allardi* (Mulsant), is a predator of *P. perpusilla* eggs in India, Pakistan and Sri Lanka.

The predatory chrysopid *Brinckochrysa scelestes* (Banks) seems to have potential as a predator of P. *perpusilla,,* as it has been widely reported as preying upon all stages of the pest in India and Pakistan (Nasir, 1947). The coniopterygid *Coniopteryx pusana* Withycombe is also a predator with potential. It has been recorded from many parts of India since 1937. The adult lays eggs singly near the egg masses of *P. perpusilla* and the larva feeds on them. The adult feeds on *P. perpusilla* honeydew.

(d) Mechanical control

The use of mechanical methods to control *P. perpusilla* began early this century. Niceville (1903) first reported control of *P. perpusilla* in this way by collecting sugarcane leaves with egg masses and burning them. Hussain (1925) also recommended the collecting of egg masses (and adults in bags) for control.

Francis (1933) was able to catch an average of 2000 adults per night using light traps but considered this method to be impracticable because of the number of light traps required for large areas.

(e) Host plant resistance

The sugarcane variety Co 223, with soft and broad leaves was the first to be shown to be particularly susceptible to *P. perpusilla;* this was in the Punjab (Venkataraman, 1929). The susceptibility to *P. perpusilla* of varieties of sugarcane with soft, broad, succulent leaves has been reported by a number of researchers. Resistance in varieties with shorter, narrow, erect or semierect leaves and a tight and enveloping leaf sheath was detected during the same period (Gupta, 1948). In terms of mechanisms of resistance, Khanna *et al* (1950) showed that the phloem bundles of the resistant sugarcane variety Bo3 were protected by a 'shield', formed by the fusion of the vascular sheaths and a sclerenchymatous rib below it. This structure made it difficult for the insect to penetrate the phloem. Kumarasinghe & Wratten (1993) studied antibiosis and antixenosis for first and third instar nymphs of P. *perpusilla* on 23 sugarcane varieties of a wide genetic range.

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