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Overview of an emerging pest in Rice: *Leptispa pygmaea* Baly (Coleoptera: Chrysomelidae)

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ABSTRACT

Leptispa pygmaea Baly, commonly known as the rice blue beetle, is an emerging pest that poses a significant threat to rice production worldwide. This review paper provides a comprehensive overview of *L. pygmaea*, including its taxonomy, distribution, life cycle, feeding habits, economic impact, and management strategies. The goal is to enhance the understanding of this pest and facilitate the development of effective management approaches to mitigate its damage. Through an in-depth analysis of available literature and research studies, this review highlights the urgent need for integrated pest management strategies that encompass cultural, biological, and chemical control methods to effectively combat the spread of *L. pygmaea*

KEY WORDS: *Leptispa*; *Coleoptera*; *Rice*; *Chrysomelidae*

1. Introduction

Rice, *Oryza sativa* is the second most important cereal crop after wheat in the world and is the most important grain with regard to human nutrition and caloric intake. It is a staple food crop for more than two third of the population of India and more than 65% of the world's population (Mathur *et al.*, 1999). Rice is probably the world's most genetically diverse crop, which thrives well under varying ecosystems starting from rainfed upland (dry systems) to rainfed lowland (wet system) and in deep water situations (Rajehja, 1995). In India, rice occupies an area of 43.95 million hectares with annual production of 106.54 million tonnes and productivity is 2.42 tonnes/ha (Anonymous, 2015). Though the production is large, the per hectare yield is very poor as compared to other rice growing countries like Spain, Japan, Australia and China. The main reasons for low productivity are vagaries of nature, low fertilizer use efficiency, poor management of insect-pests and heavy infestation of weeds.

Rice is affected by more than 100 insects, among which 10-12 pose an economic threat to rice cultivation worldwide and decrease the productivity. The emerging threat of *L. pygmaea*, commonly decrease rice production is a cause for concern in agricultural communities. This pest primarily affects rice crops by feeding on the leaves, causing significant damage.

2. Taxonomy and Distribution

The rice blue beetle belongs to the following taxonomic hierarchy position;

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Kingdom : Animalia (Animals)
Phylum : Arthropoda (Arthropods)
Class : Insecta (Insects)
Order : Coleoptera (Beetles)
Suborder : Polyphaga
Superfamily : Chrysomeloidea
Family : Chrysomelidae (Leaf beetles)
Genus : *Leptispa* Baly, 1858
Species : *L. pygmaea*

2.1 Genetic structure and Phylogeny status of *L. pygmaea*

The Polymerase Chain Reaction (PCR) targeting the COI gene fragment of *L pygmaea* resulted in the amplification of a single product measuring 695 base pairs (bp) in length. The evolutionary history of *L. pygmaea* was inferred using the Neighbor-Joining method. Phylogenetically *Colasposoma* sp., *Neolochmea dilatipenni and Chelymorpha alternans* are the nearest relative of *L pygmaea* (Mashhoor *et al*., 2013).

Leptispa pygmaea, has a global distribution, although it is native to Southeast Asia. Over time, it has spread to various regions around the world. Here are some details about its distribution and spread patterns. The blue beetle is the emerging insect pests of rice in India in recent times, the first record of rice blue beetle, *L. pygmaea* Baly from Assam and West Bengal by (Maulik, 1919) and its distribution were in Assam, Kerala, Karnataka, Maharashtra, Meghalaya and West Bengal states of India and Elsewhere in Sri Lanka (Anonymous, 1999). This pest is also known to occur in other Asian countries *viz*., Nepal, China, Ceylon, Vietnam (Sprecher, 1997), Bangladesh (APPPC, 1987), Pakistan (Fray, 1976) and Butan (Shinsaku, 2005). *L. pygmaea* was first reported as pests of paddy by Burlow (1899) and Lefroy (1906). *L. pygmaea* earlier considered as minor pest (Trehan, 1946; Patel and Patel, 1970; David and Kumaraswami, 1975 and Dale 1994).

Southeast Asia: It is indigenous to Southeast Asian countries such as Thailand, Malaysia, Indonesia, and the Philippines. It is believed to have originated in this region.

Africa: The beetle has been reported in several African countries, including Nigeria, Cameroon, Sudan, and Madagascar. It is considered an introduced pest in these areas, likely brought through trade or natural migration.

Australia: It has been detected in northern parts of Australia, including Queensland and the Northern Territory. The exact mode of its arrival in Australia is not clear, but it may have been introduced through international travel or trade.

Pacific Islands: The beetle has also been found in Pacific Island nations such as Papua New Guinea, Fiji, Solomon Islands, and Vanuatu. Its presence in these regions is likely due to human activities and the movement of agricultural commodities.

The spread patterns of *L. pygmaea* are influenced by multiple factors, including global trade, transportation and the expansion of rice cultivation. Infested plant materials, contaminated machinery, or accidental transportation by humans can facilitate the dispersal of the pest to new areas. Climate change and shifts in temperature and rainfall patterns may also influence its distribution and population dynamics.

3. Life cycle and Biology

The grub and adult blue beetles prefer young transplanted rice crop. The beetle is dark metallic blue in colour. Sexual dimorphism is observed between male and female beetles by their size. Male beetles are larger than females. The female beetles lay yellowish oval single eggs or in batch both on upper and lower surface of paddy leaves. The grub period has five larval instars and is more voracious feeders followed by female and male beetles. The severe grub feeding causes inward rolling of rice leaves often confused with the attack of leaf folder. The first four instars are yellowish green coloured and turns white before pupation. The pupa exhibits a brown coloration and is loosely attached to the leaf by its posterior end.

The adult beetle damages by scrapping of chlorophyll material on the leaf surface which looks parallel streaks in appearance. The beetle damage is more in *kharif* than rabi season. There are no varieties/Hybrids completely resistant to this pest. Both varieties/cultivars from KAU and all the tested National entries under NSN2 from DRR were not completely resistant to this beetle. ‘Jyothi’ and ‘Abhilasha’ are the most preferred and high yielding rice variety of Kerala and Karnataka respectively. The beetle can be controlled by spraying any contact chemical insecticides, but control becomes difficult during *kharif* due to continuous south west monsoon showers. The beetle was not attracted to light traps.

Adult female lays oval shaped eggs on both the sides of leaf surface either singly or in parallel rows with an average fecundity of 12.67 eggs having 0.36 mm length and 0.16 mm width (Fig. 1). The incubation period was 4.5 days. The grub undergoes five larval instars, with an average developmental period of 10.9 days. The grubs display a range of sizes, measuring between 2.48 to 4.53 mm in length and 0.69 to 1.14 mm in width. The head size of the grubs ranges from 0.15 to 0.26 mm. The grub pupated on leaf surface by getting attached loosely with its posterior end. The pupal stage lasts for a period of 4.40 days, during which the pupa measures 3.71 mm in length and 1.17 mm in width. The entire life cycle of the pest is completed in 19.80 days. The longevity of adult beetle varied with sex and male beetles lived longer than female beetles. Adult male of *L. pygmaea* lived for 37 days with size of 6.81 mm in length and 2.08 mm width and female lived for 19.96 days with size of 6.20 mm length and 1.80 mm width (Fig. 2), whereas head size of both male and females measured 0.27 mm (Krishna *et al.*, 2013b).

Egg: *L. pygmaea* female beetle lays smooth pale yellow or pale green elliptical eggs in a straight line in batches of two, three to four eggs mostly on the lower surface of the leaf with 90.96-98.81% hatching (Patel and Patel, 1970; Dalvi *et al.*, 1985; Patel and Shah, 1985). The mean incubation period was 3.79 to 7.16 days. The females oviposited clutches of upto 8 eggs mostly on the adaxial side of the leaf (Kaniyarikkal *et al.*, 2009). The female *L. pygmaea* lays about 11-16 yellowish coloured eggs/ batch which were oval shaped on both the upper and lower surface of leaf and the grub hatched within 3-4 days (Karthikeyan and Sasomma, 2008a) and eggs hatch in 4-5 days with 0.35 to 0.38 mm length and 0.10 to 0.21 mm width (Krishna *et al.*, 2013b).

Larva: *L. pygmaea* larvae is a soft bodied campodeiform grub, dorso-ventrally compressed and dirty white having a sclerotized tubular process at the abdominal tip. It had three larval instars. The first instar was completely white except head, which was brownish in colour immediately after emergence then later changed its colour to dirty white after taking food with an average period of 3.04 days. The larvae of second and third instars were dirty white in colour with duration of 3.33 and 4.97 days, respectively. The total larval period was 13.77 days in *kharif* season as against 13.22 days in off-season (Patel and Shah, 1985). The larvae arranged themselves in 7 a longitudinal line on the leaf surface, to a maximum of 10-12 with a mean of 7 per leaf (Dalvi *et al*., 1985 and Swamiappan *et al*., 1990). The grub had five larval instars each with duration of 1-2 days and completed grub development with a mean period of 8.2 days (Karthikeyan and Sosamma, 2008a). The grubs have five larval instars with mean developmental period of 10.9 days (Krishna *et al*., 2013b).

First instar: The neonate grub was completely white except head which is brown in colour. After taking food the colour of grub changed to dirty white. It measured from 2.40 to 2.55 mm in length. The width of grub was 0.58 to 0.80 mm and the head width was 0.13 to 0.17 mm. The average period of this instar was 2.2 to 3.1 days.

Second instar: The colour of second instar grub was dirty white and it measured from 3.50 to 3.90 mm in length, 0.90 to 1.12 mm in width and head width was 0.18 to 0.21 mm. Here second instar ranged from 1.80 to 2.70 days.

Third instar: The third instar grub measured from 3.90 to 4.10 mm in length. The width of grub measures from 1.10 to 1.21 mm and the head width was 0.21 to 0.24 mm, with dirty white colour and the grub of this instar was able to move faster when disturbed. The grub instar ranged from 1.50 to 2.30 days.

Fourth instar: The fourth instar grub with dirty white colour measured from 4.10 to 4.40 mm in length, 1.00 to 1.15 mm in width and head width was 0.24 to 0.27 mm. Here the grub instar ranged from 1.6 to 2.1 days.

Fifth instar: The grub colour of fifth instar was also dirty white in colour and was measured from 4.40 to 4.60 mm in length, 1.00 to 1.18 mm in width and head width was 0.25 to 0.28 mm. In this instar the grub period was ranged from 2.00 to 2.40 days.

Pre-pupa: *L. pygmaea* did not spin a cocoon before pupation. Just before completion of pre-pupal stage, a drop of sticky anal fluid oozed out which helped in sticking the caudal ventral of the pre-pupa with the leaf and the pupa was duly formed in pre-pupal body and came out by splitting epicranial suture of the pre-pupa. The pre-pupal skin was completely removed by peristaltic movement within 23 to 27 minutes. The exuviae thus removed were retained folded on the leaf surface (Patel and Shah, 1985).

Pupa: The pupa of *L. pygmaea* is milky white in colour when freshly formed, which changes subsequently to brown colour within a few minutes. The pupa is exarate type, brown coloured and attached itself to leaf surface by its posterior end. About three pale brown pupae were seen on each leaf. Appendages *viz*., head, antennae, mouthparts, wings and legs of developing adult could be seen through the pupal skin. Pupal stage lasted for 4-5 days. The total pupal period is 4.52 days during crop season as against 4.39 days during off-season.

A large number of white pupal skin was seen on leaf surfaces after beetle emergence (Patel and Patel, 1970; Dalvi *et al*., 1985; Patel and Shah, 1985; Swamiappan *et al*., 1990; Krishna *et al*., 2013b). Whereas, the pupal period was 3.2 and 2.9 days in Jyothi and Aishwarya varieties respectively and completed the life cycle within 14.8 in Jyothi and 13.8 days in Aishwarya (Karthikeyan and Sosamma Jacob, 2008). The grub pupated on the surface of the leaf as a brown colour pupa and was seen newly formed pupa was white in colour which changed its colour to brown within few minutes. The pupa measured from 3.61 to 3.80 mm in length and width measured from 1.06 to 1.28. The pupal period was ranged from 3.9 to 5.1 days (Krishna *et al*., 2013b).

Adults: Wings and abdomen of the newly emerged adults were completely white in colour (Fig 5), after one to two hours of emergence the colour of wings changed to metallic bluish green in colour (Krishna Japur et al., 2013b). The adult *L. pygmaea* is narrow, elongate and cylindrical with a slightly constriction at the centre. The beetle is deep metallic blue or dark greenish blue or dark bluish green with fine striations or small pitting on the elytra with more or less parallel rows of punctures. Elytra were finely striated at the extreme apex and also slightly reflexed to the dorsal side. The underside of the body was entirely black with 8-minute whitish hairs on it (Kadam *et al*., 1956; Patel and Shah, 1985; Dalvi *et al*., 1985; Swamiappan *et al*., 1990; Karthikeyan and Sosamma, 2008a).

The adult *L. pygmaea* displays a metallic greenish-yellow coloration and possesses longer antennae, a narrow thorax, and a lengthy body. On the other hand, the female rice blue beetle can be distinguished by its shorter antennae, broader thorax, and more robust body. The antennal scape will be broader in the female as compared to that of the male (Karthikeyan and Sosamma, 2012). Male beetles are bigger in size than females. The body length measured from 6.60 to 7.10 mm in males and 5.80 to 6.50 mm in females. The body width measured from 1.98 to 2.15 mm in males and 1.70 to 1.95 mm in females. The head width measured from 0.27 mm in both males and females. The longevity of adult varied with the sex of rice blue beetle. Male beetles lived longer than females. The life span of male beetles was ranged from 35 to 41 days and in females it was ranged from 18 to 23 days (Krishna *et al*., 2013b).

3.1 Copulation, pre-oviposition and oviposition period and fecundity

The mating behaviour of adults was found immediately after emergence from pupae and the copulation was found to be lasted for 5 to 10 minutes. The pre-oviposition period was ranged from 1.40 to 2.00 days and oviposition period was ranged from 4 to 6 days. The fecundity of *L. pygmaea* ranged from 9 to16 eggs/female on rice plants at sirsi, Karnataka (Krishna Japur et al., 2013b).

L. pygmaea female laid 38-66 eggs on rice in konkan region of Maharashtra (Dalvi *et al*., 1985) while the fecundity ranged from 43.0-58.8 eggs in south Gujarat (Patel and Shah, 1985). During August and September months there was a rapid buildup of the pest due to congenial condition and number of eggs were more during this period (70-120 eggs / 5 hills) than the rest of the year (0-55 eggs / 5 hills). No egg laying was observed from the second week of October in the rice field of South Gujarat (Patel and Shah, 1985). Adult beetle laid oval shaped yellow eggs on both the leaf surfaces either singly or parallel rows with an average fecundity of 16.8 and 14.3 eggs on short duration variety Jyothi and medium duration Aishwarya variety respectively, during June to

October 2005 (Karthikeyan and Sosamma Jacob, 2008a).

Total life cycle: *L. pygmaea* has completes its life cycle with different developmental stages *viz*., egg, grub and pupa with a mean period of 4.50, 10.90 and 4.40 days, respectively and total life cycle completes in 19.80 days (Krishna Japur et al., 2013b).

Adult's behaviour: The adults are very weak fliers (Swamiappan et al. 1990). The mating takes immediately after emergence of adults from pupae (Dalvi et al., 1985). Adults being polygamous mates throughout the day, but the active mating period are only during morning and evening hours. It also mates at night when adults were exposed to artificial light. Duration of coitus lasts for 4-8 minutes. Average periods for pre-oviposition, oviposition and post-oviposition were 4.91, 13.81 and 0.45 days, respectively (Patel and Shah, 1985). The female and male beetles were differentiated by the body size and type of antennae. Males were slightly smaller than females. In female beetle, the antenna was serrated with six uniform sized basal segments and four larger terminal segments while in males, the first basal segment was larger than the remaining segments with a remarkable serrate nature. Six segments in the middle were similar to each other and more or less of the same size. The terminal four segments were similar to each other and larger than the middle six segments (Patel and shah, 1985). The number of female beetles under field condition were less compared to males, with a sex ratio of 1:1.55 (♀: ♂) (Patel and Shah, 1985; Karthikeyan and Sosamma, 2008a).

4. Feeding habits and Damage

The adult beetles feed on rice leaves either by making holes or completely stripping the plant (Lefroy, 1906). Beetle completes its immature stages on the leaf surface and not as a leaf miner (Fletcher, 1913). Both larvae and adult feeds on the upper surface by scraping chlorophyll matter of rice leaves by making longitudinal white streaks on them (Dalvi *et al*. 1985). In the case of severe damage, the rice leaves were folded longitudinally and dried. As a result, the plants became very weak and dried up. From a distance, the rice field showed severely dried appearance. Symptoms resembled those caused by leaf folder with a difference that there will be no webbing and tying of leaf margins. When the young crop was attacked, it resulted in stunting and severe drying symptoms. Incidence was found to be higher in shaded areas (Patel and Shah, 1985; Swamiappan *et al*., 1990). Neonate larvae of rice blue beetle migrates to the base of leaf axil and feeds by scraping, which induced formation of leaf rolls from the base, but adult feeds on the adaxial side of tender rice leaves which induced partial upward rolling of the leaf lamina Kaniyarikkal *et al*. (2009). Both the grubs and adult's feeds on the rice leaves by scraping the chlorophyll content in between the veins and veinlets which leads to streaks on them. The streaks made by grubs were shorter and narrower as compared to those done by adults (Krishna *et al*., 2013b).

5. Economic impact

In the recent past it is reported to cause pest outbreaks which are much concern in rice cultivation area of Kerala (Northern Districts of Palakkad, Kannur and Kasaragod), Karnataka (coastal region of UK district), Maharashtra (Konkan region) and Gujarat (Navsari district),

Fig 1: Damage symptoms of *L. pygmaea*

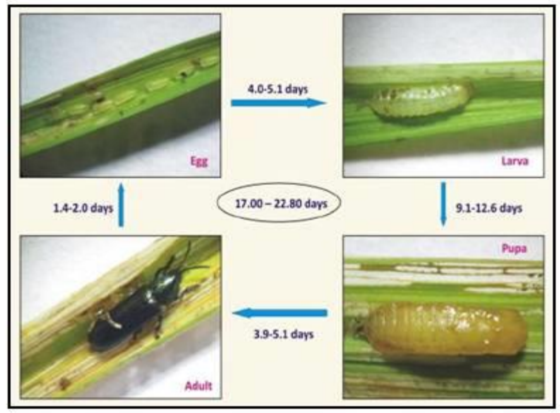

Fig 2: Biology of Rice blue beetle, *L. pygmaea*

Fig 3: Biology of Rice blue beetle, *L. pygmaea*

Fig 4: Dorsal and ventral view of pre-adult

Fig 5: Newly emerged adult with white wings

Fig 6: Dorsal and Ventral view of adult (♂ &♀) beetle

which is known to cause great loss in rice production. Weather factors, with a dominant role on the survivability, development and reproductive capacity of insect pests and exert a great influence on their population dynamics.

L. pygmaea has appeared in epidemic form for the first time during *Kharif* 1978 and since then the severe losses in localised pockets were reported from different parts of Konkan region every year in the state of Maharashtra. There were two peaks incidence of *L. pygmaea i.e.*, August to September (1^{st} peak) and March to April (2^{nd} peak) in Konkan region of Maharashtra. No egg laying and further development was observed in winter on alternate host plants during off season but it resumes its activity by January end on potted rice plant. Adults survived for 55 to 70 days on these food plants till next crop (Dalvi *et al*., 1985).

The severe outbreak of rice blue beetle occurred in kuzhithurai area of Kanyakumari District, Tamil Nadu during Nov-Dec 1988 and incidence was very severe on an area of about 50 ha of Ponmani variety during maximum tillering and panicle initiation stages (Swamiappan *et al*., 1990). *L. pygmaea* which was a minor pest of rice has recently been noticed to assume a serious status causing great concern to cultivars in several major rice growing tracts of Kerala state in India (Dale 1994; Karthikeyan and Sosamma, 2008c). The damage caused by *L. pygmaea* was more during early stage of crop especially during 1996-97 to 1998-99 (2.2 to 3.6 beetles/ hills) at Sirsi and Mundgod taluks of Uttara Kannada district (Prasad, 2003). The mean population of rice blue beetle (grubs and adults/ hill) under different rice ecosystem of Uttara Kannada district in upghat drill sown, upghat transplanted area and coastal transplanted area was (2.10, 0.92 and 0.65 respectively) (Rajendra *et al*., 2011) and (6.19, 5.40 and 4.65 respectively) (Krishna *et al*., 2014). The rice blue beetle incidence started in Navasari district of Gujarat from 4^{th} week after transplanting (WAT) during *Kharif* season reached peak level during 7^{th} WAT with population of 3.01 beetle/ plant and 3.93% leaves damage whereas during summer it reaches peak level at 10^{th} WAT with 0.55 beetle/ plant and 1.19% leaves damage (Patel *et al*., 2011).

The highest damage of blue beetle at early tillering stage was noticed in Jyothi (31.5 to 45.7%) and Aiswarya (19.5 to 29.5%) varieties under direct seeded condition. In Jyothi, 68.5 to 75.3% and Aiswarya 36.2 to 46.1% damage was noticed under transplanted crop (Karthikeyan and Sosamma, 2009a).

In India increase in blue beetle population often coincides with the transplanting of rice seedlings. The beetle leaves their hibernating sites by late May and start laying eggs by early June and oviposition continues till July end. Then the adults bury themselves in the debris and under the roots of grasses (Kuwayama, 1966). Cloudy condition with warm weather and frequent drizzling rain favours the buildup of *L. pygmaea* in the field during vegetative stage. The peak activity of rice blue beetle was observed during cooler hours of the day *viz*., early morning and late evening hours in the field and took shelter under shady portion of the plants during sunny period of the day. During the off-season, specifically from November to February, the pest manages to survive in its adult stage by residing on grasses, volunteer rice plants, ratoon rice, or sugarcane. It should be noted that the pest's level of activity is significantly reduced during this particular period. No egg laying has been observed on the alternate hosts during the pests' inactive stage (Khanvikar *et al.*, 1983).

The rice blue beetle incidence was the highest noticed in fourth week of August (14.2 beetles/hill) with 20.1% leaf damage, whereas the lowest damage was in July 1st week (6.6 beetles/hill) with 11.6% leaf damage (Krishna et *al*., 2013a). A strong negative correlation exists between the population of beetles and both grain

Table 1: Alternate hosts of rice blue beetle, *Leptispa pygmaea*

Sl. No	Common name	Botanical name	Family	Author
1	Globe finger rush	*Fimbristylis miliacea*	Cyperceae	Karthikeyan and Sosamma, 2009
2	Pickerel weed	*Monochoria vaginalis*	Pontederiaceae	Karthikeyan and Sosamma, 2009
3	Yellow sawah lettuce	*Limnocharis flava*	Limnocharitaceae	Karthikeyan and Sosamma, 2009
4	Water hyacinth/ Lilac devil	*Eicchornia crassipes*	Limnocharitaceae	Karthikeyan and Sosamma, 2009
5	Blistering ammania	*Ammania baccifera*	Lythraceae	Karthikeyan and Sosamma, 2009
6	Torpedo grass	*Panicum repens*	Poaceae	Karthikeyan and Sosamma, 2009
7	Wild rice	*Oryza rufipogon*	Poaceae	Karthikeyan and Sosamma, 2009
8	Not known	*Isachne miliacea*	Poaceae	Karthikeyan and Sosamma, 2009
9	Cupscale grass	*Sacciolepis interrupta*	Poaceae	Karthikeyan and Sosamma, 2009
10	Jungle rice / Awnless barnyard grass	*Echinochloa colona*	Poaceae	Karthikeyan and Sosamma, 2009
11	Not known	*Arundinella metzii* Hochst	Poaceae	Dalvi *et al.*, 1985
12	Kodo millet	*Paspalum scrobiculatum* Linn	Poaceae	Dalvi *et al.*, 1985
13	Not known	*Ischaemum travancorence*	Poaceae	Dalvi *et al.*, 1985
14	Vetiver bunchgrass	*Vetiver zizanoides* Linn.	Poaceae	Dalvi *et al.*, 1985
15	Elephant grass	*Pennisetum purpureotyphoides*	Poaceae	Dalvi *et al.*, 1985
16	Not known	*Arundinella* sp	Poaceae	Dalvi *et al.*, 1985
17	Guinea grass	*Panicum maximum* Jacq	Poaceae	Dalvi *et al.*, 1985
18	Angleton blue stem grass	*Dichanthiumi aristratum* (Poir)	Poaceae	Dalvi *et al.*, 1985
19	Para grass/ buffalo grass	*Brachiaria mutica* (Forst)	Poaceae	Dalvi *et al.*, 1985
20	Sugarcane	*Sacchrum officinarum* Linn.	Poaceae	Dalvi *et al.*, 1985

yield (-0.904) and straw yield (-0.969). Whereas there was a positive correlation between beetle population with leaf damage (+0.991) (Krishna *et al*., 2016).

5.1 Alternate hosts of rice blue beetle, *L. Pygmaea*

The *L. pygmaea* feeds/survive on more than twenty alternate hosts during offseason belongs to diversified families of Cyperceae, Limnocharitaceae, Lythraceae, Pontederiaceae and Poaceae as mentioned in Table 1.

6. Integrated pest management strategies

Management strategies mainly consist of mechanical and cultural methods by planting of cultivars that have genetic resistance to insects, biological agents (parasites, predators and diseases) and use of insecticides. Income per hectare in rice production is relatively low and money spent for controls such as insecticide significantly lesser profits. Insecticide prices are increasing faster than the rice price in most countries including India.

6.1 Mechanical and Cultural Methods

There are several mechanical and cultural methods recommended to control *L. pygmaea* pest earlier by spreading kerosene in the standing water in rice fields and dislodging the stages of pest by means of local devices to control the blue beetle (Usman, 1947). Plucking the infected leaves if lesser incidences and uprooting of the whole plant in case of severe incidence. The closer spacing (10 × 10 cm and 10 × 15 cm) in rice has significantly reduced the damage incidence by 59.02% as compared to 20 × 15 cm spacing in Kerala (Karthikeyan and Sosamma, 2008b). The early transplanting of rice during July 1st week has significantly reduced the *L. pygmaea* beetle incidence (46.47%) and damage (57.71%) compared to delay transplanting during last week of August in Karnataka (Krishna Japur et al., 2013a).

6.2 Biological control

Spiders, amongst the predators, are the most familiar and ubiquitous obligatory carnivores, which feed on different types of prey. In the past, multiple researchers have documented the predatory capabilities of spiders in controlling rice pests both in India and other countries. (Nath and Sarkar, 1978; Kiritani, 1979; Ghode *et al*., 1985). In rice ecosystem natural enemies play an important role in keeping the pest population below ETL. Spiders and mirid bugs are important predators active throughout crop season (Manjunath *et al*., 1978). A survey conducted on the spider fauna in 13 districts of Karnataka unveiled the presence of 45 genera belonging to 15 families. (Ansari and Pawar, 1992). Monitoring of the incidence of spiders in rice ecosystem revealed three peaks in the population of spiders *i.e.*, April-May, July and early September. The abundance of spiders was more in monocropping compared to mixed cropping, but the species diversity was opposite of abundance. It showed that a female spider of *T. mandibulata* consumed on an average 1.02 full grown larvae of rice blue beetle, *L. pygmaea* per day (Patel *et al*., 2013).

The endoparasitoids on *L. pygmaea* were reported are *Chrysonotomyia* sp. (Eulophidae) and *Trichomalopsis* sp. (Pteromalidae) Chalcid wasps belongs to the superfamily Chalcidoidea and order Hymenoptera.

6.3 Chemical Control

Throughout Asia, insecticides are more important component in the control of blue beetle, especially where resistant varieties are not available. However, several factors complicate the use of insecticides in the control of this pest. The rice blue beetle can be managed by spraying of Profenophos 50 EC @ 2 ml/l, Chlropyriphos @ 2.5 ml/litre or Quinalphos @ 2.5 ml/litre which found very effective in reducing its population. The other alternatives to these chemical insecticides are botanicals, *Vitex negundo* aqueous leaf extract @ 5% and entomopathogenic fungi, *Beauveria bassiana* @ 2 g/l (Krishna *et al*., 2012; Karthikeyan and Sosamma, 2010).

7. Current research and future directions

Researchers have been studying the biology and behaviour of *L. pygmaea* to gain a better understanding of its life cycle, feeding habits, reproduction, and host plant preferences. These studies help in identifying potential control strategies and management practices. There has been an increasing focus on developing sustainable and environmentally friendly pest management approaches. These studies contribute to a better understanding of the beetle's evolutionary history, population dynamics, and potential mechanisms underlying adaptation to different environments. To stay updated with the latest developments in *L. pygmaea* research, it is recommended to refer to scientific journals, conferences, and publications.

Investigating the impact of these interactions on the beetle's behaviour, dispersal, and reproductive success would provide important insights for developing integrated pest management strategies. Investigating the chemical ecology of *Leptispa pygmaea* and identifying the specific pheromones involved in mate attraction, aggregation, and host selection could provide opportunities for developing effective monitoring and control strategies. Additionally, understanding the variation in pheromone production among different beetle populations and its implications for population dynamics would be beneficial. Understanding the genetic basis of resistance and exploring alternative control methods, such as biopesticides or host plant resistance, would be essential for sustainable pest management.

8. Conclusion

Rice blue beetle, *Leptispa pygmaea* Baly earlier considered as minor pest has started cause outbreaks which is much concern in rice cultivation regions of India and other countries. Weather factors, with a dominant role on the survivability, development and reproductive capacity of insect pests exert a great influence on their population dynamics.

Through this comprehensive overview, we aim to consolidate existing knowledge on *Leptispa pygmaea* Baly and its impact on rice production. By understanding its biology, distribution, feeding habits, and economic implications, researchers and policymakers can develop effective management strategies tailored to the specific challenges posed by this emerging pest. The review underscores the need for integrated pest management approaches and encourages further research to minimize the damage caused by *L. pygmaea* and ensure the sustainability of rice production in the face of this growing threat.

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