A review on the biology, distribution and management of *Odoiporus longicollis* Oliver (Banana Pseudostem Weevil)

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Abstract

Banana, a food crop and as a fruit crop, enjoys the status of staple food in many of the tropical nations. Global production of banana is 102.02817 million tons, of which India contributes 29.19%, and ranks first in production (FAO STAT-2013). However, production of banana in Asia is severely affected by a complex of insect pests, particularly by banana pseudostem weevil (BPW) (*Odoiporus longicollis* Oliver). Severe incidence by this pest has been reported from across the banana growing belts of the world.. Adult feeds on the pseudostem and female makes ovipositional punctures on the outer sheath of the plant. Eggs are deposited in the air cavity, and on hatching, the grubs make longitudinal tunnels. Pseudostem of the heavily infested plant is often hollow, weak and it fall prematurely, causing 10-90% yield loss depending on the infestation stage and management efficiency. Applications of chemical insecticides are the only management measure but the insect is gaining resistance over it. Injudicious use of chemical inputs in agriculture poses challenge to sustainable agriculture and management is possible only by understanding the pest in its morphological, taxonomical, biological and distribution levels.

Keywords: banana pest, weevil borer in banana, biology of banana weevil, distribution of banana stem weevil

Introduction

Banana occupies the first position among the 40 million tonnes of fruits produced in India (NHBSTAT 2014, FAOSTAT 2014). Ravage of pests is the prime constraint in the production and productivity of banana (Visalakshi et al., 1989). Of the three weevil pests reported, *Odoiporus longicollis* Olivier, commonly known as banana pseudostem weevil (BPW), is the most noxious monophagous pest than the other two viz. *Cosmopolites sordidus* Germer (banana rhizome weevil) and *Pollytusmellerborgi* Bough (small banana weevil), infesting banana in the field at its multiple stages.

The pest BPW has a wide distribution throughout the tropics, and advancement of infestation by the weevil during the late pre-flowering stage culminatesin the failure of ascending flower bud and peduncle (Padmanabhan et al., 2001). Incidence of BPW has been reported from different parts of India and it is becoming very serious in Southern India, particularly in Tamil Nadu and Kerala (Reghunath et al., 1992; Gailce Leo Justin et al., 2008). The oviposition punctures inflicted by female weevils and the tunnels made by the grubs turn the plant fragile and weak, causing premature falling (Ravi and Palaniswami, 2002; Anitha and Nair, 2004). Infestation by weevil causes huge crop losses (Padmanaban and Sundararaju, 1999; Gold et al., 2001) to a tune of 10-90%, depending on the intensity of ravage and management efficiency (Prasuna et al., 2008). Chemical insecticides invite unwarranted long-term effect, including insecticide resistance (Gold and

Messiaen, 2000), pest resurgence, pest outbreak, ground water contamination (Kannaiyan, 2002) and radical effects on beneficial insects (David, 2008), apart from the environmental imbalances due to tottering ecosystem. To lessen the adversaries of chemical pesticides on humans and environment, a global drive is set off for exploring alternative green technologies to contain insect pests in cropping system. As this technology is targeted to the life stages of the pest, it is imperative to explore bio-ecology of the pest so as to formulate effective packages for pest management strategies.

The current study underlines the biology, distribution and management of BPW. Biology of the weevil details its morphology, taxonomy status, life cycle, longevity, ethology, host preference and life table. The study also address regarding the distribution of weevil and pest status. The review emphasise on the existing management practices against the weevil and concludes with critical suggestions concerned.

Biology

Morphology

Banana pseudostem weevil bears superficial resemblance with the rhizome weevil, but the former is slightly larger and its elytra do not cover the abdomen completely. Sing (1966) observed distinctive sexual dimorphism in BPW and categorised the black and smaller weevils as males, whereas the reddish brown and bigger ones are females. However Shukla and Kumar (1969) contradicted the observations as the black and smaller weevils as females, whereas the bigger ones as males. The colour difference of BPW has a controversy. Dutt and Maiti (1972) reported that colour of the adult weevil changes from reddish brown to black as the weevil gets older whereas Gailce et al. (2008) opined that colour variation cannot be linked with sexual dimorphism, but only a phenomenon of non-sex limited variation and of sympatry.

Based on the thickness of rostrum and its punctures, sex determination was described by Dutt and Maiti (1972), and they reported rostrum was thicker and punctures were more in male than in female. As the number of punctures per linear unit is more in male than in female, the rostral surface of male feels rougher (Nahif et al., 2000; Gailce et al., 2008). Sex ratio reveals females are dominating over males as its distribution is 1.00: 1.45 male to female (Kung, 1955), but Dutt and Maiti (1972) observed alteration in the sex ratio with respect to season, and observed male to female ratio 1.00: 1.17 during summer and 1.00:1.27 during winter.

Dutt and Maiti (1974) extensively studied the movement of BPW by giving special attention to its tarsomeres and the tenant hairs. The tarsomeres hold and act as the site of adhesion, the tenant hairs arising from the distal ends of the ventral side of the first and second tarsomeres are of pointed type while those arising from the entire ventral surface of the third tarsomeres are of forked type (Dutt and Maiti, 1974). There is variation in tenent hair length according to their location. Those arising from the ventral margin of the distal end are larger and slightly wider than others (Dutt and Maiti, 1974). Gailce et al. (2008) conducted an experiment with bentonite, an absorbent dust to verify the importance of the fluid secreted on the funnel shaped tenent hairs and cavity of the funnel, and found the treated adults failed to climb as quickly as the untreated ones and no climbing was possible until bentonite remained adhered to the tenent hairs.

Dutt and Maiti, (1972) described the morphology of egg and incubation period as regard to climatic conditions. Prasad and Singh (1988) observed a linear increase in the width of the head capsule among different larval instars. They observed an average increase in the width at each instar by 1.49 mm during February to May (25±4°C and 65.39% RH), 1.4 mm during May to August (20±5°C and 78.07% RH) and 1.36 mm during November to February (14±9°C and 73.72% RH). The progression factor for increase of the mean width of head capsule of instars was 1.360 mm and 1.406 mm respectively during summer and winter (Singh, 1966).

Taxonomy

Phylogenetically BPW is under kingdom Animalia, phylum Arthropoda, class Insecta, and super family Curculionidae. Super family Curculionoidea has been sub divided into two major families as Curculionidae Latreille, 1802 and Dryophthoridae Schonherr, 1825. Though there is a dispute, taxonomists prefer Curculionidae as the family to weevils that differentiates them from beetles. Curculionidae group include a subfamily Dryophtorinae that holds twenty different genus, including *Odoiporus, Polytus* and *Cosmopolites*. All genus hold large number of species and ploids. As proposed by several authors (Smith and Virkki, 1978; Sharma et al., 1980; Lachovska et al., 1998), the basic chromosome number of Curculionoidea is 22, but its number is high among Dryophthoridae (30) and Curculionidae (28) (Smith and Virkki, 1978). Both chromosome number and morphological variations indicate an evolution in the family Dryophtoridae. Polyploidy, tetraploidy and hexaploidy in BPW were first observed by Tripathi and Pallavi (2010) from Jammu. The increase in chromosome number from the basic 11 pairs shows the probability of divergent evolution from the super family Curculionoidea.

According to Dutrillaux et al. (1993) the sex chromosomes can be identified at late zygotene or early pachytene stages in the species of Dryophtoridae, and they form a compact rounded body during the rest of the meiotic prophase. Their study proposes a working hypothesis that the mode or chronology of sex chromosome and possibly autosome compaction at meiotic prophase is not uniform in Coleoptera, but it varies, and this variation may be a taxonomic character that would provide arguments justifying the separation of Dryophthoridae from Curculionidae.

Life cycle

Pre-oviposition period for the BPW is reported to be 15-30 days (Mohammed et al.,2010). Female lay an average of nine eggs after single mating (Gailce et al., 2008) and a single female lays 15 to 21 eggs in one season. Incubation period varies between 3-5 days during June-August, and 5-8 days during December-February (Thippaiah et al., 2012). Dutt and Maiti (1972) observed females were using rostrum to make ovipositional slits to deposit eggs (Figure 1). Mohammed et al. (2010) also observed the female weevil was making ovipositional slit with rostrum on the outer epidermal layer of the leafsheath down up to the air chamber, and inserting ovipositor to lay egg. According to them, usually one egg is laid at one air chamber, but under laboratory conditions a cluster of four to five eggs were alsoobserved at the cut end of the pseudostem, and this result corroborated with the observation of Froggatt (1928). Dutt and Maiti (1972) correlated a relationship between the diameter of the ovipositional slit and size of rostrum of the female and her ovipositor. By measuring the diameter of rostrum of BPW and the ovipositor puncture, they concluded that the weevil makes a feeding scar using the rostrum and later inserts the ovipositor through this slit. Singh (1966) has given a detailed account of grubs. Overlapping of broods is reported due to long life of the adults, and oviposition period that exceed three months (Gailce et al., 2008).

The larvae of the weevil are sluggish, apodus, leathery, soft, fleshy, creamy white, sub-cylindrical, active and red headed with biting and chewing type mouth parts. Body of the larvae is covered with sparse brownish setae of different lengths and the mandibles the head holds are bi-dentate, strong and dark brown. According to Singh (1966) the width of the head capsule increases in successive geometrical progression. The relationship of the head capsule among the different larval instars is found to be almost linear by Prasad and Singh (1988).Measurement of the width of the head capsules of the larvae at different instars was found to be 0.874 mm in summer and 0.819 in winter (Gailce et al. 2008). The study conducted by Prasad and Singh (1988) in Bihar- India, found an average ratio of increase in the width for each instar is 1.49 during February to May 1985 (at 25ºC ± 4ºC and relative humidity 65.39%) 1.4 during May to August 1985 (at 20±5ºC and 78.07% RH), 1.36 during November 1985 to February 1986 (at 14ºC ± 9ºC and 73.72% RH). Progression factor for increase of the mean width of head capsule in relation to instars is found to be 1.360 and 1.406 during summer and winter respectively.

Adult sex ratio of female to male is 1:1.25 accordingto Gold and Messiaen (2000) and is 1: 1.75 accordingto Dutt and Maiti (1972). 1:1 Sex ratio was determined from a field study by Krishnan et al. (2016).

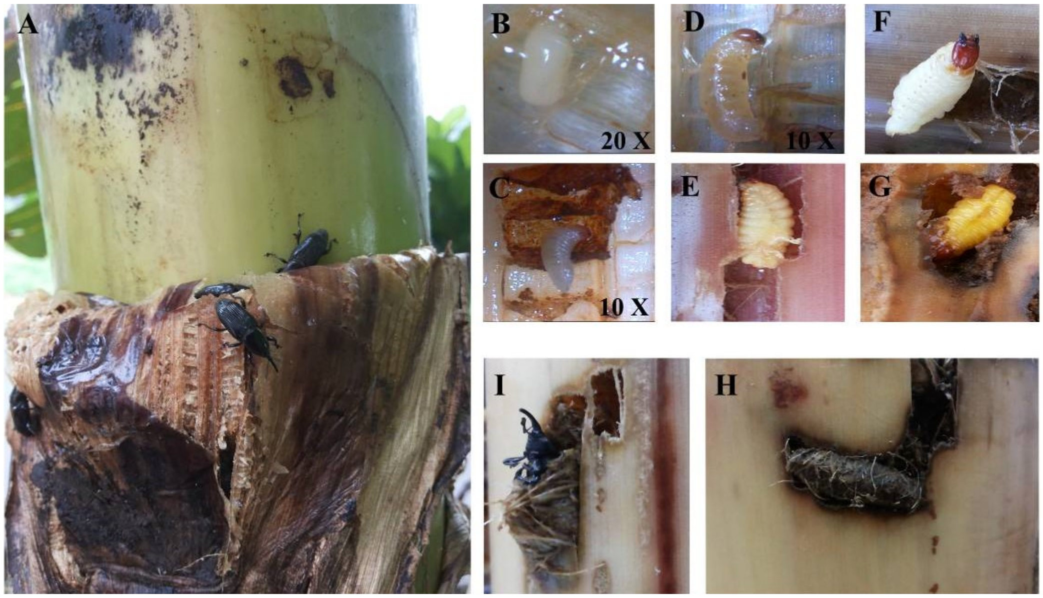

Figure 1 Life cycle of Banana Pseudostem Weevil, *O. longicollis*. A. Adult weevil on host plant, B. Egg inside the pseudostem sheet, C. First instar larvae, D. Second instar larvae, E. Third instar larvae, F. Fourth instar larvae, G. Pre-Pupae stage, H. Pupa, I. Emergence out from pupation as adult weevil.(Source: Images were captured and compiled by the Author's themselves)

Longevity

The weevil is characterised by long lifespan, (Kung, 1955). Though an extreme survival of the adult insect for 2 years reported by pinto in 1928, most adults live 6-10 months. Thus the life span of BPW is considered to be a year but no thorough studies were available till to date. Indiraet al. (2014) studied on the longevity of both the male and female weevils along with known temperature conditions and observed that 74.2± 6.87 days marks the life span in average to both the sex. Padmanabhan and sathiamoorthy (2001) counts 44 days as the life span of the adult weevil. Thippaiah et al. (2011) observed the average life span of BPW as, 81.0±5.42days. A study by Visalakshi et al. (1989) observe the life span as 105 days. Ravi and Palaniswami report (2002) the longevity of the adult weevil is up to 200 days within fallen or even in rotten pseudo-stem. No significant references were noted regarding the life span of the insect in field conditions.

Ethology

The BPW breeds throughout the year but Thippaiah et al. (2011) noticed its activity slow down during December-February in a study from Bangalore, Karnataka. Mating can happen either outside the pseudostem or in the space between the outermost and inner sheaths of the pseudostem (Dutt and Maiti, 1972). The weevil is characteristic in negative phototropism, thigmotropism, gregariousness, hydrotropism and death mimicry (Kung, 1955). In contrast to banana rhizome weevil, adults of BPW are good fliers. However, Gailce et al. (2008) found out that BPW are poor fliers and crawl swiftly on the surface of the ground. Zhou and Wu (1986) opined that adults are active during night and full-grown larvae overwinter in old banana stems. Adults show cannibalistic nature when they are kept along with the grubs, despite the availability of their natural food (Tripathi and Chaturvedi, 1978).

Reproductive behaviour of the insect was studied by Dutt and Maiti (1972), Mohammed et al. (2010), Thippaiah et al. (2011) and Irulandi et al. (2012). Adults mate frequently throughout the day and night, but prominently at daytime. By feeding adults engrave mating spaces between the leaf sheaths (Mohammed et al., 2010). Dutt and Maiti (1972) reported mating at any time outside the pseudostem or in the space between the outermost and inner sheaths of the pseudostem.

Host preference

Host preference exhibited by the adult BPW weevils was documented by Dutt and Maiti (1970);

Padmanaban et al. (2001) and Reddy et al. (2015). Dutt and Maiti (1970) noticed banana plants with a height of 6-8 feet and a circumference between 20-30 inches were preferred by BPW, subsequently Gailce (2008) also reported a similar observation. The physical and chemical factors that protect the plant from invasion by the pest includes certain plant characteristics like toughness of tissue, hairiness of leaf and stem, lack of nutrition, content of protective ash, silica, essential oil, alcohol, toxins, glucosides and alkaloids (Dutt and Maiti 1970). The pest enjoys wide varieties of banana, including highly preferred Dwarf Cavendish, Grand Naine and Robusta. Padmanaban et al. (2001) and Reddy et al. (2015) screened the germplasm of banana at the National Bureau of Plant Genetic Resources (NBPGR) Regional station, Kerala, and from Horticultural Research Station (HRS), Anantharajupet, Andhra Pradesh respectively, and categorised the following varieties resistance to the infestation by BPW, nevertheless these are not favoured for consumption, except *Rasakathali* or *Njalipoovan*. They also observed an increasing trend in weevil population from 5.5% in 1999 to 21.36% by 2000. Gailce et al. (2006) reported that highest incidence of BPW in *Nendran* variety (93.3%) followed by Poovan (80%), Robusta (66.7%) and Kappa (60%). Isahaque, (1978) identified varieties *Cheenichampa* and *Malbhog*, *Monohar*, *Jahajee*, *Kaskal*, *Bhimkhol* are highly susceptible, less susceptible, resistant, highly resistant, and completely resistant, respectively (Table 1).

Life table

Life table is an important tool in understanding the agricultural pests during different developmental stages throughout their life cycle. It is very useful to analyse the mortality of insect population to determine key factors responsible for the highest mortality within the population (Arshad Ali and Parvez Qamar Rizvi, 2009). Krishna et al. (2016) reported the stage specific and age specific life-table of BPW at minimum stress reveals. They reported 155.9±14.94 days to complete a generation at 28±2ºC followed by 114±12.35 days at 20±2ºC and 92±14.01 days at 35±2ºC. The survivorship of BPW shows a retrogressive parabola pattern,

Table 1 Cultivar varieties of banana resistance to Banana pseudostem weevil (Sources of compilation: Prasuna (2008); Padmanaban et al. (1999); Reddy et al. (2015))

Sl. No.	Local name	Genome	IC. No.
1	*Ashy Bathesa*	ABB	127981
2	*Bodles*Alta Fort	AAAA	127943
3	*Boodithabontha bath*	ABB	127987
4	*Boothibale*	ABB	TCR 216
5	*Chennabale*	AAB	127996
6	*Elavazhai*	BB	127946
7	*Ennabenian*	ABB	127994
8	Hybrid *sawai*	ABBB	127944
9	*Kalibow*	AAB	127986
10	*Kannan*	AB	127947
11	*Karibale*	AAB	127974
12	*Karivazha*	AAA	127941
13	*Karumpoovan*	AAB	84809
14	*Koombillakai*	AAB	TCR 78
15	*M. balbisiana*	BB	TCR 300
16	*Madavazha*	ABB	84760
17	*Morris*	AAA	TCR 133
18	*Morris*	AAA	TCR 221
19	*Namrai*	AAB	127938
20	*Nattuvazhai*	ABB	TCR 22
21	*Njalipoovan*	AB	84776
22	*Octoman*	ABB	127984
23	*Padalimoongil*	AB	127952
24	*Padalimoongil*	AB	TCR 241
25	*Padatti*	AAB	TCR 195
26	*Peyan*	ABB	127980
27	*PoojaKadali*	AA	127933
28	*Poozhachendu*	AAB	84863
29	Radjasree	AAB	127958
30	*Sakkaiorchakkiya*	ABB	84833
31	*Sannachenkadali*	AA	127940
32	*Senkadali*	AAA	84889
33	*Sivakositu*	ABB	TCR 29
34	*Tongat*	AA	127936
35	*Vannan*	AAB	127963
36	*Velipadathi*	AAB	127978

whereas mortality curve represents a progressive parabola (J shaped) pattern (Krishna et al., 2016). They also reported life expectancy exhibited a continuous decline with advancement of age of the weevil. The developmental stages from egg to first two stage adults of *O. longicollis* showed highest survivor fraction and lowest apparent mortality, survival ratio, indispensable mortality, and K-value is high suggesting it as an R- strategist. Replacement rate and generation time clarify the status of O. longicollis as a pest (Krishna et al., 2016).

Distribution

The pest is found to prefer tropical climatic conditions with high humidity. As regard to the weevil density, Tamil Nadu is the top among the other States (Palanichamy, 2011). The following are the first report on the pest incidence in different States of India (Table 2). Banana pseudo stem weevil was supposed to be evolved in the regions/ spots were the banana was supposed to be originated ie; from south and south east of Asia. The origin as the tropical belt of Asia was having documental supported by Padmanaban and Sathiamoorty (2001), Valmayor et al. (1994) and Froggatt (1928). The following are the first reports of pest attack in different countries.

Reports by Shukla and Kumar In 1969 and 1970 state the BPW as a major pest of Sikkim, Burma, Japan and Myanmar are the respective first report. The pest was reported in Java by Frroggatt (1928), Hong Kong by Hoffman (1933), Sri Lanka by Jepson (1935), China by Shukla and Kumar (1969), Nepal it was reported by Lefroy (1909). From all this Mohammad et al. (2010) concluded it as cosmopolitan to Asia.

Management

Injection of monocrotophos 4 mL (0.1% of 50 EC.) each at 45 and 65cm above the ground are the common practice prevailing among farmers. *Azadiractaindica* (neem) oil, crude extract of *Lantana camera* and *Gliricidiasepium* are also common in the management of pseudostem weevil (Sivasubramanian et al., 2009). Though a number of plant species have been reported to possess insecticidal properties, non-availability of sufficient quantities, cumbersome procedures in the extraction

Table 2 First hand reports of Banana Pseudostem Weevil incidence in different states of India. (Source: Compiled by the Author's themselves).

Place	Author (s)	Year
Andaman Islands	Lefroy	1909
Assam	Lefroy	1909
West Bengal	Lefroy	1909
Delhi	Batra	1952
East Uttar Pradesh	Shukla and Kumar	1969, 1970
Sikkim	Shukla and Kumar	1969, 1970
Bihar	Tiwary	1969, 1971
Uttar Pradesh	Shukla and Tripathi	1970, 1978
Goa	Sundaraju	1980
Orissa	Sundaraju	1980
Manipur	Ram and Pathak	1987
Kerala	Visalakshi et al.	1989
Tamil Nadu	Padmanaban et al.	2001
Gujarat	Patel and Jagadale	2003
Hyderabad	Sugnana et al.	2005
Seemandhra	Sugnana et al.	2005
Jammu and Kashmir	Azam	2007
Karnataka	Thippaiah et al.	2010
Arunachal Pradesh	Azad et al.	2012
Himachal Pradesh	Azad et al.	2012
Meghalaya,	Azad et al.	2012
Mizoram	Azad et al.	2012
Nagaland,	Azad et al.	2012
North eastern Himalayas,	Azad et al.	2012
Tripura	Azad et al.	2012
Maharashtra	Khairmode et al.	2015
Thelunghana	Srinivasa et.al	2015

of active principles and low extractability of the promising compounds are the prime impediments for their commercial exploitation. Isolation of phytochemicals from locally available plants by simple extraction method is a practical solution to produce bulk quantity of biopesticide. Many crops at harvest leave large quantity of biomass such as leaves, seeds etc. as waste, and the insecticidal molecules, if any in such biomass, have to be explored for the large scale extraction of pesticidal molecules.

Larval stages of the pest, being clandestine in nature, are unable to control at ease. Injecting synthetic pesticides into the pseudostem, fumigation, or swabbing with pesticide containing slurry (Padmanaban and Sathiamoorthy, 2001) are often expensive and also pose threat to man and environment. Flawless understanding on the behaviour of the pest is the underpinning factor in every pest management strategy.

Conclusions

Morphological review conclude the pest as a more adapted one in the tropics with more specialised features including adhesive pads on appendages, more sensitive antennae and long flight wings. The review observes a hypothesis that the mode or chronology of sex chromosome and possibly autosome compaction at meiotic prophase is not uniform in Coleoptera, this variation is purely reflected in the taxonomical advantages exhibited by Banana Pseudostem Weevil with that of Banana Rhizome Weevil. From the life cycle studies by various authors the review concludes that there is strong influence of climatic factors in the time scale of BPW life cycle and hence it fluctuates between 100-300 days. Life table studies are very less and hence pest status of the weevil is not well documented. Banana pseudostem weevil, *O. longicollis* enjoys a wide range of host varieties and thereby exhibit a unique belt of pest status throughout the geo-tropics. All together the review conclude the *O. longicollis* as a major pest that cause heavy economic drain that is yet not satisfactorily addressed over the developing tropical nations that are truly depended on agriculture.

The current study recommends research in the area regarding the proper documentation of life table. The authors believe a detailed study on the fore said aspect definitely find effective management measures against the pest. It was also found greatly demanded concerning a proper statistical research on the annual economic drain due to the pest. Many authors report host resistance against the weevil but proper research for developing resistance against BPW in economically valuable cultivar varieties are lacking. Since banana is a saviour crop and cannon of nutrition that supplement and nourishes village life of tropical world the issue of *Odoiporus longicollis* is posing a great threat.

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