Review

Life cycle of the Spinach Moth, Hymenia recurvalis (Lepidoptera: Pyralidae) on Purple Amaranth, Amaranthus blitum, in South-West Nigeria

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Abstract

The life cycle stages of the spinach moth, Hymenia recurvalis (F.) (Lepidoptera: Pyralidae), was studied on the host plant, purple amaranth, Amaranthus blitum L. (Caryophyllales: Amaranthaceae) and adults was fed with 5% honey-solution. The larva of these moths is a major defoliator of amaranths in Nigeria and could cause total yield loss. The first rearing phase involved transfer of 16day old larvae collected from field on webbed leaves into improvised rearing chamber equipped with regulated conditions of R.H (75±5%) and temperature (24-300C) while the second phase was carried out on tagged webbed leaves under natural conditions. The results indicated that the developmental life history of H. recurvalis consists of the egg, six-larval instars, one pre-pupa and a pupa stage before adult. Each of the life stages was isolated, measured and described. Larval instars were separated on the basis of the cast off exuviae. The life cycle from egg to adult lasted an average of 32.7days while the average egg incubation period was 4.3days. There were six larval-instars with total mean duration of 22.1days. There were significant differences in the body morphometrics of the life stages ($P<0.05$) for body length, abdominal width and head-capsule. The sex-ratio of male to female was 1:1.09. The potential fecundity of the H. recurvalis was 250.42±15.13eggs per female from dissected gravid females whereas the mean actual fecundity from mated females was 224.9±13.59eggs per female. This in-depth knowledge of biology of H. recurvalis will assist in the development of efficient and ecologically-sound management strategies for its control.

Keywords: Hymenia recurvalis; Amaranthus blitum; life cycle; body morphometrics; fecundity; sex ratio.

Introduction

One of the main features of the diet taken by people of the tropics and subtropics of the developing world is the deficiency in the supply of protein and vitamin. One of the measures recommended for the alleviation of this condition is the increased production and consumption of cheaper sources of high quality protein and vitamins. The vegetables provide such a source, the potential of which can be immediately released [1]. Protein from amaranth (African spinach) leaves provides as much as 25 % of the daily protein intake during the harvest seasons. It is grown all the year round [2]. The leaves of amaranth per 100g of edible portion contains protein, fat, mineral salts like calcium, phosphorus, iron and vitamin such as carotene, thiamine, riboflavin, niacin and ascorbic acid [3].

The leafy vegetables are valuable sources of vitamins A which are important for regulating the development of various tissues, such as the cells of the skin and lining of the respiratory, intestinal, and urinary tracts [4,5]. The leafy vegetables contribute about 33% of the vitamin A, 25% of the Ascorbic acid and substantial quantities of Thiamine, Niacin and Folic acid [6]. According to [7] the leaves of amaranths (African spinach) per 100g of edible portion contain water, protein, fat, mineral salts (like calcium, phosphorus, iron) and vitamin (such as Carotene, Thiamine, Riboflavin, Niacin and Ascorbic acid) [8]. Stated that amaranth is one of the most popular leafy vegetables in Southern Nigeria where it is grown for its leaves rather than seed [9]. Affirmed that among the different leafy vegetables grown in India, amaranth is the most popular on account of its fast-growing, high-yielding, stress-resistant, nutritious, and has nutraceutical properties earliness to mature, high nutritive value and palatability. Grain amaranth protein is of superior amino acid profile compared to proteins found in most other plant foods.

Nevertheless, the main features of the diet taken by inhabitants of the tropics and subtropics of the developing world are the deficiency in the supply of protein and vitamin. One of the measures recommended for the alleviation of this condition is the increased production and consumption of cheaper sources of high quality protein and vitamins. Therefore, leafy vegetables contribute significantly to the amount of carotene, vitamin c, protein, and minerals particularly calcium [10]. which can be immediately released and its leaves provide as much as 25% of the daily protein intake during the harvest season. Amaranth is grown all the year round [11] and are important for their nutritional values and potential as income-generating crop. It is grown all the year round during the rainy season and under irrigation during the dry season [11]. However, the greatest limiting factor increasing the productivity of this vegetable in both unimproved and improved agriculture is the range of insect pests with which they are associated. Furthermore, according to [12]. Beet worm Moth, Hymenia recurvalis was the most abundant defoliator causing loss of foliage in Amaranths in Ibadan, Southwest Nigeria.

There are numerous insect pests that have been recorded to attack this plant. Enoch et al., (2011) reported the followings as major pests of Amaranths: Sylepta derogata F. (Pyralidae: Lepidoptera), Hypolimnas missipus L. (Nymphalidae: Lepidoptera), Sjostedlina sp. (Coreidae: Heteroptera), Cletus fruscescens Wlk, Cletus unifasciata Blote (Coreidae: Heteroptera), Anoplocnemis curvipes F. (Coreidae: Heteroptera), Lygaeus festivus Thumb and Nysius maculiventris Dall in the family Pentatomidae order Heterocera, Creontiades pallidus Ramb, Helopeltis schoutedeni Reut (Miridae: Heteroptera), Aphis craccivora Koch, Aphis aspiraecola Patch (Aphidae: Homoptera), Laguia villosa F. (Lagriidae: Coleoptera), Ootheca mutabilis Sahl. (Galaricidae: Coleoptera), Epilachana chrysomelina var capensis Th. (Coccinellidae coleoptera), Gastroclisus rhomboidalis Boh., Hypolixus nubilosus Boh., Alcidodes albolinaetus Boh. and Nematocerus acerbus Fst. (Curculionidae: Coleoptera), Zonocerus variegatus (Orthoptera: Pyrgomorphidae). He also mentioned the following: Hotea gambiae Wstw (Pentatomidae: Heteroptera), Centrotus sp. (Membracidae: Homoptera), Homorocoryphus vicinus Wlk (Tettianidae: Orthoptera), Cassida sp. (Cassidae: Coleoptera) as minor pest of A. cruentus in South Western Nigeria. Banjo (2007) listed major insect pests of Amaranths but little work has been done on the various aspects of their bioecology. Other minor pests such as Aphids, Aphis fabae and Myzus persicae, form dense colonies on the shoots and leaves of some amaranth cultivars and cause direct damage by feeding and extracting plant sap, but primarily, they act as vectors for virus diseases. Similarly, amaranthus leafhopper, (Neoaliturus tenellus [Circulifer tenellus]), transmits amaranth curly top virus. Many of the insects attacking amaranths' cultivars occur in the family Lepidoptera. Among these, Hymenia recurvalis is the most important defoliator of amaranths in South-West Nigeria [12] and this was left out in the earlier report given by authors in Nigeria.

Also, there is paucity of information as regards the study of Hymenia recurvalis' life cycle. Most studies on amaranths have been essentially on the consumption levels and nutrition value, cultivation practices (which center on origin and diversity), germplasm collections, breeding and priorities for collecting and taxonomic classification and description [13]. The voracious feeding by the caterpillars and the presence of fecal pellets substantially reduces the quality and quantity of the leaves of amaranth utilized in cooking. To date, biological studies on insect pests of vegetables, especially amaranth species, have received very little attention in Nigeria and elsewhere around the world. No single insect pest, apart from the H. recurvalis, consistently attack cultivated Amaranthus spp., and the damage caused can be severe. H. recurvalis is widely distributed in tropical and subtropical regions, feeding on Amaranthaceae, Chenopodiaceae, and Portulaceae plants [14] and is thought to be migratory in Europe [15]. It infests Amaranthus spp., beetroot, soybean and Trianthema portulacastrum all over India. This species has been frequently caught on the Pacific Ocean or the East China and in China with aerial net traps. H. recurvalis cannot survive winter even in the southernmost part of Japan (Kyushu Island), because they have no hibernation stage and are less tolerant of cold temperatures [16, 17]. In Japan, H. recurvalis is thought to be one of the pests of subtropical and tropical regions, together with Cnaphalocrosis medinalis, during the rainy season [18, 19]. Indicated that southern beet webworm was the dominant caterpillar on Amaranthus hybridus in Florida corn fields during the late summer months. According to [20], the status of the reproductive maturity of females of C. medinalis caught on the sea from a paddy field have been relatively well studied, whereas none of this aspects have been evaluated for H. recurvalis. Severe attack of H. recurvalis as observed in this study results in complete skeletonising and ultimate drying of leaves. However, they construct a protective shelter by rolling a leaf and holding it together with webs. In Nigeria, production of Amaranths as mineral and vitamin supplement is on the increase. However, all Amaranthus species are being attacked by the spinach moth, thereby reducing their market value in terms of quality and quantity. Hence, there is a need to holistically design sustainable measures to prevent and control the attack of this insect pest on Amaranths. To date, there is paucity of publications on the life cycle of H. recuvalis as a premise for designing control measures. Particularly, an understanding of the development of the immature stages with regard to the period of expected emergence and behavioural and physiological characteristics of this pest would assist decision making about selection, timing and application of appropriate management option. The objective of this study therefore was to study the life cycle of the spinach moth, Hymenia recurvalis (F.), a major defoliator of susceptible Amaranthus spp. on purple amaranth, Amaranthus blitum, in Ibadan, South-West Nigeria.

Materials and Methods

Experimental site

The study was conducted in the roof top screen house and the Entomological Laboratory of the Department of Crop Protection and Environmental Biology, University of Ibadan, Nigeria at ambient temperature (27±3 OC); 75±3% relative humidity and 12:12 hour photoperiod. H. recurvalis was reared on purple amaranth, Amaranthus blitum L. L. (Caryophyllales: Amaranthaceae). The culture method and the adult oviposition cages used in the study are described below.

Life cycle study

Freshly laid eggs of H. recurvalis were collected from the leaves of A. blitum in the field planted in series at one week intervals. They were kept in culture cages, 12.7 x 8.5 x 6.4 cm, under ambient temperature 27 ± 30C and relative humidity 75 ± 30C in the laboratory. Thirty eggs were each measured with a micrometer fitted into a dissecting microscope. As the eggs hatched, three pairs of larvae were transferred into each of twenty plastic cages, which were well provided with leaves of A. blitum. The four sides of the cages were perforated with a hole, 3 cm in diameter, three of which were covered by a nylon mesh for aeration. Water was supplied through a glass vial plugged with absorbent cotton and inserted into the fourth hole. The leaves were changed daily and the fecal pellets removed. As larval development progressed, one larva was removed from each of the cages and immobilized in ethyl acetate fumes. The body length, abdominal width and the width of the vertex across the eyes were measured with the aid of micrometer eye piece fitted into the binocular microscope. The growth ratio for each of the larval instars were determined by dividing the mean width of vertex (n=20) across the eyes of one instars by that of the previous instars. The progression in growth H. recurvalis was examined by taking the mean width of vertex across the eyes of each larval instar along with the accumulated days of development of the first instars to the adult using the method of [21] with modifications.

Results

The developmental or life cycle stages of H. recurvalis was shown in (Plate i - xv) Female moths began to oviposit at the underside of leaf (Plate i and ii), three days after mating and oviposition lasted 5-6 days. The average number of eggs laid per female was 224.9 with a range from 196.4 - 253.3 (Table 1). The eggs which are elliptical, iridescent white and flattened were laid singly and in batches of 10 - 43 on the adaxial surfaces of leaves near the mid-rib (Plate ii). The eggs measured 0.75 ± 0.005 mm long, 0.40 ± 0.0435 mm wide and 0.24 ± 0.0418 mm in height (Table 2). Each female had an oviposition period of 3 days (Table 1), fecundity rate of 224.9 eggs (Table 1) and more than 50% were laid in the first 2 days. Eclosion occurred 4.2 days after oviposition and mean duration of each stadium varied widely from 1st instar (3 days); 2nd instar (2 days); 3rd instar (3 days); 4th instar (3 days); 5th instar (5 days); 6th instar (3 days); Pre-pupa (2 days) and pupa (9.7 days) (Table 2). The average growth rate for larvae was 1.503 (Table 2). However, the head capsule size increased at each molt by an average of 1.50 (1.29-1.69) approximating the expected constant ratio of 1.4 for lepidopterous larvae [22] .The total developmental period averaged 32.7 days. The sex ratio was 1:1.09 in favor of females. The average postoviposition was 3 days and longevity of adult was 11.5 days for mated females and 15.3 days for mated males. The unmated adult supplied with 5% honey on cotton balls and changed daily , recorded higher longevity, 22.2 ± 0.797 days and 14.1 ± 0.533 for female and male respectively (Table 2). Average adult wingspan was 19.95 ± 0.0.196 mm for female and 18.18 ± 0.115 mm for male (Table 2).

Parameters	Duration (Days ± SE)	Range	
Fecundity	224.9± 13.59	196.45-253.35	
Oviposition (days)	3.05 ± 0.073	2.89-3.20	
Postoviposition (days)	2.99 ± 0.054	2.87-3.10	
Incubation (days)	4.25 ± 0.106	3.50-5.10	
	Longevity (Mated female)	22.2 ± 0.80	20.57-23.83

Table 1:- Reproductive parameters and longevity of Hymenia recurvalis on water for 5days followed by 5% honey solution.

Life stages	Sample size (n)	Body length (X ± SE) (mm)	Body width (X ± SE) (mm)	Headcapsule width (X ± SE) (mm)	Growth Rate	Duration of stages (days)	
						Mean	Range
Egg	30	0.75 ± 0.005				4.2	3.5-4.8
		(0.74-0.76)					
1st Instar	20	2.83 ± 0.012	0.49 ± 0.007	0.27 ± 0.004	-	3.2	2.9-3.4
		(2.80-2.86)	(0.47-0.50)	(0.26-0.28)			
2nd Instar	20	4.25 ± 0.010	0.64 ± 0.007	0.39 ± 0.004	1.44	2.3	1.9-2.6
		(4.24-4.28)	(0.62-0.65)	(0.38-0.40)			
3rd Instar	20	7.27 ± 0.009	1.01 ± 0.008	0.66 ± 0.009	1.692	3.2	2.9-3.5
		(7.25-7.28)	(0.99-1.03)	(0.64-0.67)			
4th Instar	20	12.84 ± 0.015	1.71 ± 0.010	1.08 ± 0.010	1.636	3.1	2.6-3.4
		(12.81-12.87)	(1.69-1.73)	(1.06-1.10)			
5th Instar	20	18.10 ± 0.018	2.28 ± 0.008	1.57 ± 0.009	1.454	5.2	5-5.4
		(18.04-18.11)	(2.27-2.30)	(1.56-1.59)			
6th Instar	20	27.10 ± 0.064	3.28 ± 0.007	2.03 ± 0.016	1.293	5.1	4.7-5.3
		(26.91-27.18)	3.26-3.29	(2.00-2.07)			
Pupa	20	16.84 ± 0.92	3.79 ± 0.054			9.7	9.1-10.3
		(16.65-17.03)	(3.87-4.09)				
Adult							
Female	20	11.97±0.32	3.27±0.024		-		
		(11.75-12.23)	(3.11-3.45)				
Male	20	10.25±0.018	2.83±0.018		-		
		(10.10-10.40)	(2.65-2.96)				
Mean Growth Ratio of Larva					1.503		

Table 2:- Developmental durations and body morphometrics of Hymenia recurvalis on susceptible amaranthus leaf (larval instars) and water for 5days followed by 5% honey solution (adults)

Discussion

The lifecycle of the H. recurvalis consists of the egg, six larval instars, a pre-pupa and a pupa before the adult (Plates i - xv). The developmental life stages, body morphometrics and the periods of development of each stadium varied significantly as presented in Table 2. H. recurvalis eggs are elliptical, iridescent white and flattened and laid singly or in batches on the adaxial surfaces of leaves near the mid-rib. Each egg is elongated, almost cylindrical in shape and milk-white to transparent white at oviposition. The color however changes with time in a fertilized egg to amber by the second day and deep orange red by the third day at hatching. There is no progressive color change in an unfertilized egg. There are six larval instars. The first instar emerges after elusion at 3 days after deposition. It is characteristically apodous with 10 body segments. It is whitish all through the trunk but with a dark spot at the anterior end of the body.

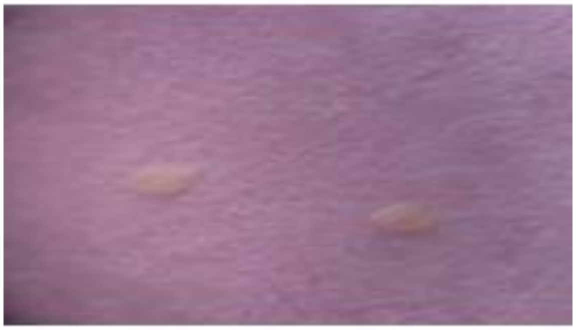

Plate (i): *Hymenia recurvalis* eggs viewed under microscope

Plate (ii): *Hymenia recurvalis* egg at the underside of leaf

Plate (iii): 1st Instar larva

Plate (iv): 2nd Instar larva

Plate (v): 3rd Instar larva

Plate (vi): 4th Instar larva

Plate (vii): 5th Instar Larva

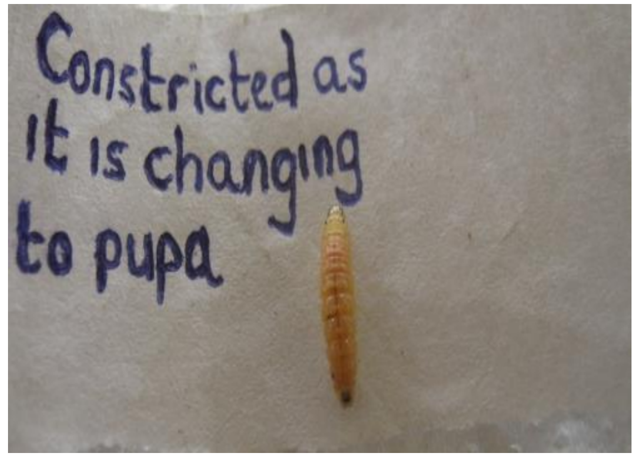

Plate (x): Prepupa 2 of *Hymenia recuvalis*

Plate (viii): 6th Instar larva

Plate (xi): Pupae of *Hymenia recurvalis*

Plate (ix): Prepupa 1 of *Hymenia recurvalis*

Plate (xii): Adult *Hymenia recurvalis* newly emerged from pupa

Plate (xiii): Adult male *Hymenia recurvalis*

Plate (xiv): Adult female *Hymenia recurvalis* with its robust abdomen

Plate (xv): Adult *Hymenia recurvalis* staged for wing span measurement

Figure 1: Developmental stages of Hymenia recurvalis

Similarly, a somewhat light- green colour appeared on both sides of the body as the larva progressively feeds on the amaranthus leaf. The green color gradually changes to pale green as the larva approaches third instar and continues in the fourth instar and later to milky-white at the fifth instar. The sixth instar become reddish and constricted as it approaches the pupa stage. The pre pupa becomes light brown as it tends toward pupa. The one-day old pupa is light brown and very fragile but becomes dark brown and tanned gradually with age. The stage lasts nine to ten days. By the fifth day, the pupa's sex can be separated by morphological differences in body size; the female usually being bigger than the male. The description was achieved following the method of [23]. As a result of the frequency distribution of the head capsule width, six larval instars of H. recurvalis were identified as shown in (Figures 3 - 10). Table 2 shows the head capsule widths of the various larval instars. The observed values when compared with the calculated values complied with Dyar's rule [24]. The newly emerged adult (the moth) has white wavy lines on the dark wing. Each adult male is 10.25 mm long and 2.83 mm wide with slender body compared to the robust and compact body of the female (Table 2). Males fly around in the cage more actively than the females with comparatively shorter life span. The adult female is 11.97 mm long and 3.27 mm wide (Table 2). The female abdomen is usually distended and full of matured eggs at emergence. Mating occurred within one day after emergence. During mating, male and female remain in coition facing opposite direction. Mating occurred only once in a female. The male died within a day after mating.

Conclusion

The reduction in market value of Amaranthus species by Hymenia recurvalis could be mitigated by identifying and engaging appropriate Integrated Pest Management (IPM) methods. However, an understanding of the development of the immature stages with regard to the period of expected emergence, behavioral and physiological characteristics of this pest would assist decision making about selection, timing and application of appropriate management option. Therefore, proper understanding of the biology of this pest provides the basis for a more sustainable and environment friendly control strategies.

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