Biotic Decimating Factors Affecting the Distribution of *Cirina forda* Westwood *(Lepidoptera: Saturniidae*) Population in Niger State, Nigeria

M. I. Muhammad[1] and A. T. Ande[2]
[1]*Department of Basic Sciences, College of Agriculture, P.M.B, 109, Mokwa, Niger State*
[2] *Department of Zoology, University of Ilorin, Kwara State, Nigeria*
Corresponding author; Email: *masudmohdizom@yahoo.com*

Abstract

The biotic agents, i.e. predators, parasites and pathogens that could be responsible for the mysterious occurrence and decimation of *C. forda* (Westwood) in Niger State, Nigeria, were monitored, identified, and their individual interactive effects reported from farm lands and villages from six local government areas, namely Katcha, Paikoro, Gurara, Lavun, Lapai and Rafi. All the developmental stages, i.e. eggs, larva, pupa and adult of *C. forda* had a biotic agent affecting them. The checklist of the agents include *Anastatus* spp, an egg parasitoid; larval predator including *Ocecophyla longinoda*; Spiders, and black crow bird; larval pathogens of viral origin, i.e. *Nuclear polyhedrosis virus* and *Granulosis virus* and of fungal origin i.e. *Nomerae arileyi* and *Beauveria bassiana;* a pupalparasitoid, *Hockeria* spp;and Agama lizard, a predator of imago stage. The possible roles of each of these agents in the ephemeral nature and beliefs about the mysterious distribution of *C. forda* were substantiated and discussed.

Introduction

The emperor moth, *Cirina forda* Westwood (Lepidoptera: Saturniidae) caterpillar, is one of the most popular edible food insects in Nigeria (Fasoranti & Ajiboye, 1983; Ande, 1991; Ande & Fasoranti, 1995). Like all other Lepidopterans, *C. forda* is holometabolous (Ande & Fasoramti, 1996, 1997). It is typically an African moth whose sole host is the shea butter tree, *Vittelaria paradoxa* (Ande,1991; Ande & Fasoranti, 1996). *C. forda* distribution coincides with the occurrence of *V. paradoxa* in Nigeria with Niger State featuring very prominently (Ande, 1991). *C. forda* is a univoltine insect whose caterpillar, i.e. the most conspicuous developmental stage, are noticed between June and September annually (Ande & Fsaoranti, 1997). The caterpillars defoliate matured fruiting-bearing trees, thus, causing extensive damage to *V. paradoxa* trees (Greenwood, 1929) such that 90% of the trees' leafy area is damaged in a season (Owusu-Manu & Kuma, 1990). Unfortunately the period of this caterpillar attack coincides with the period of seed maturation and ripening of *V. paradoxa* fruits (Ande & Fasoranti, 1995).

The occurrence and distribution of this insect remains a mystery as they are generally regarded as ephemeral. Even locations that are renowned for their presence, when they are in season, frequently come up with no harvest or very low yield even in contiguous harvest seasons. Some of the factors responsible for this undesirable development include environmental factors such as bush burning and biotic decimating factors that include human factors such as inordinate harvest pressure, over cropping and mode

West African Journal of Applied Ecology, vol. **22**(2), 2014: 57–68.

of harvest (Ande, 1991). Other biotic factors such as predators, parasites and pathogens abound, but dearth of knowledge with respect to specific forms of these and their respective interactive activities have been identified, more so that the quality and importance of each of these factors vary with location. An attempt is made in this paper to report for the first time the various decimating biotic factors that affect the natural field population of *C. forda* in Niger State, Nigeria.

Materials and methods

Natural field population of *C. forda* in six local government areas, i.e. Katcha, Paikoro, Gurara, Lavun, Lapai and Rafi in Niger State were monitored for predatory, parasitic, pathogenic and other vertebrates over two seasons. Farmlands and villages featuring thriving populations of *C. forda* were identified based on positive responses to the questionnaires in 2009 and confirmatory visitations in December–April for pupae; June for adults; June–July for eggs and July–September for various instars of larvae in the cropping season to the sites were utilised for the study in 2010 and 2011. Each of these locations were frequently visited and scrutinised for biotic interactions that resulted in reduced viability or mortality of each of the developmental stages of *C. forda* on the field. A three 10-m^2 subloci were mapped out of each locus (100 m^2) to provide replicate values per study site.

Soils around *V. paradoxa* plant base and within one meter quadrat were scrapped carefully with a hoe and shovel (three random throws of quadrat per sublocus and, or nine throws of quadrat per site. The total number of pupae per site was taken in each local government area. All pupae encountered were carefully uprooted and mean density and (SD±) noted. The living status of each was ascertained by rocking the abdomen and mean density and (SD±) of survival pupae noted. Stiff abdomen indicated dead pupae while a responsive pupa was living, the experiment for pupal parasites and parasitoids was put under observation daily for 5 days for pathogens and parasitoid emergence using sterilised plastic containers with a layer of filter paper at the bottom.

The containers were placed in a biochemical incubator (ZSD-1160, Zhcheng, China) maintained at 25 ± 2 ^{0}C and 75–80% RH. Fungus infested individuals collected dead and those dying in the laboratory were placed in microscope slides on moist filter papers in petri dish for 1 week to stimulate sporulation of fungi. Any emerging fungal pathogen was isolated by inoculating the conidia onto potato detrose agar (PDA) and fungal growth (Odebiyi *et al.*, 2003) and the microbes identified were confirmed at the Microbiology Department of Federal University of Technology, Minna, while pupal parasitoids identified were confirmed at Insect Museum and Identification Unit of Institute of Agricultural Research, Ahmadu Bello University, Zaria.

Results

All the developmental stages, i.e. egg, larva, pupa and adult, of *C. forda* were affected by different biotic agents, Table 1ab.

Eggs

Eggs of *Cirina forda* in Niger State were conspicuously destroyed by a parasitoid wasp identified to be *Anastatus* spp. (Fig. 1a). The ovarian chalcid wasp is a minute individual 2–4 mm long, very active, brisk and had wing patterns, which makes it looked more like small black ants with metallic black

TABLE 1a

Effects of biotic agents'interaction and interactive mode withpupa of C. forda

LGA	*Mean (SD±) of pupae uprooted*		*Mean survival (SD±)*		*Mean mortality(SD±)*		*Mean (SD±) pupae with parasitoids*		*Mean (SD±) pupae with fungal infestation*	
	2010	*2011*	*2010*	*2011*	*2010*	*2011*	*2010*	*2011*	*2010*	*2011*
Gurara	147.14 ± 37.4	48.8 ± 7.08	18±8.04	34.07 ± 16.9	131.7 ± 37.8	24.42 ± 11.2	93.3 ± 16.0	27 ± 10.5	1.5 ± 14.7	1.5 ± 5.1
Katcha	102 ± 33.372	82 ± 28.618	32 ± 16.294	33 ± 3.749	70 ± 28.381	68 ± 15.874	61.3 ± 24.0	60 .± 13.7	1.5 ± 14.7	2.0 ± 14.7
Lapai	42 ± 52.263	44.5 ± 50.7	45 ± 38.183	14.6 ± 13.48	22.6 ± 23.06	22.8 ± 40.29	12.4 ± 6.22	20 .± 17.5	1.8 ± 14.0	1.0 ± 5.19
Lavun	77.4 ± 42.50	77.4 ± 41.6	40.5 ± 36.37	40.8 ± 37.69	45 ± 12.727	20.2 ± 12.23	39.5 ± 22.3	39 ± 19.3	1.0 ± 12.7	1 ± 11.0
Paikoro	60.3 ± 17.51	44.7 ± 17.7	24.7 ± 7.977	16 ± 8.746	40.5 ± 11.42	28.8 ± 14.57	44.3 ± 15.6	38 ± 15.9	1.5 ± 3.6	1.7 ± 4.3
Rafi	42 ± 13.747	29.25 ±13.5	9.0 ± 0.0	6.0 ± 5.196	36 ± 15.588	14.7 ± 14.77	26.6 ± 12.8	20 ± 8.7	1 ± 5.196	1.2 ± 4.5

TABLE 1b

Effects of biotic agents'interaction and interactive mode with eggs and larvae of C.forda.

LGA	*Egg stage (eggclusters)* Anastatu *ssp*				*Larval stage Nuclear polyhedrosis virus (NPV)*		*Larval stage Granulosis virus (GV)*		*Larval stage Nomeraearileyi (Nr)*		*Larval stage Beauveria bassiana (Bb)*	
	2010 Total	2011 Infested (%)	Total	Total (%)	2010 Total (%)	2011 Total (%)	2010 Total/ (%)	2011 Total (%)	2010 Total (%)	2011 Total (%)	2010 Total (%)	2011 Total (%
Gurara	587	480 (81.7)	723	608 (84)	238 (75.5)	197 (62.8)	77 (24.4)	170 (75.3)	–	–	–	–
Katcha	827	471 (56.9)	919	771 (80)	179 (44)	180 (44.4)	46 (11.3)	45 (11.1)	119 (29.3)	104 (25.6)	61 (15.0)	75 (18.5)
Lapai	442	369 (78.1)	535	438 (81)	200 (74.0)	144 (53.3)	70 (28.9)	124 (49.6)	–	–	–	–
Lavun	447	337 (75.3)	576	479 (81)	164 (72.8)	170 (75.3)	59 (26.2)	55 (24.4)	–	–	–	–
Paikoro	816	568 (69.9)	950	814 (85)	237 (52)	237 (52.6)	213 (47.3)	213 (47.3)	–	–	–	–
Rafi	232	160 (68.9)	382	250 (82)	108 (60.0)	108 (60.0)	72 (40.0)	72 (40.0)	–	–	–	–

body. This wasp in the family of Chacididae with an ovipositor protruding strongly used the ovipositor by the female *Anastatus* spp. to puncture the egg chorion, and usually found roaming around the cluster of *C. forda* egg mass. All the eggs destroyed by *Anastatus* spp. were empty shells (Fig. 1b). During the two sessions, over 66% in 2010 and 82% in 2011 of egg masses examined were attacked by *Anastatus* across Niger State.

Larvae

Predatory attack of *C. forda* larvae by the adult red ants, *Oecophyla* sp. were frequently noticed across the State and in all the local government areas sampled. The 1 and 11 instars were most affected. The ants attacked their prey by biting, demobilising and retrieving them to their nests for devouring. The mature *C. forda* instars were also vulnerable, as the gregarious predators gathered to demobilize them from their residence constructed from leaves of *V. paradoxa* (Fig. 2) in the canopy of the host plant.

The same was the case with the solitary spiders, residing on the leaves and trunk of the *V. paradoxa* canopy. Three different types of these spiders were recovered, one of which was identified as *Opisthoncus polyphemus* (Fig 3a).The other two were identified to be members of the family Salticidae and Thomisidae. These spiders bounced on their prey individually from hiding or webbed them up, after which they bite and paralyzed the larvae before sucking the juice out of their preys, leaving behind the undigested exoskeletal excuvie (Fig. 3b).The Blackcrow birds, *Corvuscapensis*, (Fig. 4abc) fed on all *C. forda* larval instars by probing and picking them up from the twigs of host trees across the State. Two fungal species, *Nomeraearileya* (Moniliales, family Moniliaceae), and *Beauveria bassiana* (Hypocreales: order Cordycipitaceae) were isolated from *C. forda* larvae in Niger State. The hyphae of the fungus, *Nomeraeaerileyi*, (Moniliales: Moniliaceae) a dimorphichy phomycete, emerged on the larval cuticle at the intersegmental membranes produced spores that was seen as creamy reddish brown powder enveloping the body.

The fungus was responsible for epizootic death of *C. forda* larvae in all the sampled locations that were damp across Niger State. The affected larvae were relatively inactive and became stiff prior to death with an observable coloured mould attachment emerging from the intersegmental regions soon after death (Fig. 5). Since the infestation of this fungus was not detectable at the onset until after the larvae had stiffened out, it was not possible to determine spontaneous occurrence or the infestation. *Beauveria bassiana* is an entomopathogenic fungus that infected the larvae of *C. forda*. They are contact-pathogens that replicated on cuticular surface of the larvae and developed a whitish mould that continued to increase even after the dead of the larvae (Fig. 8), or the destructive capability of the pathogen per location. Dead larvae featuring this disease were, however, more frequent in Katcha LGA, seen sometimes in an upright position still attached to a leaf or stem in an upper part of the trees.

Two virus types i.e. *Nuclear polyhedrosis virus*(NPV) and *Granulosisvirusis* (GV) were encountered infesting *C. forda* larvae in Niger State. *Nuclear polyhedrosis virus* (NPV) is *C. forda* larvae pathogen most likely contacted from ingesting virus-contaminated foliage. Once contacted, the larval feeding and movement capabilities were affected.

Fig. 1a. *Anastatus* spp. caught in the act of destroying the egg clusters.

Fig. 1b. The destroyed eggmass by the ovarian parasitoid, *Anastatus* spp.

Fig. 2. *Ocecophyla longinoda* in their nests on host tree where they retrieved their preys into.

Fig. 3a and 3b. Larvae were webbed massively to dead by spider and, the wilted larvae can be seen in silks of spider.

Fig. 4a.Blackcrow on a twig resting after picking larvae of *Cirina forda*.

Fig. 4b. The Blackcrow captured on the field contagious with larval population of *Cirina forda*.

Fig. 5. *Nomerae arileyi* infested larva in cotton cream coverage in an inactive but stiffened position hanging on the leaf in upper part of the tree

Fig. 6. NPV-infected larva becomes black and eventually dies hanging.

Fig. 7. GV-infected larva differs from NPV-infected by turning milky white and stops feeding.

Fig. 8. *Beauveria bassiana*-infected larva died hanging with white cuticular coverage that turned black later, the fungus enzyme showed the presence of beauvericin toxin.

Fig. 9a. Hedgehog. Feeds on the fifth and penultimate larva, (B) devoured larva preyed upon by hedgehog.

The NPV-infected larvae became sluggish and stopped feeding, only to develop a whitish ventral region that turned black along the intersegmental membranes as skin darkens and eventually died hanging as shown in Fig. 6.

Granulosis virus infection was similar to NPV in most respect . GV infested larvae turned milky white and the skin of the larvae breaks easily to release the infectious virus (Fig. 7). The matured larval instars, i.e. 5th and penultimate instars, were devoured by the Hedgehog, a spiny rat (Fig. 9) that were readily observed within the ecosystem under study, hence, they predated frequently on larvae attempting to bore into the soil to form pre-pupa.

Pupae

Hockeria spp. (Walker), a Hymenopteran chalcidparasitoid wasp species of the superfamily Chalcidoidae and suborder Apocrita, was the only biotic agent observed parasitizing on the pupae of *C. forda* in Niger State. Mature *Hockeria* spp. parasitoid emerged from pupal body by which time the pupa was dead. The parasitoid, *Hockeria* spp, was usually active on bright and clear day and had a colour range of black to brown with armoured and sclerotized body. They oviposited eggs on pupal body of the *Cirina forda* using stout ovipositor. They subsequently developed within the pupae to adult wasp that emerged from the pupal case. The infected pupae took sometimes, approximately 46 days to die.

Adult

Agama spp. predated on the imgo of *C. forda*. This was, however, not frequently observed, as the *C. forda* adults rooted on *V. paradoxa* tree canopy where the lizards seldom occur during the day.

Discussion

Whereas the egg, pupa and adult developmental stages of *C. forda* had one biological agent each of the larval stage, which happens to be the most easily noticed, the most destructive to host plant and the sole stage responsible for its dispersal (Ande, 1991) had the largest number of adversarial biological agents. These agents included predators and pathogens. Although it was not possible to determine the instantaneous decimating effect and dispersal mode of the pathogens amongst the larvae, its cumulative effect may be colossal since the mature larvae and pre-pupa stages are the stages consumed by humans and most of the time these pathogens would have killed its host before it matures. Mermithid nematode infestation, reported to emerge from the body of mature larva and pre-pupa (Ande, 1991), was never observed in this study. The possibility of a snake predating on pre-pupae descending the tree (Ande, 1991) may exist but was not observed throughout the study period. These predatory activities contributed significantly to decimation, especially predation of the early vulnerable instar stages by *Oechophyla* and the spiders.

The gregarious habit of *C. forda* at the larval stage nullified the effect of decimation of this stage by these numerous agents, thus, their impact was hardly noticed. Unfortunately the larvae that matured to the fourth and fifth also fell victims of the pathogens and predators just as fungal pathogens such as *Trichoderma* sp. *Aspergillus nigers*, *A. flavus* and *Fusarium solani* were implicated by Odebiyi *et al.* (2003). Thus, few larvae actually transformed successfully to pupae. Man in fact can also be listed as a major *C. forda* larval predator, since he often harvested the larvae enmass for consumption and as an item of commerce (Ande, 2002). The adult stage also featured a predatory agent, i.e. *Agama* spp. but the effect of this was not conspicuous as they did not share the same ecological niche. Apart from this, adult *C. forda* were only active at night (11:00 p.m. –5:00 a.m.) for 2–3 days (Ande & Fasoranti, 1997), during which the poikiothermic reptiles (Agama lizards) are inactive and resting. Unfortunately as predators, the reptiles have preference for active or mobile insects within reach. Fortunately *C. forda* adults do not qualify, as they are inactive and situated high up on the host tree (Ande, 1991).

The pathogens recorded included two viruses, i.e. *Nuclear polyhedrosis virus*, *Granulosis virus* and two fungi, i.e. *Nomerae arileya*, and *Beauveria bassiana* both of which contributed to the reduction in population of *C. forda* larvae considerably, especially at the mature larva stage of fourth and fifth instar. The parasitoids were restricted to the egg and pupa developmental stages despite their seemingly hard protective covering. The pupalparasitoid, *Hockeria* spp. featured quite prominently in Niger State. Dwomoh *et al.* (2004) noticed a similar situation in Ghana where pupae of *C. forda* showed high presence of *Hockeria* spp. infestation, particularly pupae collected in December and January. The activity of this pupal parasitoid may be distinctly less destructive at 30.4% in 2010 and at 41% in 2011, as compared to the egg parasitoid, as virtually all eggs in a cluster (60% in 2010 and over 82% in 2011) were infested as against individual pupal infestation. However, the dead percentage rate of pupae eventually rose with some dying in the laboratory.

Conclusion

For the first time, field experiment has identified the biotic decimating factors of *Cirina forda* in Niger State, Nigeria. These findings proffered answers to the ephemeral nature and beliefs about the mysterious occurrence, dispersal and distribution of *Cirina forda*. The numerous insidious and devastating activities of predators, parasites and pathogen identified no doubt culminated in the decline and distinction of *Cirina forda* population. The study is ongoing on the impact of each and collective depleting activities on the distribution and population of *C. forda* in Niger State, Nigeria.

Acknowledgements

The authors are grateful to the Higher National Diploma (HND) students of Niger State College of Agriculture, Mokwa, Niger State, Nigeria, for their technical assistance, and Local Government staff as farmers' contact of the six local government areas of Niger State, Nigeria, for their assistance when conducting the trial.

Reference

Ande A. T. (1991). *Some aspects of Biology of Cirina forda* (Westwood). (Ph. D Thesis.) University of Ilorin, Nigeria. 327 pp.

Ande A. T. and **Fasoranti J. O.** (1995.) Determination of the number of instars in *Cirina forda* (Lepidoptera: Saturniidae) *Bioscience Research Communication* **7**: 57-60.

Ande A. T and **Fasoranti J. O.** (1996). Description of the life stages of *Cirina forda* (Westwood) Lepidoptera: Saturniidae, *Nigerian Journal of Entomology* **13**: 57–60.

Ande, A. T. and Fasoranti J. O. (1997). Life history notes for the pallid emperor moth, *Cirina forda* (Westwood) (Lepidoptera: Saturniidae). *Journal of Lepidopterists' Society* **13**: 57–60.

Ande A. T. (2002). The influence of local harvesting and processing methods on some nutrient content of *Cirina forda* (Westwood) Lepidoptera: Saturniidae) in Nigeria. *Nigeria Journal of Pure and Applied Science* **17**: 1165–1168.

Dwomoh E. A., Akrofi A. Y and **Ahadzi S. K. (**2004). Natural Enemies of the Shea defoliator, *Cirina forda*, *Tropical Science*. **44**: 124–127.

Fasoranti J. O. and **Ajiboye D. O.** (1993). Some edible insects of Kwara State of Nigeria, *American Entomologist* **93**: 113–116.

Greenwood M. (1929). Shea nut and Shea butter. *8th Annual Bulletin of the Agricultural Department*, Nigeria. pp. 59–103.

Odebiyi J. A., Omoloye A. A., Bada S. O., Awodoyin R. O. and **Oni P. I**. (2003). Spatial distribution, Pupation behaviour, and Natural Enemies of Cirina forda Westwood (Lepidoptera: Saturniidae) around its host, the sheanut tree, *Vitellaria paradoxa* C.F. Gert. *Insect Science Application* **23**(3):267–272.

Owusu-Manu E. and **Kuma N. K.** (1990). Effect of *Cirina forda* (Westwood) damage on yield. *Report, Cocoa Research Institute of Ghana*, 1989/90. pp. 73.