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Some Biology Features of *Pempelia* spp. (Lepidoptera: Pyralidae): An Insect Pest of *Jatropha curcas*

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Abstract

***Jatropha curcas* L., a biofuel tree, is attacked by several insect pests, including *Pempelia* spp. (Lepidoptera: Pyralidae). This insect pest feeds on the stem and the leaves of the plant and can inflict severe damage to the shrub. This is why we studied its biology. *Pempelia* spp. larvae were collected in *J. curcas*' plantations in the Léo, Biéha, Silly and Niabouri communes in the Sissili province of Burkina Faso, West Africa and were bred inside transparent plastic boxes. Immerged adults were separated into boxes after pairing them and were bred until their death. The female deposits its eggs in batches on the apical parts of *J. curcas*. Newly laid eggs are white pale. The first instar larvae are tiny and white pale or yellow. The 2nd instar larvae have a light green coloration, with longitudinal stripes. The 3rd instar larvae are lightly green with dorsal longitudinal stripes. The 4th instar larvae have a black head and a grey body. The 5th instar larvae have a blackish brown head with a dark reddish or light reddish longitudinal body. The mean duration of an instar is 8 days. The pre-pupa stadium is a period during which the larvae surround themselves with a white web developed from their saliva secretion. The pupa lives within a dark red cocoon. *Pempelia* spp. adults are grey. Female adults have large abdomen whereas males show a cylindrical and slender abdomen. These findings are the first of their kind reported in Burkina Faso. They are discussed in this paper.**

Keywords

***Pempelia* spp., Life Cycle, *Jatropha curcas*, Burkina Faso**

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1. Introduction

In Burkina Faso, four species of physic nut are known: *J. curcas* L., *J. gossypiifolia* L., *J. podagricas* H. and *J. integerima* J. [1]. Among these four species, *J. curcas* is the most popular and the most exploited one.

Jatropha curcas is now being promoted in several countries in the world for biofuels production and for increasing growers' incomes, contributing to poverty alleviation in rural areas through the promotion of short chains of crude vegetal oil production [2]. *Jatropha curcas* also contributes to soil fertility management through the control of wind and water erosion. Finally, the plant can be used to mitigate greenhouse gas emissions through carbon sequestration.

Nonetheless, *J. curcas* seed production is usually jeopardized by many insect pests. Several insects of the orders of Hemiptera, Coleoptera, Lepidopterous and Orthoptera are reported as insect pests of *J. curcas* in Nicaragua, in Brazil, in India, in Australia and in Africa [3]. According to the same authors, some of these insects feed on *J. curcas*'s flowers or its fruits and these result either in the abortion of flowers or the deformity of the fruits, while others eat the leaves of young plants and can bring about a poor development of these young plants.

Amidst these insect pests, several caterpillars of the lepidopterous species and belonging to the Pyralidae and Noctuidae families were observed on *J. curcas*, inflicting damages to the plants. In India, [4] reported the presence of *Pempelia morosalis*, a species belonging to the Pyralidae family. According to that author, *P. morosalis* caterpillars lead to the fall of *J. curcas* flowers and capsules. In Burkina Faso, according to [5], the *P. morosalis* species in the larval stage is a potential pest for *J. curcas*' plants. According to the same author, the frequency of observations of that species in *J. curcas*' plantations is about 49.32%. This stem borer usually attacks the stems and young branches easily identified from far because of the skeletal nerves of the defoliated young branches and the presence of a web soiled by the feces of the insect pest. Usually, the larvae in batches of 3 to 5 individuals damage the *J. curcas* plants.

Pempelia spp.'s damages have considerable impact on the production of *J. curcas*' seeds despite the existence of natural enemies associated with the insect pest. These enemies include a diptera, *Stomphastis thraustica* and an arachnid, *Stegodyphus sp.* [3]. Thus, in order to mitigate damages inflicted by *Pempelia* spp. on the production of *J. curcas*, it is necessary to study the biology and the ecology of this insect pest.

2. Material and Methods

2.1. Study Site

The study on the biology of the insect pest was conducted in 2014 in the Léo commune, specifically in the laboratory of Fondation Fasobiocarburant. Léo is the major city of the Sissili province. It is located at 165 km, South-West of Ouagadougou; its geographical coordinates are 11˚5'N; 2˚6'W and a mean altitude of 359.36 m. Four study sites were selected. These include Biéha, Léo, Niabouri and Silly. *Jatropha curcas* is usually found as being part of the cropping system of the Sissili province.

The landscape ranges from tree and bush savannas to shrub savannas composed of *Detarium microcarpum*, *Isoberlinia doka*, *Burkia africana*, *Ficus plastyphylla*, *Pilostigma toningii*, and *Daniella oliveri*. The province is an agricultural and animal husbandry zone, and primarily taurine cattle are raised. Agriculture is associated with woody plants such as *Mangifera indica*, *Anacardium occidentalis*, *Vitellaria paradoxa*, *Parkia biglobosa*, *Jatropha curcas* and *Tamarindus indica*.

2.2. Material

2.2.1. Plant Material

The plant material that was used in this study was composed of *J. curcas* plants of at least 4 years. These plants were grown by farmers in different types (pure plantations, associated with crops and live-fences).

2.2.2. Insect Material

Pempelia spp. at different developmental stages was the animal material. This material was collected in *Jatropha curcas*' plantations across the Sissili province.

2.2.3. Technical Material

The technical material that was used was of two types, namely the material used to collect *Pempelia* spp. in the

field and that used for breeding the insect pest in the laboratory.

- A pair of hand-pruning shears to cut off plant parts that are infested by *Pempelia* spp.
- A plastic box to store the cut parts;
- Plastic boxes with grilled slatted shutters, used for the breeding of *Pempelia* spp. larvae and the infested parts;
- Absorbent cotton was used to moisten the bottom of the plastic boxes;
- Labels, for the labeling of the various breading boxes;
- A binocular microscope to observe the insect pest;
- A caliper measure for the various measurements of the insect at its various developmental stages;
- A harvest net to catch *Pempelia* spp. adults in case they escape from the breading box during manipulations;
- A digital camera to take pictures in the field and in the laboratory;
- A record book to record the various observations;
- A voltcraft for measuring the temperature and relative humidity.

2.3. Methods

Pempelia spp.'s larvae were collected in the field and brought back to the laboratory and put into small plastic boxes of 50 × 40 cm. The insects were kept in conditions closed to those of the surrounding environment (30˚C temperature, 69% RH, and a photo period of 12:12 [L:D] h). The laboratory was well-ventilated thanks to large windows. Some absorbent cotton soaked with water was placed in the bottom of each breeding box in order to slightly increase the humidity that was necessary for the feeding and the development of the caterpillars. The soaking of the cotton was repeated every two days. At emergence, the feeding of the larvae was supplemented with diluted honey. Several larvae were put together in the same box in order to get couples. At each pairing, the couple was isolated in a new box. Ten couples of *Pempelia* spp. were bred. Every breading box was labeled with information such as the breeding date and the zone of origin. Parameters recorded in the laboratory included the number of eggs at each oviposition, the number of ovipositions per female, the places of eggs oviposition, the duration of eggs incubation, the number of developmental stages, the duration of each developmental stage and the fertility of *Pempelia* spp. Adults that emerged from each breeding were also fed and observed until their death. Observations were done twice daily, at 7 a.m. and 5 p.m.

Data Processing

1) Duration of egg incubation

The duration of incubation, **DI**, of eggs is the time span between the date of oviposition $\mathbf{D_0}$ and the date of emergence $\mathbf{D_1}$. It is determined by the following formula:

$$\mathbf{DI = D_1 - D_0}$$

With **DI** = duration of incubation; $\mathbf{D_1}$ = date of emergence; $\mathbf{D_0}$ = date of oviposition.

2) Duration of larval instars

The duration of development, **T**, for a larval instar, is defined as the time spent in moving from an initial instar $\mathbf{T_i}$, to the following instar $\mathbf{T_S}$. It is determined by the formula below:

$$\mathbf{T = T_S - T_i}$$

With **T** = duration of the instar; $\mathbf{T_i}$ = duration of the initial instar and $\mathbf{T_S}$ = duration of the immediate following instar.

This formula was used to compute the duration of each larval instar.

3) Adult life span duration

Adult life span duration, **D**, is the time period comprised between the date of emergence of the adult, $\mathbf{D_0}$, and the date of its death, $\mathbf{D_1}$. It is the difference between $\mathbf{D_1}$ and $\mathbf{D_0}$.

$$\mathbf{D = D_1 - D_0}$$

4) Egg size

Eggs were laid in batches; their size was determined by measuring the size of each batch.

5) Larva and adult size

The length **L** of the body of larvae is comprised between the head of the insect, $\mathbf{L_0}$, and its tail, $\mathbf{L_1}$. It is the difference between $\mathbf{L_1}$ and $\mathbf{L_0}$.

$$\mathbf{L = L_1 - L_0}$$

6) Female fecundity, fertility and sex ratio

The fecundity of a female is defined as the number of eggs laid by that female during its life's span.

The fertility of a female is the number of adults emerged from its eggs.

The sex-ratio, r, is the ratio between the number of male adults issued from the eggs of a female over the number of females emerged from that same female.

7) Data analysis

Data collected in the laboratory were processed with the software Excel of Microsoft 2007.

The software XLSTAST version 2013 was used for statistical analysis such as:

An ANOVA used to compute:

- The mean duration of developmental stages,
- The mean length of the body at each of developmental stage.

The statistical charts were drawn using the worksheet of Microsoft Office 2007 software.

3. Results

3.1. Description of the Developmental Stages of *Pempelia* spp.

The female of *Pempelia* spp., after copulation, lays its eggs on the apical parts of the plant. Eggs were laid on the stems and on the apical leaves of the seedlings that were introduced inside the breeding boxes (**Figure 1**). The newly laid eggs have a light white coloration with a form varying from oval to round and turn yellow 3 to 4 days after egg laying.

At emergence, *Pempelia* spp. larvae are tiny. Newly hatched larvae molted 4 times (**Figure 2**). Molting is expressed by changes in the color and shape and also by exuviate discharges. The last larval instar is followed by a pre-pupal stage, a pupal stage and finally an adult. The 1st larval instar was tiny, with a light white to yellowish coloration. Actually, the coloration changes according to the evolution of age, because the caterpillars of the 2nd stage that were observed had a light green coloration with longitudinal stripes. The 3rd instar has a light green coloration and dorsal longitudinal stripes. Larvae of the 4th instar have a black head and a grey body, while those of the last instar showed a blackish brown head, with a dark reddish body which at times is longitudinal light reddish.

3.2. Duration of *Pempelia* spp. Developmental Stages

Table 1 illustrates the duration of the developmental stages of *Pempelia* spp. The average eggs' incubation duration was 6 ± 0.52 days. The minimum incubation duration was 5 days, whereas the maximal incubation duration was 7 days.

Duration of the 1st larval instar was 2 ± 0.49 days in laboratory conditions. The 2nd larval instar lasted 4 ± 0.69 days during the experiment. The 5th larval instar had the longest duration (9 ± 0.57) while the 3rd and the 4th larval instars had 6 and 7 days duration respectively. The pre-pupa duration was relatively short (2.50 ± 0.50 days) while the pupa and the adult (both male and female) had the same duration.

Stem Sheath

Figure 1. *Pempelia* spp.' eggs are laid either on the stem or on the sheath of *J. curcas.*

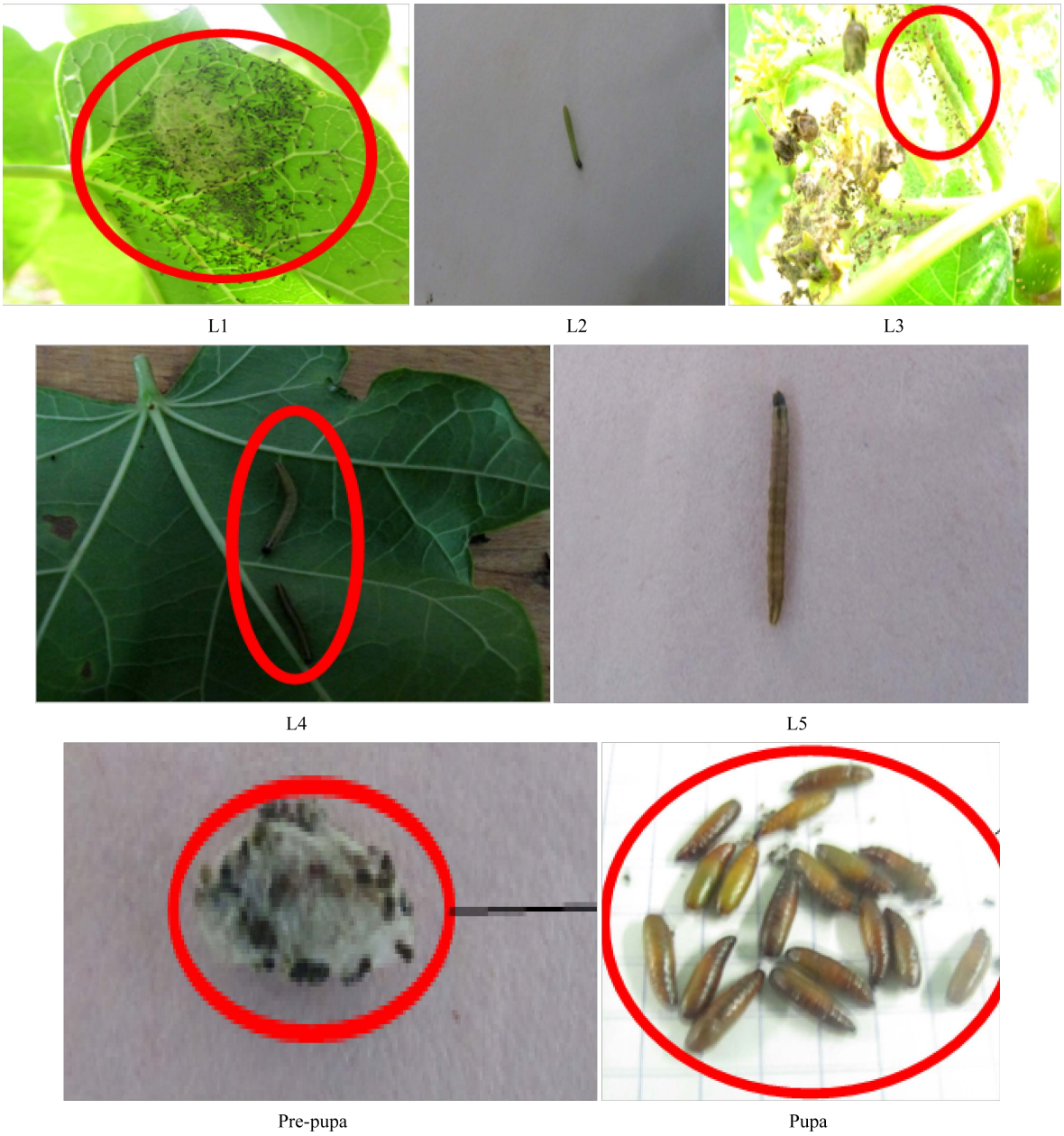

Figure 2. Developmental stages of *Pempelia* spp.: L1 stadium; L2 stadium; L3 stadium; L4 stadium; Pre-pupa and Pupa.

3.3. Morphometric Parameters of *Pempelia* spp.

The morphometric parameters of *Pempilia* spp. are reported in **Table 2**. In this study, we used 36 eggs laid by females bred in the laboratory. The average egg size was 0.57 ± 0.00 mm. The 1st instar larva measured in average 2.62 ± 0.04 mm. The 2nd instar larva differed from the 1st one by its size, 5.52 ± 0.09 mm almost twice that of the 1st one and by its light green coloration and the presence of longitudinal lines on its abdomen. Dorsal longitudinal stripes were found on the body of the 3rd instar which measured in average 9.48 ± 0.04 mm. The 4th instar had a grey body and was 14.88 ± 0.01 mm long. Finally, the 5th instar was found to be in average 21.2 ± 0.34 long. Its body was a lightly reddish and longitudinal. The pre-pupa was shorter in length (15.36 ± 2.03 mm) than the 5th instar larva. The pupa lives in a cocoon. It measured in average 7.74 ± 0.44 mm. *Pempelia* spp. female adults were larger than the male adults. They had a wide abdomen with a tubular opening. The female measured in average 10.76 ± 0.47 mm while the male was found in average to be 8.46 ± 0.72 mm long.

3.4. Frequency of Oviposition and Fecundity of *Pempelia* spp.

The adults became mature some few hours after emergence. The copulation occurred at sunset and lasted for some few hours. Female adults oviposited generally one time during their life span and the number of eggs laid varied from 43 to 55 per individual. Eggs were laid in batches and the average fecundity was 55 eggs (**Table 3**).

3.5. Fertility and Sex-Ratio of *Pempelia* spp.

We studied the fertility of 36 female adults and found an average number of 35.85 (**Table 3**).

The sex ratio was 1:0.44.

Table 1. Some few statistical parameters on the duration of developmental stages of *Pempelia* spp.

Stages	Average lenght (mm)	Standard deviation
Eggs	6	0.52
L1	2	0.49
L2	4	0.69
L3	6	0.66
L4	7	0.62
L5	9	0.57
Pre-pupa	2.5	0.5
Pupa	7	0.77
Female adult	8	0.5
Male adult	5.5	0.57

Table 2. Some morphometric parameters of *Pempelia* spp.

Stages	Average lenght (mm)	Standard deviation
Eggs	0.6	0
L1	2.6	0.04
L2	5.5	0.09
L3	9.5	0.04
L4	14.8	0.01
L5	21.2	0.34
Pre-pupa	15.3	2.03
Pupa	7.7	0.44
Female adult	10.76	0.47
Male adult	8	0.72

Table 3. Some statistical parameters of the reproductive biology of *Pempelia* spp.

Parameters	Average number	Standard deviation
Fecundity	50	3.17
Fertility	35.85	4.46
Sex-ratio	1.44	0.25

4. Discussion

Adult female of *Pempelia* spp. laid its eggs in batches on the apical parts of the seedlings of *J. curcas*. The newly laid had a light white color with a shape varying from oval to round, and turned yellow 3 to 4 days after the oviposition. Similar results were reported by [4]. Actually, these authors reported that the females laid their lightly white colored eggs with a shape varying from oval to round in batches on the apical parts of *J. curcas*. At emergence, the 1st instar larvae were tiny, with a coloration varying from lightly white to yellowish. The 2nd instar larvae were green with longitudinal lines, whereas the 3rd instar had a light green coloration with dorsal longitudinal stripes. The 4th instar larvae had a black head with a grey body whereas the 5th instar larvae showed a blackish brown head, with a dark reddish body which sometimes was light reddish and longitudinal. Our descriptions match with those reported by [6]. The description of the pre-pupae, the pupae and the adults of *Pempelia* spp. are also in accordance with that made by [6].

The average egg incubation of *Pempelia* spp. was 6 days. Similar results were reported in India by [7] and by [7]. Authors [6] found from a 2-year study (2009 and 2010) an average duration of 6.17 days and 5.94 days respectively while [7] reported a duration of egg incubation between 5 and 7 days. Authors also reported similar results with an average duration of 5.83 days. The variations observed in the duration of the incubation could be explained by variation in climate and breeding conditions.

The average duration of the larval stage of the insect was between 23 and 33 days. Our findings differ slightly from those reported by [6] and [7]. Actually, the former authors reported average duration of the larval stage of the insect comprised between 29 and 30 days. Authors [6] found an average duration of larval stage between 23 and 30 days. These variations that were observed on the average duration of the larval stage can be explained on one hand, by the quality of feeding of the insect pest and on the other hand by the variations in climate conditions (temperature and relative humidity). The availability of food resources and adequate climate conditions are supportive to the normal evolution of the insect's development cycle.

Our findings on the other developmental stages of the *Pempelia* spp. are closed to those reported by several authors [4] [7]. These results are the first reported on this insect pest associated with *J. curcas* in Burkina Faso. A comprehensive study of the biology and ecology of this insect pest is necessary to develop control methods.

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