

Study of Some Biological Parameters of *Cirina butyrospermi* Vuillet (Lepidoptera, Attacidae), an Edible Insect and Shea Caterpillar (*Butyrospermum paradoxum* Gaertn. F.) in a Context of Climate Change in Burkina Faso

Dabire Anogmain Rémy¹, Bama Bapio Hervé¹, Ouedraogo Nafiba Sylvain²

¹Farako-Bâ Research Center, Environmental and Agricultural Research Institut, Bobo-Dioulasso, Burkina Faso

²University Center of Dédougou, Dédougou, Burkina Faso

Email: dabire_remy@yahoo.fr

How to cite this paper: Rémy, D.A., Hervé, B.B. and Sylvain, O.N. (2018) Study of Some Biological Parameters of *Cirina butyrospermi* Vuillet (Lepidoptera, Attacidae), an Edible Insect and Shea Caterpillar (*Butyrospermum paradoxum* Gaertn. F.) in a Context of Climate Change in Burkina Faso. *Advances in Entomology*, 6, 1-8.
<https://doi.org/10.4236/ae.2018.61001>

Received: October 19, 2017

Accepted: December 25, 2017

Published: December 29, 2017

Copyright © 2018 by authors and Scientific Research Publishing Inc. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

Cirina butyrospermi is the main lepidoptera whose larvae constitute one of the main sources of edible insect protein in human food and are consumed by many ethnic groups in Burkina Faso and elsewhere in Africa. The preservation and mass production of this useful insect call for increased knowledge of its biological parameters. This study was carried out at the Farako-Bâ experimental, environmental and agricultural research station of the Burkina Faso Institute of Environment and Agricultural Research. The approach has been to feed the larvae individually in the petri dishes with the leaves of shea and then to measure the different biological parameters. Laboratory results—under temperature conditions varying between 24.5°C - 31°C and relative humidity varying between 58.40% - 84.80% with a 12:12 photoperiod—show that the incubation time of eggs is 30 days on average. The development cycle, which includes five larval stages, all feeding on shea leaves, lasts 33.3 ± 3.5 days. Adults (imago) live on average 2.28 ± 0.63 days for males and 2.47 ± 0.56 days for females. Finally, the average number of eggs laid per female is 283.19 ± 96, with an average fertility rate of 84.26% ± 2.16%. Thus, some biological parameters of this insect in our study conditions are now known. These results could contribute to knowledge of the bio-ecology of this insect, improving prospects for diversification and increased nutritional quality for humans.

Keywords

Cirina butyrospermi, Proteins, Edible Insects, Shea, Biology

1. Introduction

The shea caterpillar, *Cirina butyrospermi*, which feeds exclusively on shea leaves, is very rich in proteins. It is therefore a source of protein in human food and is consumed by many ethnic groups in Burkina Faso and elsewhere in Africa [1]. Consumption of this caterpillar helps offset protein deficiency in many populations as global demand for food (especially animal protein) increases due to population growth, urbanization, and the emergence of the middle classes [1]. According to [1] the world's population will exceed 9 billion people by 2050. Traditional food production must be intensified by using resources efficiently and at the same time diversifying the use of alternative protein sources in a context of climate change.

One of the main constraints on the consumption of this insect is its seasonal availability. Indeed, this insect observes during its development cycle a mandatory diapause of up to 11 months. The work of [2] and [3] have helped to remove this mandatory diapause via use of a moulting hormone. However, in light of the effects of climate change in recent years, very few studies have been conducted on the biology of the insect using laboratory breeding. This limits the handling of the shea caterpillar under natural farming conditions. This study on some of the insect's main biological parameters will contribute to the availability of updated information and to the development of continuous insect mass rearing methods.

2. Material and Methods

2.1. Site and Study Conditions

The study was conducted in Bobo-Dioulasso at the Agricultural Entomology Laboratory of the Farako-Bâ experimental station of the Institute of Environment and Agricultural Research (INERA) in Burkina Faso. The study period extended from May 2014 to November 2016, at temperatures ranging from 24.5°C to 31°C, a relative humidity between 58.4% and 84.8%, and a photoperiod of 12L:12D. These climatic conditions are close to those observed in the wild in western Burkina Faso.

2.2. Unfolding of the Trial

To study the biological parameters of the shea caterpillar, pupae were collected at the foot of the shea trees in the wild and brought back to the laboratory. As they emerged, male and female adults were paired in 1 m × 1 m × 1 m breeding cages containing leaves of the host plant (shea tree), which served as a substrate for the egg laying. The leaves were changed daily until the death of the pair. The trial was repeated 20 times. The quantified parameter was fertility, which was determined by the count of the eggs laid per day and per pair (Picture 1).

After 35 days of incubation, the number of sterile eggs was counted under a binocular microscope to determine the duration of egg incubation and the fertility of the females. To establish the development time of each stage of the insect



Picture 1. Eggs from an ootheca separated for the count. Scale: \leftrightarrow 1 mm.

under ambient conditions in the laboratory, each L1 larvae was placed individually, on its hatching day, in a petri dish containing a portion of leaflet kept fresh by a piece of cotton soaked in water and coiled at the tip of the leaf stalk (**Picture 2**). Every day, the larva was removed from the tube in order to check (under a binocular lens) whether it had carried out its first moulting. Moulting was verified by finding, near the larva, the old cephalic capsule that is shed during moulting. The larva was observed in the same way during the following stages until the formation of the pupa. This experiment was repeated 100 times (that is, four replications of 25 larvae). When the larvae passed into the immobile pupae stage, the latter were recovered and placed in the breeding cages containing sterilized sand in order to determine the pupal development time until the emergence of the adults.

2.3. Statistical Analysis

Analysis of variance (ANOVA) was used to test the effect of the treatments on the measured variables for the balanced devices (significance level: $P = 0.05$). For unbalanced devices with missing values, the general linear model (GLM) was applied at the same level of significance as ANOVA. When significant effects were indicated by the analysis, the Student-Newman-Keuls (SNK) t-test was applied to separate the averages at the threshold $\alpha = 0.05$. SAS/STAT 2010 software was used.

3. Results and Discussion

3.1. Incubation Time and Egg's Fertility

Because hatchings take place in the morning, the neonate caterpillar comes out of the egg by practicing a lateral hole. Egg incubation lasted 29 to 31 days, an average period of 30.15 ± 1.05 days (**Table 1**). Moreover, it was observed that the duration of incubation of the eggs was inversely proportional to the temperature of the medium.

3.2. Duration of the Developmental Stages of *Cirina butyrospermi*

After hatching, the larvae pass through several successive developmental stages. The intermediate moult that occurs immediately after hatching gives rise to a



Picture 2. Larva L1 isolated in a petri dish. Scale: \leftrightarrow 1 cm.

Table 1. Egg incubation time (in days) and hatching rates (in%).

Parameters measured	Mean (SD)
Duration of egg incubation (days)	30.15 \pm 1.05
Fertility (in %)	84.26 \pm 2.16

1st-instar larva. Then, the larvae pass through five successive stages before pupating.

Figure 1 below illustrates the developmental time of the five larval instars and the one in the pupal stage. ANOVA indicates a highly significant difference between the developmental time of the various stages ($P < 0.0001$). The observation of **Figure 1** shows that Stage 1 is the shortest of the stages (4.12 days on average). It is followed by Stage 4, with an average development duration of 4.5 days. The lengths of Stages 2 and 3 are not significantly different and are 6.17 and 6.27 days, respectively. The duration of Stage 5 follows, lasting 12.24 days on average. The average developmental duration of the pupal stage is the longest at 286.18 days. The mean total duration of the shea caterpillar, from the egg to the emergence of the adult, is 349.3 days (11 months, 19 days) under ambient conditions in the laboratory. Larvae that yield male adults take two days fewer to reach the adult stage compared to those that yield female adults (**Table 2**).

3.3. Female Fertility and Lifespan

The means of the measured parameters are recorded in **Table 3**. The duration of the pre-copulatory period averages 24 hours, during which the mating takes place. The pre-oviposition takes a few hours. The females die immediately after laying eggs and are very prolific, each laying an average of 483 eggs, with extreme values of 390 to 636 eggs (indicating significant individual variability in egg production) (**Table 3**). They only lay eggs at night between 7 pm and 6 am. Of the 483.19 ± 96 eggs laid per female, 407 ± 81 hatched, an average fertility rate of $84.26\% \pm 2.16\%$. As sex-based comparison of adult longevity revealed no significant difference ($P = 0.6238$).

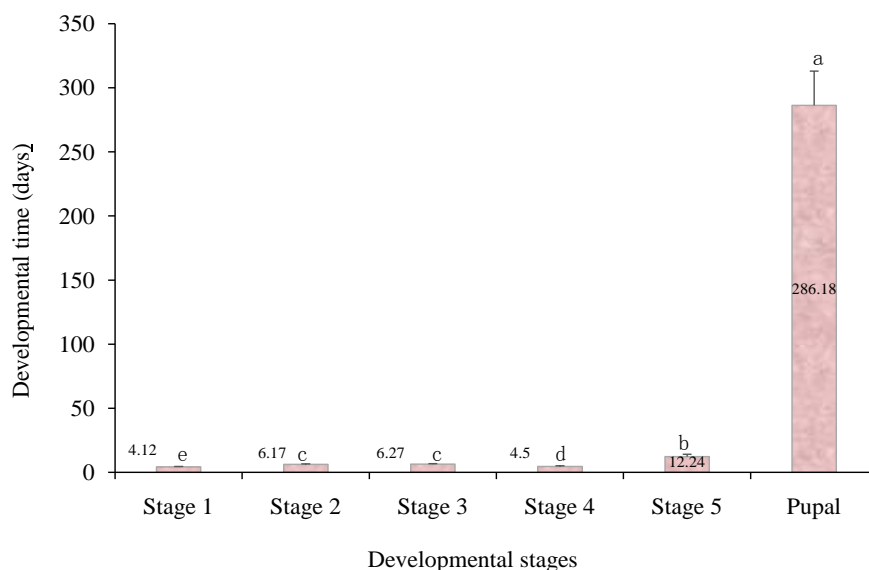


Figure 1. Mean duration of the developmental stages of *Cirina butyrospermi*. *The letters a, b, c, d, e, represent statistical comparisons. The same letters indicate that there are no significant differences between the means.

Table 2. Duration of the adult.

Sex	Number of adults	Mean duration
Male	34	284.29 ± 0.28 b
Female	53	286.45 ± 0.57 a
Sex-ratio	0.64	-

Table 3. Mean female fertility, egg incubation duration, hatching rate, and adult lifespan.

Parameters measured	Mean (±SD)
Fertility of females	483.19 ± 96 eggs
Lifespan { Males	2.28 ± 0.63 (days)
Females	2.47 ± 0.56 (days)

4. Discussion

This study of the biology of the shea caterpillar reveals a duration of incubation and fertility of the eggs close to the findings of [4]. This author [4] obtained an average egg incubation time of 30.15 days and a fertility of 84.69% for the same locality. Under the conditions of our studies, the fertility of the eggs was not significantly affected because the egg of *C. butyrospermi* probably possesses a thick chorion. It is then likely, as suggested by [5], that this provides protection against high temperatures and allows eggs to withstand desiccation. These findings seem to confirm that the effects of climate change have not been able to disrupt the life cycle of this insect. The egg stage (immobile) is, with the first larval stage, one of the most exposed to the weather. In the wild, the female deposits the eggs, in general, on the branches inside the tree, thus avoiding long

exposure to the sun at constant temperatures above 37°C and limiting the vulnerability of the eggs. Thus, this behaviour will give larvae a greater chance of surviving and reaching the maximum hatching rate, even when it is relatively warm.

Individual breeding of the larvae revealed five larval stages. Our findings are in line with those of [4], who obtained the same number of stages with the same durations for this insect. According to [4], larval development depends on the quality of the feed. The same author indicates that if the larvae are fed with young leaves, the average duration from Stage 1 to pupation is 34 days. Our findings are consistent with those obtained by this author, as the larvae were fed with young leaves, and we observed an average development time of 33 days. The duration of development in the pupal stage, which was 319.3 days (10 months 19 days) is also in line with the results obtained by [4] and by [6], each of whom obtained a developmental period of the pupae of 10 months. The duration of development of the pupa is very long, and this is certainly due to the fact that the insect in the wild is obliged to go into diapause to await better conditions. According to [7], diapause is a slow, genetically determined form of life, a phase of pause in development during adverse environmental periods. This important adaptive mechanism allows animals to resist and survive seasonal variations in habitat, such as low winter temperatures, high summer heat, dry periods, and lack of food. It also synchronizes the different stages of the life cycle with that of the seasons. This explains why in the *C. butyrospermi* the duration of pupation is quite long. This duration seems to be related to a diapause occurring in mid-August. At the end of this period (until mid-May of the following year), adults emerge. According to [4], this phenomenon observed in the shea caterpillar appears to be linked to certain climatic conditions.

Our study showed that maximum egg deposition was observed on the second day after adult emergence and corresponded to the female's first day of laying. The results thus obtained (483.19 eggs on average) are close to those of [4], who obtained an average of 484.70 for the same locality. The duration of pre-oviposition is therefore on average one day. Authors [4] and [6] reported a similar pre-oviposition. Favourable conditions for high fertility of females (483.19 eggs) were observed in the laboratory during the rainy season, the optimum period for the insect. The mean temperatures fluctuated between 23°C at night and 30°C during the day, and the relative humidity of the air fluctuated between 58% and 84%. These results are consistent with those reported by [4] under fluctuating (24°C - 35°C) and wetter (70% - 85%) conditions in Burkina Faso. The insect, however, showed its ability to adapt to the Sahel environment. The larval development and fertility of high-performing females at constant temperatures between 25°C and 38°C—in which more than 50% of the larvae survive and the female lays an average of more than 400 eggs—also show the integration of this insect into the Sahel climate.

5. Conclusions

The growing need for protein due to the increasing world population is pushing

mankind more and more into the search for alternatives to traditional sources. This leads us to turn to entomophagy, which is a practice that goes back to time immemorial. To achieve this, food-gathering alone is no longer enough. Some edible species must be farmed and disseminated according to the Organization of the United Nations for Food and Agriculture (FAO) recommendations. To succeed in this farming, it is essential to master some biological parameters of insects. The work carried out during our study made it possible to obtain important information about the shea caterpillar.

Under the conditions of our studies, the cycle of development from egg to adult took 10 to 11 months. The larva passed through five larval stages before pupating. The egg incubation lasted about 30 days, the average larval development time being 35 days and the average development in the pupal stage being 319 days. Adults lived only 72 hours at the most. Parameters such as duration of larval development, survival rate, different fertility components, and adult life-span were highlighted in this study. It has therefore been shown that optimal conditions for embryonic development time, larval development, and reproduction are a temperature between 28°C and 35°C and a relative humidity of 60% - 70%. The quality of the natural substrate has an impact on larval development and survival. Thus, it has been found that the leaves of some shea plants have proved unsuitable for the growth and survival of the caterpillar. Biological studies show that the longer larval Stages 3, 4, and 5 hardly thrive on poor quality feed (older leaves). They are, with the adult stage, the stages of development most difficult to handle and master. It is therefore recommended that mass multiplication programs of this insect aim to reduce the larval cycle. In conclusion, this study showed that it is possible to do the mass rearing of this insect for the human consumption. In the future, it would be interesting to conduct a study to make the link between the quality of the food and the mass production of this insect.

References

- [1] FAO/WUR (2013) Edible Insects: Future Prospects for Food and Feed Security. Rome, Italy, 45 p.
- [2] Bama, H. (2016) Etude de quelques paramètres bioécologiques et physiologiques de *Cirina butyrospermi* Vuillet (Lepidoptera, Attacidae), défoliateur du karité (*Butyrospermum paradoxum* Gaertn. F.) au Burkina Faso. Mémoire Master 2 en Agriculture & Environnement, IN2SA, 2016, 44 p. [Study of Some Bio-Ecological and Physiological Parameters of *Cirina butyrospermi* Vuillet (Lepidoptera, Attacidae), Defoliator of the Shea Caterpillar (*Butyrospermum paradoxum* Gaertn. F.) in Burkina Faso. MSc. Thesis in Agriculture and Environment, IN2SA, 2016, 44 p.]
- [3] Dabire, A.R, Bama, B.H, Ouedraogo, N.S. and Kam, H. (2017) Parasitism Impact on Shea Caterpillar *Cirina butyrospermi* Population Dynamics in West of Burkina Faso (West Africa). *Global Scholastic Research Journal of Multidisciplinary*, 15-21.
- [4] Ouédraogo, M. (1993) Quelques observations bioécologiques sur *Cirina butyrospermi* Vuillet (Lepidoptera, Attacidae) défoliateur du karité (*Butyrospermum paradoxum* Gaertn. F.) au Burkina Faso. Thèse de doctorat de 3ème cycle, Biologie

- animale; option entomologie. Université nationale de Côte d'Ivoire, 128 p. [Some Bio-Ecological Observations on *Cirina butyrospermi* Vuillet (Lepidoptera, Attacidae) Defoliator of the Shea Caterpillar (*Butyrospermum paradoxum* Gaertn. F) in Burkina Faso. PhD. Thesis, Animal Biology, Option: Entomology. National University of Côte d'Ivoire, 128 p.]
- [5] Wigglesworth, V.B. (1972) The Principles of Insect Physiology. 8th Edition. Chapman and Hall, London, 434 p. <https://doi.org/10.1007/978-94-009-5973-6>
- [6] Ouattara, M. (2006) Etude de quelques paramètres bioécologiques de *Cirina butyrospermi* L. (Lépidoptera, Attacidea), chenille défoliatrice du karité. Mémoire d'Ingénieur, Biologie animale. Université nationale de Côte d'Ivoire, 128 pp. [Study of Some Bio-Ecological Parameters of *Cirina butyrospermi* L. (Lepidoptera, Attacidae), Defoliator of the Shea Caterpillar. BSc. Thesis in Animal Biology. National University of Côte d'Ivoire, 128 p.]
- [7] Lafont, R. and Dinan, L. (2003) Practical Uses for Ecdysteroids in Mammals Including Humans: an Update. *Journal of Insect Science*, **3**, 1-30. <https://doi.org/10.1673/031.003.0701>