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Inventory and population dynamics of insects associated with shea kernel stocks in farming areas

Kambou Siébou François[1], Yamkoulga Marcellin[2], Ilboudo Mayouré Edith[3], Sanon Antoine[1], and Ilboudo Zakaria[1]

[1]Laboratoire d'Entomologie Fondamentale et Appliquée, UFR, SVT, Université Joseph KI-ZERBO, 06 BP 9499 Ouagadougou 06, Burkina Faso

[2]Institut de l'Environnement et de Recherches Agricoles (INERA), Département Environnement et Forêts (DEF), station de Saria, BP 10 Koudougou, Burkina Faso

[3]Ecole Normale Supérieure (ENS), 01 BP 1757 Ouagadougou, Burkina Faso

ABSTRACT: Shea kernels are generally stored by Burkinabè households. A prospective study conducted in Ziro province revealed the damage caused by insects. The objective of this study was to inventory the pests associated with shea kernel stocks. Samples of shea kernels were collected from farmers' stocks in three localities of the province over a six-month period. At each period, 4 samples were taken from each locality to constitute 12 batches that were brought to the Laboratory of Fundamental and Applied Entomology of the Joseph KI-ZERBO University. Each batch was analyzed and kept for insect emergence monitoring for 45 days. Six (06) species of predators were identified, among which *Ephestia cautella* (Walker) was the most abundant (87.33% of individuals). Four (04) species of the order Coleoptera, were recorded with proportions of individuals lower than 4%. *Bracon hebetor* (Say), a parasitic Hymenoptera, was recorded with a proportion of 7.26%. The rate of perforation of kernels, which was significant at the beginning of storage (28.87%), increased progressively to reach a maximum of 57.73% after six months of storage. It is important to study the behavior of *H. hebetor* toward *E. cautella* in order to clarify its status and possibly consider the implementation of a biological control against this pest.

KEYWORDS: Shea kernel, insect, pest, stock, Burkina Faso.

1 INTRODUCTION

The shea tree (*Vitellaria paradoxa parkii,* C.F. Gaertn) is a common component of the woody flora of the Sudanian and Guinean savannas of Africa south of the [1]. In Burkina Faso, it is one of the dominant tree species in Sudano-Sahelian agrarian systems [2]. Its distribution area covers 70% of the territory of Burkina Faso [3]. The shea tree provides several non-timber forest products, of which the kernels have the greatest socio-economic importance. These kernels from the nuts collected by the women are dried and sold raw or transformed into shea butter [2]. Given their economic importance, particularly in the cosmetics industry, there is a growing demand for shea kernels by Western companies [4]. The biochemical composition of shea butter makes it a fat of excellent nutritional value [3]. It is also used to moisturize the skin [4]. In Burkina Faso, very few studies have focused on the post-harvest management of shea kernels. However, the development of the shea industry necessarily requires a good mastery of the post-harvest operations of these kernels. This could contribute to the fight against household poverty, especially in rural areas, by providing significant financial income [5]. Indeed, previous investigations we conducted among producers in the localities of Ziro province identified insects as the main biotic agents that impact the quality of shea kernels during storage [6]. Many producers have noted a deterioration of their shea kernel stocks during storage. According to these producers, most of the damage observed is due to insects. Given the threat that insects pose to the post-harvest management of shea kernels, this study aims to identify potential insect pests of shea kernels during storage in order to develop an effective and sustainable control strategy. The specific objectives of the study were (i) to inventory the pests

Corresponding Author: Ilboudo Zakaria

associated with shea kernel stocks on the farm; (ii) to analyze the dynamics of insect populations associated with shea kernels and their relative importance; and (iii) to assess the extent of damage caused by the insect populations.

2 MATERIALS AND METHODS

2.1 SAMPLE COLLECTION SITES

Samples were collected from three communes (Bakata, Cassou and Sapouy) of Ziro province in the central-western region of Burkina Faso. This province is located in the north Sudan type phytogeographic sector with an average annual rainfall varying between 700 and 900 mm and a dry season lasting 6 to 7 months [7]. *Vitellaria paradoxa* C.F. Gaertn is one of the dominant species in this zone. Its average density is 23.64 feet/ha [8]. Sampling occurred from October 2021 to March 2022 in the three locations of the province. October is when stocking activities begin in the area. During the sampling period, relative humidity ranged from 21% to 68%, while the temperature ranged from 25°C to 33.2°C (data collected at the Agence Nationale de la Météorologie du Burkina Faso).

2.2 CHOICE OF COLLECTORS

In each of the three (03) localities of the province, with the help of the technical agents of the environment, four women collectors were selected on the basis of voluntary participation and the availability of sufficient stocks of shea kernels to cover the entire study period. The collectors were organized around a storage warehouse owned by a women's group. The group purchases from the store are orders from a particular buyer who is exported to larger cities.

2.3 SAMPLING METHODS

In each locality, three samples were taken from family stocks and one sample from a group's storage warehouse. These samples were used to make up 12 lots. In all localities visited, the shelled nuts (kernel) were stored in polypropylene bags inside the family concessions. We decided, by mutual agreement with the collectors, to take 500g of shelled kernels per collector and per outing period so that they could support the weight of the samples during the entire observation period. Thus, four (04) samples were taken, one every six (06) weeks. At each sampling, the sampled shea kernels were placed in small sewn and labeled bags that were transported to the laboratory.

2.4 ANALYSIS AND FOLLOW-UP OF SAMPLES IN THE LABORATORY

Once at the Laboratory of fundamental and Applied Entomology of Joseph KI-ZERBO University, the samples were systematically analyzed. To do this, all samples were examined with the naked eye to isolate the adult forms of insects. The adults of Lepidoptera were counted and preserved in papillotes, the Coleoptera and parasitoids collected were preserved separately in tubes of 50 ml containing alcohol at 70° and labeled. Perforated and non-perforated kernels were also counted. At the end of this examination, the samples were then introduced into small cloth bags with the opening tied, for monitoring the emergence of the hidden forms (eggs, larvae and pupae). Samples were examined every three days to collect the emerged insects. Monitoring lasted 45 days under ambient laboratory conditions to allow the emergence of the first generation of insects. The average temperature and relative humidity were 27.51 ± 2.34°C and 46.76 ± 15.27% respectively. At the end of this emergence monitoring phase, the perforated kernels were counted. Lepidoptera were preserved in papillotes, while beetles and parasitoids were preserved in 70° alcohols. Insects were identified under binocular loupe, considering morphological criteria. The following identification keys and books: [9], [10], [11], [12], [13], were used to identify the various specimens.

The following parameters were determined:

- The average abundance of each insect species;
- The density of identified insects according to the sampling periods;
- The perforation rate of the kernels (PRK):

$$\mathrm{PRK} = \frac{\text{Number of perforated kernels after emergence of the 1st generation}}{\text{Total number of kernels}} \mathrm{X}\ 100$$

2.5 STATISTICAL ANALYSIS OF DATA

The data obtained were entered using the Excel 2016 spreadsheet program, which was used to calculate the different means, proportions and to make the different graphs. The Shapiro-Wilk test showed that the distribution of the data was normal, so they were subjected to an analysis of variance following the linear model using the ANOVA function. All tests were performed using R software version 3.2.5. The tests were considered significant at the 5% probability level.

3 RESULTS

3.1 INVENTORY, DISTRIBUTION AND ABUNDANCE OF INSECTS ASSOCIATED WITH SHEA KERNEL STOCKS IN DIFFERENT LOCALITIES

3.1.1 INVENTORY AND DISTRIBUTION OF INSECT PESTS OF SHEA KERNEL STOCKS AND THEIR PARASITOIDS IN DIFFERENT LOCALITIES

Table I indicates that three (03) orders of insects, namely, the order of Lepidoptera, the order of Coleoptera and the order of Hymenoptera have been inventoried. The order Lepidoptera is represented by the family Pyralidae with only one species (*Ephestia cautella*). The species belonging to the order of Coleoptera are divided into four (04) families, which are:

- The family Tenebrionidae, represented by *Tribolium castaneum*;
- The family Nitidulidae, represented by *Carpophilus dimidiatus;*
- The family Bostrichidae, represented by *Rhyzopertha dominica*
- The family Silvanidae, represented by *Oryzaephilus surinamensis*

The order Hymenoptera is represented by the species *Habrobracon hebetor,* a parasitoid belonging to the family Braconidae. The analysis shows that each family is represented by only one species. The species, *E. cautella* and *T. castaneum* were recorded in all sampling localities. Three (03) other species were recorded in at least two localities: *H. hebetor, R. dominica* and *O. surinamensis.*

Table 1. Insects identified in shea kernel stocks by locality

Orders	Families	Species	Sampling locations		
			Cassou	Sapouy	Bakata
Lepidoptera	Pyralidae	*Ephestia cautella* (Walker)	+	+	+
Hymenoptera	Braconidae	*Habrobracon hebetor* Say	+	+	-
Coleoptera	Tenebrionidae	*Tribolium castaneum* H.	+	+	+
	Nitidulidae	*Carpophilus dimidiatus* F.	+	-	-
	Bostrichidae	*Rhyzopertha dominica* F.	+	+	-
	Silvanidae	*Oryzaephilus surinamensis* L.	+	+	-
Totals	**6**	**6**	**6**	**5**	**2**

Figure 1 presents the six (06) species of insects identified during the different periods of collection of shea kernels from the farmers' stocks.

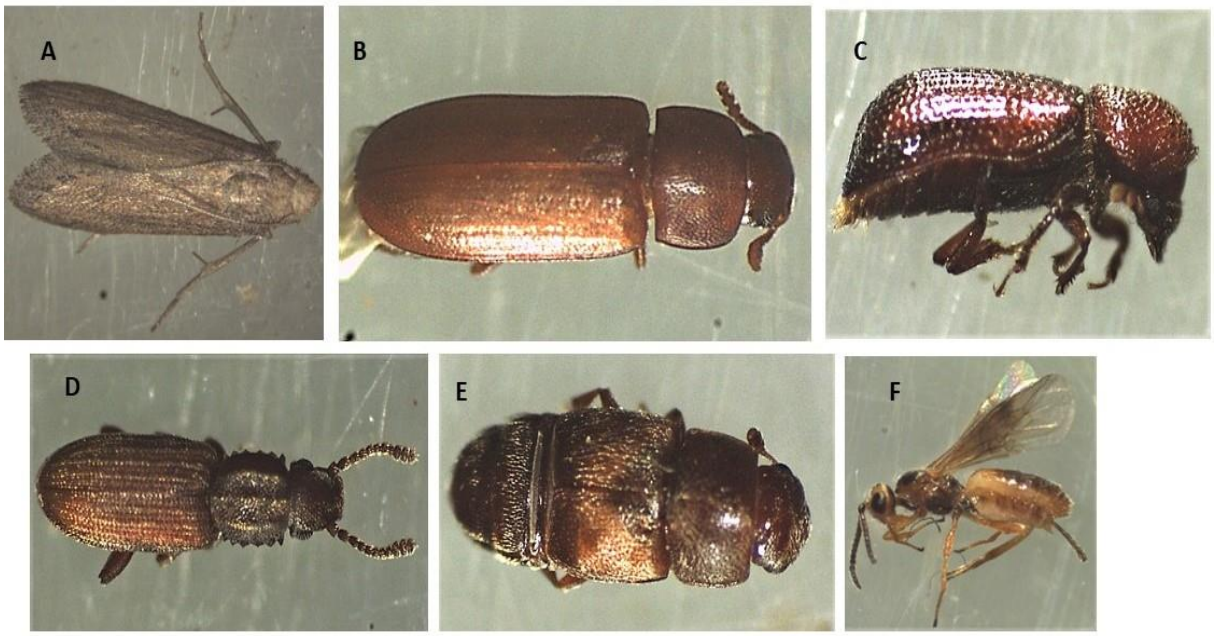

Fig. 1. Insect species identified in shea kernel stocks: A = Ephestia cautella; B = Tribolium castaneum; C = Rhyzopertha dominica; D = Oryzaephilus surinamensis; E = Carpophilus dimidiatus; F = Habrobracon hebetor

3.1.2 Abundance Of Insect Species Identified In Shea Kernel Stocks

E. cautella was significantly (F = 6.84; P = 0.0009) the most abundant species compared with the other five insect species. The number of 565 individuals represents 87.33% of the total number of the emerged insects (Figure 2). The parasitoid *H. hebetor* followed with 47 individuals, or 7.26% of the total number of the emerged insects. It is followed by *T. castaneum* which represents 3.55% of the total number of the emerged insects.

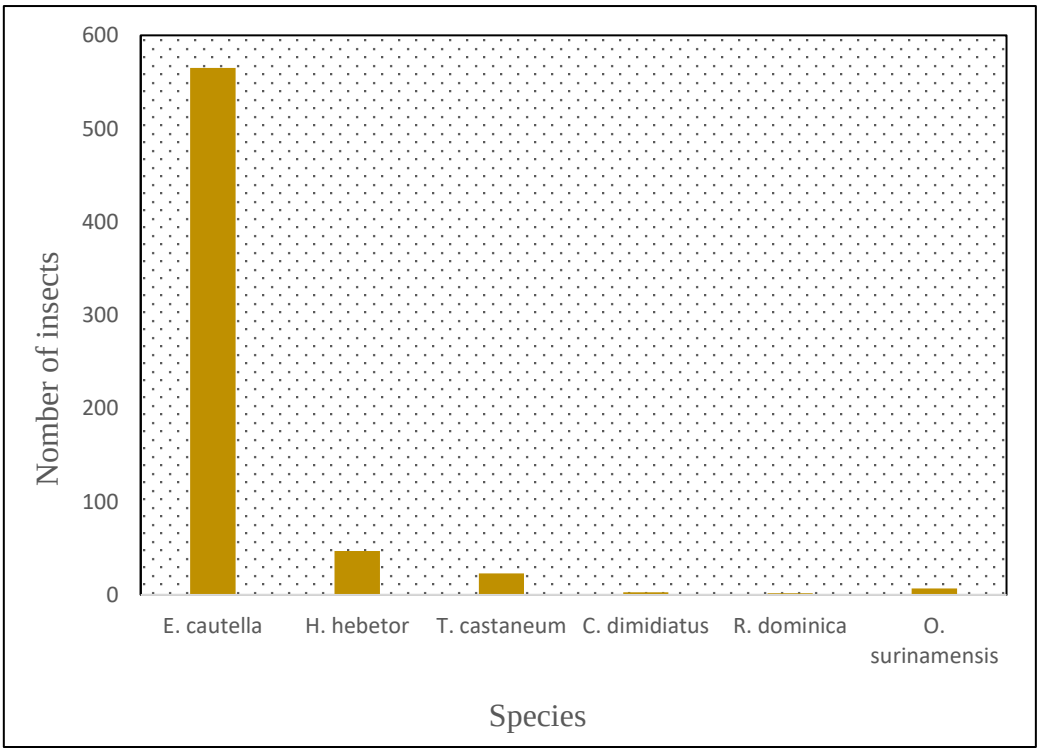

Fig. 2. Abundance of species collected during monitoring of shea kernel samples collected

3.2 POPULATION DYNAMICS OF INSECTS ASSOCIATED WITH SHEA KERNEL STOCKSP

3.2.1 EVOLUTION OF THE TOTAL DENSITY OF INSECTS IDENTIFIED IN THE FARMERS' STOCKS

The number of *E. cautella,* important at the beginning of storage (October), decreased slightly between November and December, and gradually increased exponentially until the end of our observations (March) (figure 3). The species, *H. hebetor, T. castaneum* and *C. dimidiatus,* recorded at the beginning of storage with small numbers, except *C. dimidiatus,* could maintain themselves during 4 months of storage. *R. dominica* and *O. surinamensis,* were respectively recorded after three to four months of storage with very small numbers. No fluctuation in the populations of these species was observed following the analysis of the evolution of the density of the populations. The Hymenoptera, *H. hebetor* probably a parasitoid of one or more of the pests that did not show a significant fluctuation, was observed among the emergences during the first three periods of our sampling.

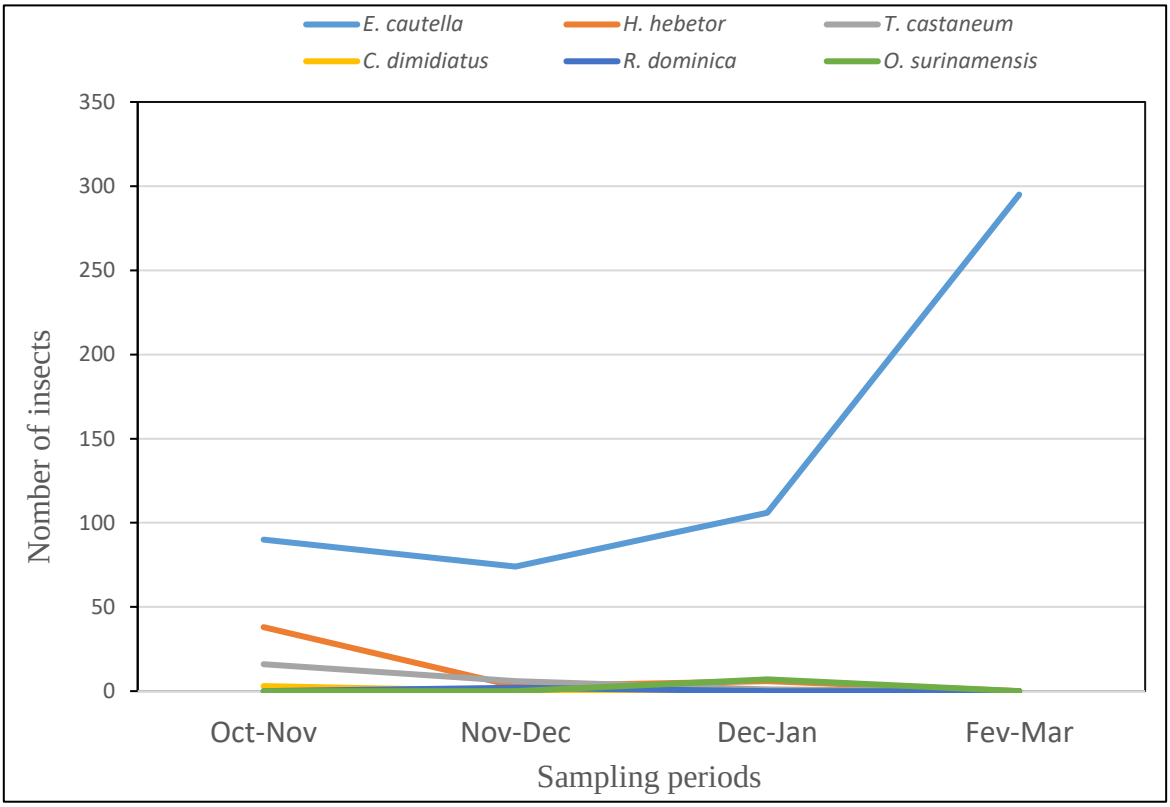

Fig. 3. Evolution of total insect density in shea kernel stocks during the storage period

3.2.2 EVOLUTION OF THE PERFORATION RATES OF KERNELS DURING CONSERVATION IN THE FARMING ENVIRONMENT

Analysis of the evolution of average perforation rates of shea kernels during storage shows significant proportions of perforated kernels from the beginning of storage, which increases significantly ($F = 4.238$; $P = 0.0108$) at the end of our sampling (Figure 4). From an average of 28.87% between October and November, marked by a small drop between November and December, the perforation rate progressively increases to a maximum of 57.73% after six (6) months of storage. Approximately 90% of the batches constituted from the different samples taken at the end of February, presented perforation rates higher than 25%. This shows that *E. cautella* is a major pest of shea kernels.

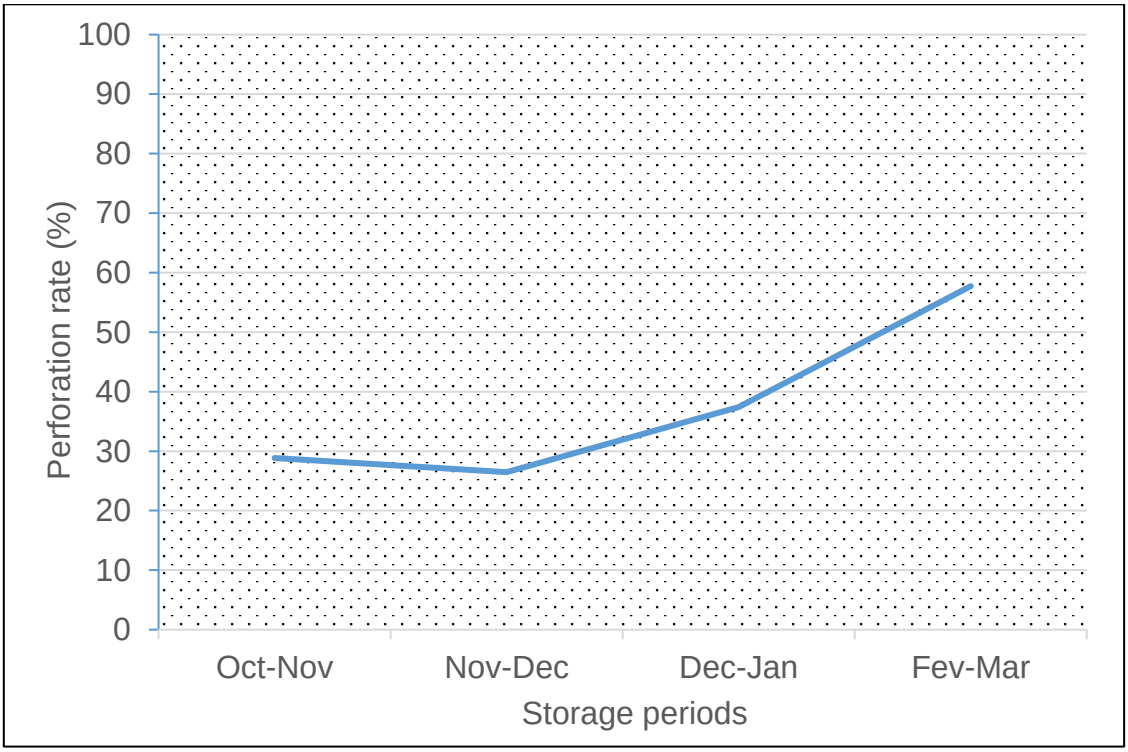

Fig. 4. Evolution of the average rate of perforated shea kernels during storage

4 DISCUSSION

The results of this study showed that six (06) species of insects, including one Lepidoptera, four (4) Coleoptera and one Hymenoptera are present in stored shea kernels. Insects belonging to the orders Lepidoptera and Coleoptera are considered the main insect pests infesting stored commodities and rendering them unfit for consumption [14]. Among the species recorded, *E. cautella* belonging to the family Pyralidae, was the most abundant with a rate of 87.33% of all insects counted. With a steadily increasing population, it could maintain itself in the stocks during all six months of monitoring. This species is the main cause of damage to shea kernels and is therefore the major pest of shea kernel stocks in the study area. This is the first time that a study has revealed this result in Burkina Faso, and even elsewhere, the bibliographic review and grey literature do not mention this result in previous works. *E. cautella, Corcyra cephalonica* Stainton (Lepidoptera: Pyralidae), *Sitotroga cerealella* Olivier (Lepidoptera: Gelechiidae) and *Plodia interpunctella* Hubner (Lepidoptera: Pyralidae), are Lepidoptera pests that can cause appreciable damage to cereals and kernels in storage [14]. The genus *Ephestia* with two species (*E. cautella* and *E. figulilella*), also called kernel and even cereal flour moth, has been reported on dates in Morocco ([15], [16]). These authors identified three species of moths that can develop on dates in the field and in stocks with different incidences. These are *Ectomyelois ceratoniae* Zeller (Lepidoptera: Pyralidae), *Plodia interpunctella* and *Ephestia figulilella* of which the first one was considered as the main pest and the other two as secondary pests. The species, T*. castaneum, C. dimidiatus, O. surinamensis, R. dominica,* respectively belonging to the families Tenebrionidae, Nitidulidae, Silvanidae, Bostrichidae, of the order Coleoptera, appeared in the stocks at precise periods with very small numbers. Only the species *T. castaneum,* identified at the beginning of storage, could survive during 4 months of storage. This species, already recognized as one of the insect pests of stored cereals and their by-products ([17], [18]), appears to be a secondary pest of shea kernel stocks in Burkina Faso. Investigations carried out during this study could not reveal the potential host of the only Hymenoptera, *H. hebetor,* which is a parasitoid belonging to the family Braconidae. However, previous studies have shown that *H. hebetor* parasitizes the larvae of *E. cautella* (ex *Cadra cautella* W.) and *P. interpunctella* [19]. Indeed, these authors demonstrated that *H. hebetor* females paralyze and feed on *E. cautella* larvae; they cause of important mortalities observed. In addition, *H. hebetor* had been recorded among the populations of the date moth *E. ceratoniae* [16]. According to these authors, its impact on the host was limited. This is because this parasitoid species prefers older larval stages, whereas *E. ceratoniae* larvae penetrate dates at the first stage [16]. Moreover, this parasitoid is known to be the natural enemy of pests evolving on other crops [16]). Further investigations will focus on this parasitoid in order to clarify its status and to consider the possibility of its use in the control of pests of shea nut stocks. The damage caused during the conservation of kernels, especially the perforations, could be due to the feeding of *E. cautella* larvae. Indeed, our observations of the samples in the laboratory have shown that the first larval stages perforate

the kernels and continue their development inside them. The emergence of the inert adult occurs only at the end of pupation. The released powder, adult and larval droppings associated with the exuviae depreciate the stock [12]. In view of the low numbers of beetles observed and their inability to maintain themselves in the stocks, they would be accidental or secondary pests of kernels. These species are commonly found in grain stocks. *T. castaneum, R. dominica and O. surinamensis,* are commonly listed pest Coleoptera in cereal stocks in sub-Saharan Africa ([20], [14], [12]). Their presence in shea kernel stocks could be justified by mixed storage. Indeed, the kernels packaged in polypropylene bags, were sometimes kept in association with cereal or legume stocks. Thus, they could have free access to the kernel stocks.

The gradual increase in *E. cautella* populations observed during the entire study period would be due to its adaptation to the substrate and climatic conditions that affect insect population dynamics. Knowledge of the biology of *E. cautella* evolving on shea kernels as well as its economic impact is an essential prerequisite for the healthy and sustainable conservation of shea kernels in Burkina Faso.

5 CONCLUSION

This inventory of shea kernel pests in the Ziro province of Burkina Faso identified six species, including one Lepidoptera, four Coleoptera and one parasitic Hymenoptera. *E. cautella,* of the order Lepidoptera, was the most abundant species with a population of individuals that gradually increased until the end of our observations. Four species of Coleoptera that are: *T. castaneum, R. dominica, C. dimidiatus* and *O. surinamensis,* were recorded with small numbers. These species disappeared during conservation; they could be considered secondary or accidental pests. The outbreak of the *E. cautella* population could be limited by the parasitoid *H. hebetor,* which did not show significant population fluctuation and which also disappeared during the conservation period. The knowledge of the biological parameters of this shea kernel moth will allow the establishment of an adequate control method. It is important to study the behavior of *H. hebetor* toward *E. cautella* in order to clarify its status and possibly consider the implementation of a biological control against this pest.

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