Inventory of the entomofauna cohabiting with colonies of the domestic honeybee, Apis mellifera adansonii, in two agroecological zones of Burkina Faso.

Abstract

In Burkina Faso, beekeeping is a growing, promising sector, as reflected in the rising number of beekeepers. Unfortunately, the quantity and quality of hive products are increasingly declining due to numerous constraints, notably sanitary ones. These sanitary constraints are thought to be caused mainly by arthropods invading the hives. To improve beekeeping production, it is essential to identify the pests responsible for weakening honeybee colony dynamics. This study aims to identify the entomofauna cohabiting with colonies of the domestic honeybee, *Apis mellifera adansonii*. Insects were first collected from hives in three regions — Hauts-Bassins, Centre-Ouest and Plateau Central — located in two agroecological zones of Burkina Faso. Collection was carried out over two years across a total of 90 hives. All collected insects were then identified. Finally, ecological composition indices (total richness and frequency of occurrence) and biodiversity indices (Shannon, Pielou and Simpson) were calculated. The results reveal 15 insect species, with a total of 5,877 individuals recorded. *Galleria mellonella* was the only species constant across all three regions. The Shannon index ranged from 2.64 to 2.21, while Pielou's evenness index ranged from 0.91 to 0.87. These results provide useful preliminary information for developing integrated management methods against pests of the domestic honeybee and hive products.

Keywords: Bees, pests, bee products, identification, Burkina Faso

Introduction

Domestic and wild bees play a key role in natural and agricultural ecosystems. Most phanerogams could not complete their development cycle without pollinators, particularly bees (Williams 1998; Garibaldi et al. 2016). Bees contribute decisively to the reproduction of many plants and to the maintenance of genetic diversity (Garibaldi et al. 2016; Gonella 2025). The domestication of *Apis mellifera adansonii* gave rise to beekeeping, or apiculture, as early as antiquity (Ighobriouen and Lalam 2021). Still widespread worldwide, this activity complements agriculture and livestock farming, especially in Africa (Paterson and Cockle 2008). In Burkina Faso, beekeeping is a young, fast-growing sector, driven mainly by rising demand for hive products. Annual production rose from 550 tonnes, generating 1.5 billion

CFA francs per year over the 2011–2015 period, to more than 1,000 tonnes in 2018, worth over 2.6 billion CFA francs (MRAH 2019). A growing number of actors in the beekeeping sector could strengthen the national effort to fight poverty.

In recent years, however, apiaries have faced a general weakening of colonies, leading to a sharp rise in bee mortality rates worldwide (Potts et al. 2016). The causes of this decline vary and sometimes remain unexplained. Nevertheless, several studies identify global warming, bee habitat loss (Le Conte and Navajas 2008; Darricau 2020; Leyton 2024), pesticide effects (Wintermantel 2019; Le Peley 2024), and bee pests (Chiron and Hattenberger 2008; Ighobriouen and Lalam 2021; Paris 2017) as the main drivers. According to Rogel (2017), only one certainty now stands out: a combination of these factors weakens bees and causes their death.

In Burkina Faso, few studies have addressed the collapse of domestic bee colonies of *Apis mellifera adansonii*. Nevertheless, some studies, such as Fernand et al. (2015), have shown that ten species belonging to eight insect families cohabited with bees in hives in the Centre-East region of Burkina Faso. That study covered a single region and therefore could not capture the full range of honey bee pests in hives. We therefore considered it necessary to update the data on honey bee pests in hives by inventorying the arthropods present in bee colonies in three regions of Burkina Faso: Hauts-Bassins, Plateau-Central, and Centre-Ouest.

Materials and Methods

Study sites

The study was carried out in the Hauts-Bassins and Plateau Central regions of Burkina Faso. Two villages were selected in each region. In Hauts-Bassins, the villages of Kiri and Péni, in the commune of Bobo-Dioulasso, were chosen. In Plateau Central, the villages of Gonsé and Monyargo, in the commune of Ziniaré, were chosen. In Centre-Ouest, the villages of Bassawarga and Gallo, in the commune of Sapouy, were selected.

Collection of ainsect from the hives

In each village, five beekeepers were selected. Three hives were retained per beekeeper, giving a total of 30 hives per commune. Three collection periods were chosen: July for the rainy season, and November and April for the dry season, during the minor and major honey flows. For each period, two collections were carried out in each of the selected hives, over two years. Collection was performed between 6 p.m. and 8 p.m. (Nombré, 2003), and also between 7 a.m. and 10 a.m. The hives were inspected to collect arthropods found inside or outside the hives, on the frames and on the boards. Insects on the board were captured by trapping: greased-bottom Petri dishes were placed to collect arthropods falling from the frames or trying to enter the hive. Those on the frames were brushed off with a paintbrush. A mouth aspirator was used to capture the more mobile insect groups. All collected arthropods were placed in labeled 60 ml vials containing 70° alcohol and taken to the Natural History Laboratory (LHN) of the Institute of Environment and Agricultural Research (INERA) for identification.

Identification of arthropods

Identification of the collected arthropods was carried out at the Natural History Laboratory (LHN) of INERA. Arthropods were separated into classes, orders, families and species using identification documents and keys (Villiers et al. 1979; Delvare and Aberlenc 1989; Delobel and Tran 1993; Mike et al. 2004).

Data processing

The collected data were used to assess sampling quality and to determine ecological composition and structure indices.

Sampling quality

Sampling quality was determined as the ratio of the number of species seen only once to the total number of surveys. The smaller the **a/N** ratio, the higher the sampling quality. This is given by the following formula (Ighobriouen and Lalam 2021).

$Q = a/N$

Q: Sampling quality.

a: Number of species seen only once, with a single specimen, throughout all surveys.

N: Total number of surveys, i.e. the number of sampling sessions carried out.

Ecological composition indices

The ecological composition indices determined were: total richness (S), centesimal frequency (F.C. %) and frequency of occurrence (F.O. %). These indices describe the quantitative aspect of the entomofauna studied.

Total richness (S)

The total richness of a biocenosis corresponds to the sum of the species that compose it (Ramade

2003). In the present study, total richness (S) corresponds to the total number of sampled species.

Centesimal frequency (F.C. %) or relative abundance (A.R. %)

Centesimal frequency is the percentage of individuals of the species (ni) considered, relative to the total number of individuals N of all species combined (Dajoz 1971). It is given by the following formula:

$$\mathbf{F.C.\ \% = (ni/N) \times 100}$$

F.C. %: Centesimal frequency;

N: Total number of individuals of all species;

ni: Number of individuals of the species encountered.

Frequency of occurrence (F.O. %)

Frequency of occurrence is the percentage ratio of the number of surveys containing the species (Pi) considered, relative to the total number of surveys (P) (Dajoz 1982). According to Fauri et al. (2003), it is defined as follows:

$$\mathbf{F.O.\ \% = (Pi / P) \times 100}$$

F.O. %: Frequency of occurrence;

Pi: Number of surveys containing the species studied;

P: Total number of surveys carried out.

According to Dajoz (1971), based on the value of F.O. (%), the following categories can be distinguished, and species are said to be:

- **Omnipresent** if F.O. = 100%;
- **Constant** if 75% ≤ F.O. < 100%;
- **Regular** if 50% ≤ F.O. < 75%;
- **Accessory** if 25% ≤ F.O. < 50%;
- **Accidental** if 5% ≤ F.O. < 25%;
- **Rare** if F.O. < 5%.

Ecological structure indices

Ecological structure indices describe the qualitative aspect of the entomofauna studied. These are Shannon-Weaver diversity, maximum diversity and the evenness index.

Shannon diversity index

According to Ramade (1984), it is necessary to combine the relative abundance of species with total richness to obtain a mathematical expression of the general Shannon diversity index. It is given by the following formula:

$$\mathbf{H' = \Sigma\, qi \log_2 qi}$$

H': Shannon-Weaver diversity index, expressed in bits;

qi: Relative frequency of species *i* relative to the individuals of the whole community, which can be written as **qi = ni/N**, where **ni** is the number of individuals of each species in the sample and **N** is the sum of **ni** across all species.

Maximum diversity

Maximum diversity (H' max.) corresponds to the highest possible diversity value of the community, calculated on the basis of equal density for all species present (Mehria and Ahlem 2017). It is given by the following formula:

$$H'_{max} = \log_2 S$$

S: Total number of insect species present.

Evenness index

According to Barbault and Maury (1981), evenness (E) is the ratio of the observed diversity (H') to the theoretical maximum diversity (H' max.):

$$E = H' / H'_{max}$$

Evenness ranges between 0 and 1. It tends toward 0 when the abundances of the species present are out of balance; in this case, one or two species dominate the whole community by their numbers. It tends toward 1 when all species are represented by very similar abundances, meaning that the abundances of the captured species tend to be balanced.

Results

Total richness (S)

All insects inventoried at the honeybee colonies in the three agroecological zones are brought together after identification in Table 1. A total of 15 species and 5,877 individuals were captured. The captured individuals belong to 7 orders (Blattaria, Coleoptera, Dermaptera, Diptera, Hymenoptera, Lepidoptera, Mantodea), distributed across 11 families (Blattidae, Nitidulidae, Scarabaeidae, Cleridae, Forficulidae, Braulidae, Formicidae, Vespidae, Pyralidae, Sphingidae, Mantidae). The orders Hymenoptera, Coleoptera and Lepidoptera yielded the most collected species, with 4, 4 and 3 species, respectively. More species were collected in the three agroecological zones during July, namely 1,311, 847 and 1,271 in Bobo, Ziniaré and Sapouy, respectively. The number of individuals captured in the Bobo zone was higher (2,373) than those captured in the other two agroecological zones, Ziniaré and Sapouy (1,334 and 2,170, respectively).

Table 1: Insects captured in the hives in the three zones during the three observation periods

Orders	Families	Species	Bobo-Dioulasso			Ziniaré			Sapouy		
			Nov	Mar	Ju	Nov	Mar	Ju	Nov	Mar	Ju
Blattaria	**Blattidae**	***Periplaneta americana***	14	10	5	0	0	0	10	0	10
Coleoptera	**Nitidulidae**	***Aethinatumida***	132	102	336	132	80	201	168	81	401
	Scarabaeidae	***Oplostomusfuligineus***	4	39	29	0	0	3	10	2	41
		Cyphonistes sp.	0	1	15	0	1	15	15	1	45
	Cleridae	***Trichodesapiaries***	0	0	6	0	0	2	0	1	8
Dermaptera	**Forficulidae**	***Forficulaauricularia***	0	0	3	0	0	3	1	0	2
Diptera	**Braulidae**	***Braula Coeca***	14	1	24	0	0	0	1	0	25
Hymenoptera	**Formicidae**	***Camponotus maculatus***	45	65	102	11	21	102	40	12	82
		Pheidole megacephala	60	40	90	16	12	90	60	12	50
	Vespidae	***Belonogaster juncea***	5	5	15	0	0	0	0	0	20
		Vespa velutina	0	0	5	0	0	0	1	1	2
Lepidoptera	**Pyralidae**	***Galleria mellonella***	200	296	612	114	85	402	250	202	512

		Achroiagrisella	20	5	60	12	0	22	12	10	65
	Sphingidae	***Acherontiaatropose st***	0	3	4	0	3	1	0	3	7
Mantodea	**Mantidae**	***Mantis religiosa***	0	1	5	0	0	6	5	1	1
Total wealth (S)			494	568	1311	285	202	847	573	326	1271
Total species caught by area			**2373**			**1334**			**2 170**		
Total number of arthropods caught			**5877**								

Nov: November; **Mar:** March; **Ju:** July

Frequency of occurrence (F.O. %) applied to the insect species captured according to collection periods

Frequency of occurrence (F.O. %) of species in November : Minor honey flow

The data on the frequencies of occurrence of the species captured in the three agroecological zones during the minor honey flow are reported in the table 2. *G. mellonella* was the only constant species in the three zones during the minor honey flow. There were three regular species (*A. tumida, C. maculatus, P. megacephala*) at Bobo-Dioulasso, one regular species at Ziniaré (*A. tumida*) and two regular species at Sapouy (*A. tumida*, *P. megacephala*). As for accidental species, three species were classified in this category at Bobo-Dioulasso and Ziniaré, while there was one accidental species at Sapouy. For accessory species, there were none at Bobo-Dioulasso and Ziniaré, and one species at Sapouy. Finally, for the rare species category, there were eight at Bobo-Dioulasso, 10 at Ziniaré and 10 at Sapouy (Table 2).

Table 2: Classification of species according to frequency of occurrence (F.O. %) during the early honey flow

Species	*Bobo-Dioulasso*	*Statutsof Species*	*Ziniaré*	*Statutsof Species s*	*Sapouy*	*Statutsof Species*
Aethinatumida	66.66	Regular	53.33	Regular	66.6	Regular
Oplostomusfuligineus	3.33	Rare	0	Rare	5	Accidental
Cyphonistes sp.	0	Rare	0	Rare	1.66	Rare
Camponotus maculatus	58.33	Regular	5	Accidental	43.33	Accessory
Pheidole megacephala	53.33	Regular	8.33	Accidental	60	Regular
Belonogaster juncea	6.66	Accidental	0	Rares	0	Rares
Periplaneta americana	5	Accidental	0	Rares	1.66	Rare
Mantis religiosa	0	Rare	0	Rare	3.33	Rare
ForficulaAuricularia	0	Rare	0	Rare	1.66	Rare
Galleria mellonella	90	Constant	83.33	Constant	80	Constant
Achroiagrisella	3.33	Rare	5	Accidental	1.66	Rare
Braula Coeca	6.66	Accidental	0	Rare	1.66	Rare
Vespa velutina	0	Rare	0	Rare	1.66	Rare
Acherontiaatroposest	0	Rare	0	Rare	0	Rare
Trichodesapiaries	0	Rare	0	Rare	0	Rare

Frequency of occurrence (F.O. %) of species in March (major honey flow)

G. mellonella was the only constant species during the major honey flow in all three zones. For regular species, one species was classified in this category at Bobo-Dioulasso (*C. maculatus)* and one at Sapouy (*Aethinatumida*). As for accessory species, there were two at Bobo-Dioulasso (*A. tumida; P. megacephala*) and one at Ziniaré (*A. tumida*). There was one accidental species at Bobo-Dioulasso (*O. fuligineus*) and one accidental species at Sapouy (*P. megacephala*). Finally, there were 10, 13 and 12 rare species at Bobo-Dioulasso, Ziniaré and Sapouy, respectively (Table 3).

Table 3: Classification of species according to their frequency of occurrence (F.O. %) during the main honey flow

Species	*Bobo - Dioulasso*	*Statutsof Species*	*Ziniaré*	*Statutsof Species*	*Sapouy*	*Statutsof Species*
Aethinatumida	25	Accessory	41.66	Accessory	71.66	Regular
Oplostomusfuligineus	8.33	Accidental	0	Rare	1.66	Rare
Cyphonistes sp.	1.66	Rare	1.66	Rare	1.66	Rare
Camponotus maculatus	58.33	Regular	1.66	Rare	3.33	Rare
Pheidole megacephala	25	Accessory	3.33	Rare	6.66	Accidental
Belonogaster juncea	1.66	Rare	0	Rare	0	Rare
Periplaneta americana	3.33	Rare	0	Rare	0	Rare
Mantis religiosa	0	Rare	0	Rare	1.66	Rare
Forficulaauricularia	0	Rare	0	Rare	0	Rare
Galleria mellonella	93.33	Constant	75	Constant	86.66	Constant
Achroiagrisella	1.66	Rare	0	Rare	5	Rare
Braula Coeca	1.66	Rare	0	Rare	0	Rare
Vespa velutina	0	Rare	0	Rare	1.66	Rare
Acherontiaatroposest	1.66	Rare	1.66	Rare	1.66	Rare

Trichodesapiarius	0	Rare	0	Rare	1.66	Rare

Frequency of occurrence (F.O. %) of species in July: Rainy season

In the rainy season. in addition to *G. mellonella*. which remains a constant species in all three zones.*A. tumida* is also a constant species at Bobo-Dioulasso and Sapouy. For the regular species category. one species (*C. maculatus*) was observed at Bobo-Dioulasso. three species (*A. tumida*. *C. maculatus and P. megacephala*) at Ziniaré. and no regular species at Sapouy. As for accessory species. there were two. zero and four species at Bobo-Dioulasso.Ziniaré and Sapouy. respectively. For accidental species. there were four. zero and four species at Bobo-Dioulasso.Ziniaré and Sapouy. respectively. The rare species category consisted of six. eleven and five species at Bobo-Dioulasso.Ziniaré and Sapouy.Respectively (Table 4).

Table 4: Classification of species according to frequency of occurrence (F.O. %) during the rainy season

Species	***Bobo - Dioulasso***	***Statutsof Species***	***Ziniaré***	***Statutsof Species***	***Sapouy***	***Statutsof Species***
Aethinatumida	83.33	Constant	70	Regular	80	Constant
Oplostomusfuligineus	25	Accessory	1.66	Rare	25	Accessory
Cyphonistes sp.	13.33	Accidenta	3.33	Rare	35	Accessory
Camponotusmaculatus	63.33	Regular	66.66	Regular	45	Accessory
Pheidole megacephala	45	Accessory	58.33	Regular	30	Accessory
Belonogaster juncea	3.33	Rare	0	Rare	5	Accidental
Periplaneta americana	6.66	Accidental	0	Rare	6.66	Accidental
Mantis religiosa	1.66	Rare	0	Rare	1.66	Rare
Forficulaauricularia	1.66	Rare	0	Rare	1.66	Rare

Galleria mellonella	96.66	Constant	85	Constant	91.66	Constant
Achroiagrisella	10	Accidental	0	Rare	13.33	Accidental
Braula Coeca	16.66	Accidental	0	Rare	16.66	Accidental
Vespa velutina	1.66	Rare	0	Rare	1.66	Rare
Acherontiaatroposest	3.33	Rare	1.66	Rare	1.66	Rare
Trichodesapiarius	3.33	Rare	0	Rare	1.66	Rare

Bidiversity indices

Shannon's H index ranges from 2.64 (Bobo-Dioulasso) to 2.21 (Ziniaré). As for Piélou's equitability index, it ranges from 0.91 (Bobo-Dioulasso) to 0.87 (Ziniaré). The Simpson index ranges from 0.26 (Bobo-Dioulasso) to 0.25 (Ziniaré and Sapouy). Translate into English whilst keeping the message intact, whilst making each sentence more direct and effective.

Table 5: Shannon, Piélou and Simpson indices

Biodiversity index	***Bobo-Dioulasso***	***Ziniaré***	***Sapouy***
ShannonIndice	2.64	2.21	2.48
Piélou'sEquity Index	0.91	0.87	0.89
Simpson's Index	0.26	0.25	0.25

Principal Component Analysis (PCA)

The PCA summarized the structure of the hive entomofauna on a plane that retained 97.5% of the total inertia (Dim1: 73.3%; Dim2: 24.2%). This high cumulative percentage indicates that the first factorial plane provides an excellent representation of the data.Dim1, which captured most of the variance, was driven mainly by the two dominant hive pests, *Galleria mellonella* and *Aethinatumida*. Both taxa displayed the widest confidence ellipses and were displaced toward positive scores on Dim1, reflecting their high abundance and marked variation among samples. The remaining species formed a compact cloud near the origin. Their ellipses were elongated along Dim2 and overlapped strongly, indicating a weaker contribution to the main gradient and similar occurrence profiles.

The three sites were projected close to the centroid, with short vectors. Community composition therefore differed little among Bobo-Dioulasso, Ziniaré, and Sapouy. Sapouy was slightly shifted toward positive Dim1, in the same direction as *G. mellonella* and *A. tumida*, whereas Ziniaré and Bobo-Dioulasso remained nearer the origin.

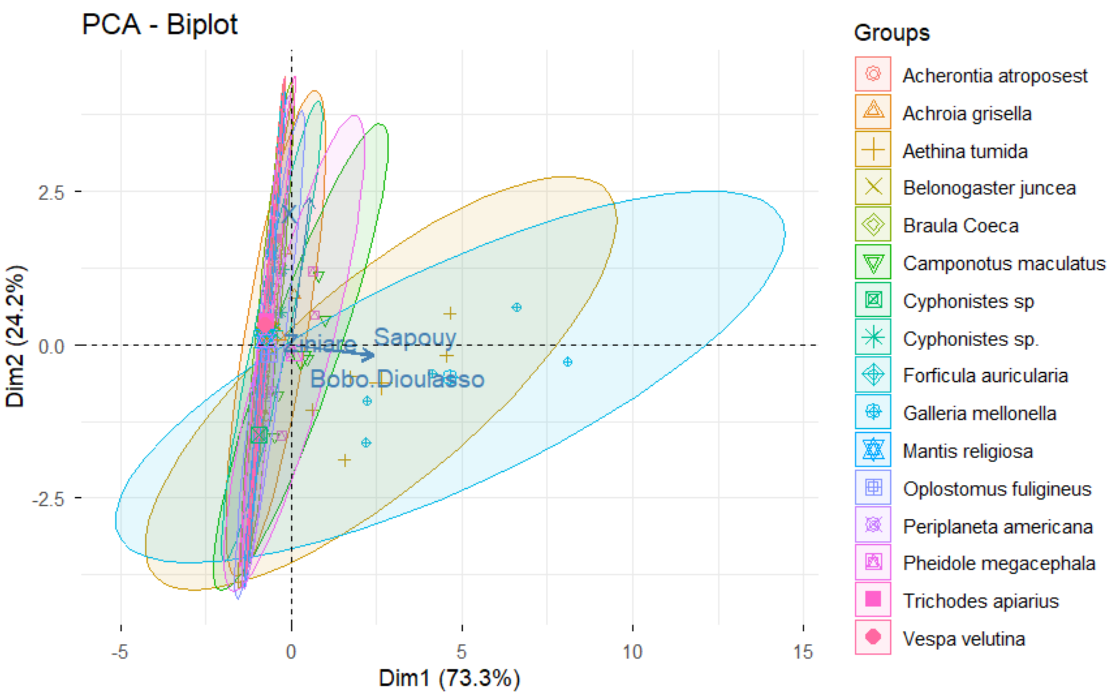

Figure 1: Principal component analysis (PCA) biplot of the insect assemblages associated with *Apis mellifera adansonii* colonies in Bobo-Dioulasso, Ziniaré, and Sapouy.

Discussion

The inventory of arthropods associated with colonies of the honey bee, *Apis mellifera adansonii*, in the municipalities of Bobo-Dioulasso, Ziniaré, and Sapouy during the minor honey flow, the major honey flow, and the rainy season revealed a diverse insect fauna. This fauna comprises 11 insect families belonging to seven orders. In total, 15 insect species were collected. The thermal stability and humidity provided by the hives, together with stores of honey, pollen, and wax, attract many animal species seeking food or shelter (Nekrouche and Yazid 2021). The total number of insects collected across the three periods in the three areas ranged from 1,748 to

3,193 individuals. These results are close to those of Sankara et al. (2015), who collected between 476 and 2,941 insects in hives during the minor honey flow, the major honey flow, and the dry and rainy seasons in the Centre-Est region of Burkina Faso. In terms of species richness, however, Sankara et al. (2015) recorded 10 species, compared with 15 in the present study. In Algeria, Ighobriouen and Lalam (2021) collected 774 individuals belonging to 34 insect species from various taxonomic groups. In Benin, Donou et al. (2011) inventoried the enemies of bees and hive products and recorded 24 insect species.

In this study, most insect species belonged to the orders Hymenoptera, Coleoptera, and Lepidoptera. This confirms that pests of the honey bee and of hive products belong mainly to these orders. These findings corroborate those of Semmar et al. (2014), who reported that Hymenoptera are represented mainly by Formicidae, the most frequent insects in *A. mellifera intermissa* colonies. Coleoptera ranked second, followed by Lepidoptera. However, Ighobriouen and Lalam (2021) found that, among hive pests, Diptera ranked first with nine families, followed by Hymenoptera with six families, represented mainly by Formicidae, and Coleoptera, also with six families. In the present study, the lepidopteran *G. mellonella* was the only constant species in the hives of all three areas throughout the observation periods. The small hive beetle *A. tumida* ranked second after *G. mellonella* in frequency of occurrence across the three areas. Several studies have reported *G. mellonella* and *A. tumida* in hives (Fekhar 2021; Maumin 2019; Mosteghanemi and Hammad 2024). In addition to these species, *Camponotus maculatus* and *Pheidole megacephala* (Formicidae) were also prominent among the arthropods collected in the hives. Ants such as *Pheidole megacephala* attack honey and brood (Sankara et al. 2015).

The permanent presence of pests such as *G. mellonella* in the hives indicates that honey bee colonies are increasingly weakened. The causes of colony weakening or decline are variable and sometimes unexplained. The main causes most often cited are climate warming, habitat loss (Le Conte and Navajas 2008), pesticides (Merchermek and Khalfoun 2023), and pathogens (Velghe 2017; Moussaoui and Osmani 2023; Bilek et al. 2022; Arouri and Amimer 2024).

The large insect populations collected in the hives during this study therefore confirm that the honey bee is under threat. Excessive pesticide use may be one of the main causes of bee decline. Suitable solutions to protect bees are urgently needed. The results of this study will provide a basis for developing integrated pest management programs against honey bee pest

Conclusion

Honey bee colonies of *Apis mellifera adansonii* coexist with various insects in the hive, which provides a microenvironment. The insect community in *A. mellifera adansonii* hives comprises 15 species belonging to the families Nitidulidae, Scarabaeidae, and Cleridae (Coleoptera); Formicidae and Vespidae (Hymenoptera); Blattidae (Blattaria); Mantidae (Mantodea); Sphingidae and Pyralidae (Lepidoptera); Forficulidae (Dermaptera); and Braulidae (Diptera).

Within this insect community, *G. mellonella* is the only constant species across all periods and study areas. Other species, such as *A. tumida* and *C. maculatus*, are highly abundant in the hives and are regular in some cases and accessory in others. Acting alone or together, these insects disrupt the normal development of *A. mellifera adansonii* colonies. In extreme cases, the bees desert the hive, and hive products are usually damaged or even destroyed. These effects reduce hive-product yields. Knowledge of these insects and of their biology allows the development of integrated management methods that safeguard consumer health and protect the environment.

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