Indigenous knowledge system associated with the uses of insects for therapeutic or medicinal purposes in two main provinces of Burkina Faso, West Africa

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Abstract

Background: Some insects are harmful to humans, plants and animals, but some of them can also be a source of proteins, fats, vitamins and minerals and be of therapeutic value. The therapeutic potential requires that medicinal insects and their derived products need to be scrutinized. This study highlights the indigenous knowledge related to their use of medicinal insects in peri-urban and urban areas of Burkina Faso.

Methods: The survey was carried out among 60 traditional healers spread across two phytogeographical zones of Burkina Faso. The questionnaire focused on medicinal insects used by experienced traditional healers. Chi-square tests and principal component analysis were performed to test for significant differences regarding knowledge of how insects in phytogeographically different areas were used therapeutically in connection with different disease categories.

Results: A total of 19 species of medicinal insects belonging to 6 orders were cited in connection with treatments of at least 78 pathologies and symptoms. Most frequently mentioned was gastroenteritis. Our study showed that 48.78% of the insects and their products were associated with 46 plant species for the treatment of pathologies. In addition, honey, beeswax and nests were the most widely insect products used.

Conclusion: The current study allows us to identify medicinal insects as well as their products used in the treatment of pathologies and symptoms, suggesting the presence of a considerable diversity of therapeutically important insect species. These insects are used alone and/or with their products but often in association with medicinal plants. The results constitute a useful database for future studies of medicinal insects in central and western parts of Burkina Faso.

Keywords: Entomotherapy, Insect-derived products, Associated pathologies, Folk medicine, Traditional healing

Introduction

In terms of species, insects are the most numerous groups of living organisms. Up to now, more than one million species of insects have been described, comprising about 70% of all organisms [1]. Insects can be found in almost all habitat on earth and they interact with all components (abiotic and biotic) of their environments. Many of them are known to be destructive and harmful, and around 228 million cases of malaria accounting for...
405,000 deaths (including 93% in Africa alone) are linked to *Anopheles* mosquitoes, major vector to malaria transmission [2]. *Sarcoptes scabiei*, not an insect, an arachnid belonging to arthropod, responsible of scabies diseases, affects about 300 million cases yearly worldwide [3]. Severe yield losses of crops amounting to 100,852. 85 ha per annum have been recorded due to caterpillars of the moth *Spodoptera frugiperda* infestations during the 2017/2018 agricultural campaign in Burkina Faso [4]. Some species of insects have even been involved in the destruction of a country’s infrastructure [5]. This is the case of *Coptotermes formosanus* that is an opportunistic feeder of any material containing cellulose. It is known to damage non-cellulose materials in search of food, including plastic, concrete and soft metal [6]. However, these various negative effects insects should not hide the insects’ undeniably useful roles in the ecosystem. Indeed, they balance the ecosystem for the following reasons: they play an important role in (i) Pollination (80% of the world’s flowering plant species depend on entomogamy) [7], (ii) Scavenging, recycling and fertilizing, (iii) Positive interactions with the soil [8], (iv) Biological control [9], (v) Entomophagy as food for humans and animals [10], (vi) Providing economic benefits (marketing of products like honey, wax, silk, lac) and (vii) The treatment of disorders and diseases [11, 12]. For a long time, immortal humans have used insects and their products for the treatment of various pathologies [12, 13]. Medicinal insects and their products can be used to treat many different diseases either directly or indirectly. Thus, honey bees and their products like honey, propolis, royal jelly, their venom, etc. can be used to treat different health problems [14, 15]. Insect therapy can be an excellent avenue for drug research regarding the great diversity in this group [11–13, 16–18]. This requires a deep knowledge of the medicinal insects, their chemical composition and their potential applications. However, if in countries like China, Korea, India or Brazil, many documents provide information on medicinal insects [14, 16, 18–22], this is not the case for many African countries and even more Burkina Faso. The existing data remained very scarce [8, 23] and need to be deepened. Our objective aimed at Burkina Faso. The existing data remained very scarce not the case for many African countries and even more insects and their products can be used to treat many differen
diseases either directly or indirectly. Thus, honey bees and their products like honey, propolis, royal jelly, their venom, etc. can be used to treat different health problems [14, 15]. Insect therapy can be an excellent avenue for drug research regarding the great diversity in this group [11–13, 16–18]. This requires a deep knowledge of the medicinal insects, their chemical composition and their potential applications. However, if in countries like China, Korea, India or Brazil, many documents provide information on medicinal insects [14, 16, 18–22], this is not the case for many African countries and even more Burkina Faso. The existing data remained very scarce [8, 23] and need to be deepened. Our objective aimed at Burkina Faso.

### Methods

#### Study areas

This study was conducted from May to September 2020 in five localities across the Sudanian and Sudano-sahelian zones of Burkina Faso, located in the west part of the African continent. They are Bobo Dioulasso, Dafinso belonging to the province of Houët (9°–11°30’ N) and Ouagadougou, Saaba and Gonsé located in the province of Kadiogo (11°30’–14° N) (Fig. 1). The climate is tropical with two seasons: the dry (from October to April) and the rainy (from May to September) seasons in both study zones [24]. Mean annual rainfall ranged from 600 to 900 mm in the North Sudanian zone and 900 to 1000 mm in the South Sudanian zone (Fig. 1). The vegetation of the South Sudanian zone consists of a mosaic of savanna, dry forest and patches of gallery forests [25] and is characterized by Sudanian and Guinean species, whereas the North Sudanian zone is dominated by savanna with annual growing grass, trees, and shrubs [24, 25].

#### Data collection

Survey was carried out in traditional healers in the study area. In each province, 30 informants were interviewed through individual semi-structured interviews. Members of all ten ethnic groups were interviewed in both provinces. There were bissa, bobo, dafaing, dioula, guarnantché, gourounsi, mossi, san, senoufo and turka without regarding their religious affiliation and their ages. Traditional healers were between 23 and 82 years old. A total of 60 traditional healers were interviewed in each site. The questionnaire included the photographs illustrating some medicinal insects and their products and also insects collection. During interviews or at a given period, insect specimens were collected and kept in bottles containing alcohol for identification according to Scholtz classification [26].

#### Statistical analysis

Data processing and analysis were performed with the XLSTAT-Premium software 2016. Chi-square analysis was used to determine whether there were statistically significant differences among two climatic zones in knowledge of medicinal insects. Statistical significance was tested at the 5% level. Principal component analysis (PCA) was used to explore the variations in the medicinal insects use in different medical categories.

### Results

#### Local knowledge extent on medicinal insects

*Medicinal insects used and frequency of citations*

Nineteen (19) insect species belonging to six (6) orders that are Orthoptera, Blattodea known as hemimetabolous insects (exopterygota) and Hymenoptera, Coleoptera, Lepidoptera, and Diptera known as holometabolous insects (endopterygota) were cited as medicinal insects in the two climatic zones (Fig. 2). The cited medicinal insects belonging to Orthoptera were crickets (*Acheta domesticus*) and locusts (*Schistocerca gregaria*) with 0.45% frequency of citation per insect. For the Blattodea, we had *Trinervitermes sp.*, *Macrotermes sp.*
tree-nesting termites (Nasutitermes sp.) and the cockroach (Periplaneta americana) with 4.91%, 12.95%, 0.45% and 4.02% as frequency of citation, respectively. Hymenoptera was honey bees (Apis mellifera), mason wasp (Sceliphron sp.), common wasp (Vespula vulgaris), carpenter ants (Camponotus spp.), hypoge nest ants (Pachycondyla sp.), ground-nest ants (Tetramorium sp.) and sugar ants (Camponotus maculatus) with 45.54%, 9.38%, 1.34%, 0.89%, 4.46%, 6.70% and 0.44% as frequency of citation, respectively. In Coleoptera, a longhorned beetles (Cerambycidae), acantharids (Lytta sp.), dung beetles (Scarabaeus laticollis), 7-spotted ladybirds (Coccinella septempunctata), belonged to Coleoptera were cited with 0.89%, 0.89%, 0.45%, at 0.45% of frequency of citation, respectively. Lepidoptera is represented by the shea caterpillar butterfly (Cirina butyrospermi) with 4.46% of frequency of citation. The Diptera was represented by flies (Musca domestica) with 0.89% of frequency of citation. (Fig. 3).

Comparison of medicinal insects used in the two climatic zones

In both provinces, medicinal insects were used. However, the insects used to treat sick people are not always the same regardless climatic areas. Periplaneta americana (A); Macrotermes sp. (B); Trinervitermes sp.; Apis mellifera (C), Vespula vulgaris; Sceliphron sp.; Pachycondyla sp. (D), Tetramorium sp.; Lytta sp. (E) and Cirina butyrospermi; were used in two climatic areas (Fig. 4). These medicinal insect’s species represented 52.63% of the cited species. However, five medicinal insects’ species were specific to the localities of the province of Houët. These are the cricket (Acheta domesticus), the carpenter ant (Camponotus spp.), the sugar ant (Camponotus maculatus) (F) (Fig. 4), the 7-spotted ladybird (Coccinella septempunctata), and the house fly (Musca domestica). As for the localities of the province of Kadiogo, the locust (Schistocerca gregaria), longhorn beetle (Cerambycidae), tree nest termites

(Fig. 1) Map of the study areas indicating southern and northern Sudanese zones in Burkina Faso

Legend
- Sahelian Zone
- Sudan-Sahelian Zone
- Sudanian Zone
- Studies Area
- Protected Area
- Major Road

Source: BNDT 2012  Author: OUANGO M.
(Nasutitermes) and dung beetle (scarabaeus laticollis) were used specifically. However, the tests did not reveal a significant difference ($\chi^2 = 23.930, P = 0.2767)$ regarding the knowledge of medicinal insects in the two study areas. The difference in knowledge of traditional healers on medicinal insects is also not significant between sites in the Sudano-sahelian areas on the one hand and those in the Sudanian area on the other hand with respective $\chi^2$ and $p$ values of 13.407, 0.495 and 2.436, 0.494.

Fig. 2 Citations by insects Orders in two climatic areas

Fig. 3 The frequency of citations of medicinal insects in two climatic zones
Stages of development and insect-derived products used

**Different stages of development of medicinal insects used**

Medicinal insects were used at different stages of their development. Among the insects cited in the climatic areas, 13 of them representing 68.42% of the above-mentioned species were used at different stages of development to produce drugs. Thus, *Camponotus maculatus* was used at both pupae and imago stage, *Cirina butyrospermii* and *Musca domestica* at the larvae stage and the other ones at the adult stage. However, we have not recorded any medicinal insects used in the egg stage (Table 1).

**Products derived from insects used in therapy**

A rate of 52.26%, i.e., 10 of the insects cited were qualified as medicinal, because their products had the therapeutic virtues (Table 2). Nests and honey were the products most involved in the treatment of pathologies by traditional healers in the climatic areas with a frequency of citations of 44.16 and 42.42%, respectively. The honey and the wax (Fig. 5C) used were those of the honey bee. The nests used by traditional healers were from various insects: wasps (Fig. 5D), termites (Fig. 5A and B) and ants. There were also materials transformed by insects such as wood gnawed by longhorned beetles (Fig. 5E), the dung ball rolled by the dung beetle and the food accumulated by the ants in their nests.

### Table 1: Developmental stages of insects used in therapy

| Insects/groups | Order         | Egg | Larvae | Pupae | Adult |
|----------------|---------------|-----|--------|-------|-------|
| Acheta domestica | Orthoptera    | 0   | 0      | –     | 1     |
| Schistocerca gregaria |           | 0   | 0      | –     | 1     |
| Periplaneta americana | Blattodea    | 0   | 0      | 0     | 6     |
| Trinervitermes sp. |             | 0   | 0      | 0     | 5     |
| Macrotermes sp.  |               | 0   | 0      | 0     | 4     |
| Apis mellifera   | Hymenoptera   | 0   | 0      | 0     | 2     |
| Camponotus spp.  |               | 0   | 0      | 0     | 2     |
| Camponotus maculatus |           | 0   | 0      | 0     | 2     |
| Sceliphron sp.   |               | 0   | 0      | 0     | 2     |
| Coccinella septempunctata | Coleoptera | 0   | 0      | 0     | 1     |
| Lytta sp.        |               | 0   | 0      | 0     | 1     |
| Cirina butyrospermii | Lepidoptera | 0   | 10     | 0     | 0     |
| Musca domestica  | Diptera       | 0   | 0      | 0     | 1     |

**Medicinal insects and pathologies treated**

Medicinal insects cited were involved in the treatment of 78 pathologies and symptoms. The various pathologies were grouped into 21 medical categories. Pathologies
of gastroenterology and pulmonology were the most treated with medicinal insects in the two areas with the frequency of citations of 20.98% and 13.39%, respectively. While diseases of psychiatry, endocrinology and allergology with a frequency of citation of 0.4% per category were the least treated with insects and their products in these areas. One or more insects or products or the insect and its product may be used by a treatment of the given pathologies (Table 3). In 68.75% of cases, the pathology or symptom cited is treated by a single insect against 31.25% of cases where several insects were associated in the treatment of a given pathology. The diseases and symptoms treated by the same insects (Table 3) in these different localities were constipation, inflammation, difficulty in breathing, general fatigue, headache, cold, cough and vomiting.

### Distribution of medicinal insects by medical category

The insects used in the different medical categories were subjected to a principal component analysis (PCA) (Fig. 6). The analysis revealed that the first two components explained 48.31% of the variability observed within the surveyed population. PCA showed medical categories treated by *Cirina butyrospermi* (Lepidoptera), opposite to *Macrotermes sp.*, *Trinervitermes sp.*, *Periplaneta Americana* (Blattodea), *Apis mellifera Sceliphron sp.*, *Pachycondyla sp.* and *Tetramorium sp.* (Hymenoptera).

### Different associations between medicinal plants and insects in therapy

In 46.88% of cases, insects were associated with medicinal plants in the treatment of pathologies. Forty-six plant species associated with insects were reported in various treatments advised by traditional healers in the two provinces. The part of plants concerned were both grasses and woody plants. However, insects were not associated only with plants but also with either mineral substance including ash with 0.45% as frequency of citation or fat of animal such as lion’s fat (0.45% frequency of citation) for certain treatments. Survey showed that some medicinal insects are involved in the same disease treatments in both localities. Overall, the kind of association of medicinal insects with plants varied from one province to another. Globally, *Apis mellifera* was most medicinal insect associated with various plants that targeting a large spectrum of pathologies (Table 3).

### Discussion

**Local knowledge regarding medicinal insects**

**Medicinal insects used**

Our study revealed nineteen (19) medicinal insects used by traditional healers, showing very rich ethnomedicine knowledge in the two provinces of Burkina Faso. There are similarities with other studies carried out in the world generally, and in Africa specifically, where bees (Hymenoptera) and their products, but also beetles (Coleoptera) and cockroaches (Blattodea), were predominant in the

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### Table 2 Medicinal products from insects

| Insects/groups  | Order               | Honey | Beeswax | Nests | Materials impacted |
|-----------------|---------------------|-------|---------|-------|-------------------|
| Trinervitermes sp. | Blattodea           | 0     | 0       | 7     | 0                 |
| Macrotermes sp.   | Blattodea           | 0     | 0       | 33    | 0                 |
| Nasutitermes sp.  | Blattodea           | 0     | 0       | 1     | 0                 |
| Apis mellifera    | Hymenoptera         | 98    | 27      | 0     | 0                 |
| Pachycondyla sp.  | Hymenoptera         | 0     | 0       | 14    | 1                 |
| Tetramorium sp.   | Hymenoptera         | 0     | 0       | 18    | 0                 |
| Sceliphron sp.    | Hymenoptera         | 0     | 0       | 22    | 0                 |
| Vespula vulgaris  | Hymenoptera         | 0     | 0       | 4     | 0                 |
| Scarabaeus laticollis | Coleoptera    | 0     | 0       | 0     | 1                 |
| Cerambycidae      | Coleoptera          | 0     | 0       | 0     | 2                 |

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![Fig. 5 Medicinal product from insects.](image-url)
| Insect species (family) | Vernacular name | Insect or product | Preparation | Application | Disease cured | Used in combination with | Province |
|------------------------|----------------|-------------------|-------------|-------------|---------------|-------------------------|----------|
| Orthoptera             |                |                   |             |             |               |                         |          |
| 1. Acheta domesticus   | sokeereee       | Adult insect      | NA          | Oral        | Deafness      | NA                      | Houët    |
| (Gryllidea)            | (dioula)       |                   |             |             |               |                         |          |
| 2. Schistocerca gregaria | bugilunvare     | Adult insect      | Burnt insect powder | Topical    | Wound         |                         | Kadiogo  |
| (Acrididae)            | (moore)        |                   |             |             |               |                         |          |
| Blattodeae             |                |                   |             |             |               |                         |          |
| 3. Macrotermes sp. (Termitidae) | Yao-bi (moore) | Nest              | Powder      | Topical     | Knee pain     | Decoction of Cissus quadangularis branch | Houët   |
|                         |                |                   |             |             |               | Decoction of Securidaca longipedunculata branch | Kadiogo |
|                         |                |                   |             | Oral        | Diarrhea      | Water                   | Houët    |
|                         |                |                   |             | Topical     | Articular pain | Water                   | Houët Kadiogo |
|                         |                |                   |             | Topical     | Bone pain     | Datura stramonium       | Houët    |
|                         |                |                   |             | Topical     | Sprain        | Lemon juice             | Houët    |
|                         |                |                   |             | Oral        | General fatigue | –                      | Houët Kadiogo |
|                         |                |                   |             | Topical     | Fracture      | –                       | Houët    |
|                         |                |                   |             | Oral        | Gonorrhea     | NA                      | Kadiogo  |
|                         |                |                   |             | Topical     | Inflammation  | Water                   | Houët    |
|                         |                |                   |             | Topical     | Dislocation   | Lemon juice + ash       | Kadiogo  |
|                         |                |                   |             | Topical     | Congenital malformation | NA              | Kadiogo  |
|                         |                |                   |             | Topical     | Headache      | NA                      | Kadiogo  |
|                         |                |                   |             | Topical     | General infertility | NA                  | Kadiogo  |
|                         |                |                   |             | Oral        | Vomiting      | Securidaca longipedunculata branch decoction | Kadiogo |
| 3. Macrotermes sp. (Termitidae) | Yao-bi (moore) | Nest              | Powder      | Topical     | Mumps         | Crushed leaves of Guiera senegalensis | Kadiogo |
|                         |                |                   |             | Topical     | Burn          | Azania nitida bark decoction + Honey | Houët    |
|                         |                |                   |             | NA          | Iron deficiency | NA                     | Houët    |
|                         |                |                   |             | Topical     | Fracture      | Water                   | Houët    |
| 4. Trinervitermes sp. (Termitidae) | Tämbeko (moore) | Nest              | Powder      | Topical     | Mumps         | Crushed leaves of Guiera senegalensis | Kadiogo |
|                         |                |                   |             | Topical     | Burn          | Azania nitida bark decoction + Honey | Houët    |
|                         |                |                   |             | NA          | Iron deficiency | NA                     | Houët    |
|                         |                |                   |             | Topical     | Fracture      | Water                   | Houët    |
| Insect species (family) | Vernacular name | Insect or product | Preparation | Application | Disease cured | Used in combination with | Province |
|------------------------|-----------------|-------------------|-------------|-------------|--------------|--------------------------|----------|
| 4. Trinervitermes sp. (Termitidae) | Tambeko (mooré) | Nest | Powder | Topical | Dropsy | Water | Kadiogo |
|                          |                 |                   |            | Topical | Inflammation | Water | Houët Kadiogo |
|                          |                 |                   |            | Topical | Edemas | Water | Houët |
|                          |                 |                   |            | Topical | Wound | NA | Kadiogo |
|                          |                 |                   |            | Oral | Vomiting | Water | Kadiogo |
|                          |                 |                   |            | Topical | Inflammation | Water | Kadiogo |
| 5. Nasutitermes sp. (Termitidae) | Ti-mogdo (mooré) | Nests | Powder | Topical | Inflammation | Water | Kadiogo |
| 6. Periplaneta Americana (Blattidae) | Yalle (mooré) | Adult insect | NA | NA | Headache | NA | Kadiogo |
|                                      | njëbëre (dioula) |                | Crushed live | Topical | Earache | – | Kadio | Houët |
|                                      |                 |                   | Burnt insect powder | Anal | Rectal prolapse | Shea Butter | Houët |
|                                      |                 |                   | Crushed live | Oral | Toxin | Unidentified plant bark | Kadiogo |
|                                      |                 |                   | Crushed live | Topical | Shingles | Guiera senegalensis leaves + Piliostigma reticulatum roots decoction | Houët |
| Table 3 (continued) | Insect or product | Insect species | Family | Vernacular name | Used in combination with | Preparation | Application | Disease cured |
|---------------------|-------------------|---------------|--------|----------------|--------------------------|------------|------------|---------------|
| 7. Apis mellifera | Honey | Apis mellifera | Liden (doula) | Powder | Oral | Sickle cell anemia | NA | Cold | NA |
| | Trichilia emetica roots | | | | | | | | |
| | Diospyros mespiliformis bark | | | | | | | | |
| | Bombax ceiba leaves | | | | | | | | |
| | Diospyros mespiliformis bark | | | | | | | | |
| | Calotropis procera bark | | | | | | | | |
| | Tapinanthus sp. branch | | | | | | | | |
| | Acacia albida bark and leaves | | | | | | | | |
| | Bombax ceiba bark | | | | | | | | |
| | Lemon fruit juice | | | | | | | | |
| | Bombax ceiba bark | | | | | | | | |
| | General fatigue | | | | | | | | |
| | Intestinal helminthiasis | | | | | | | | |
| | Strangled hernia | | | | | | | | |
| | Sexual impotence | | | | | | | | |
| | Inomnia | | | | | | | | |
| | Memory loss | | | | | | | | |
| | Honey + beeswax | | | | | | | | |
| | Cassia sieberiana roots | | | | | | | | |
| | Vitellaria paradoxa flowers | | | | | | | | |
| | Strangled hernia | | | | | | | | |
| | Vitellaria paradoxa flowers | | | | | | | | |
| | Sexual impotence | | | | | | | | |
| | Inomnia | | | | | | | | |
| | Memory loss | | | | | | | | |
| Insect species (family) | Vernacular name | Insect or product | Preparation | Application | Disease cured | Used in combination with | Province |
|-------------------------|----------------|-------------------|-------------|-------------|---------------|--------------------------|----------|
| 7. *Apis mellifera* (Apidae) | Liden (dioula) | Honey + beeswax | NA | Oral | Memory loss | *Piliostigma Thonningii* (leaves), or *Cassia Sieberiana* (roots) decoction | Houët |
| Honey | NA | Heart diseases | NA | Houët |
| NA | Asthma | NA | Houët |
| NA | Difficulty breathing | Acacia albida roots decoction or *Curcuma longa* crushed bulb | Kadiogo |
| NA | Voice extinction | *Combretum micranthum* leaves decoction | Kadiogo |
| NA | Cough | *Acacia nilotica* bark decoction | Houët Kadiogo |
| NA | Oral | Pneumonia | Decoction of *Acacia albida* bark or *Boswellia dalzielii* bark + *Acacia albida* bark + *Acacia nilotica* bark + *Glossonema boveanum* leaves + *Sterculia setigera* bark + *Brachystelma binger* (roots) decoction | Kadiogo |
| NA | Oral | Bladder lithiasis | *Vitex agnus-castus* fruit | Kadiogo |
| 3 years old honey | Oral | Diabetes | NA | Houët |
| Insect species (family) | Vernacular name | Insect or product | Preparation | Application | Disease cured | Used in combination with | Province |
|------------------------|-----------------|-------------------|-------------|-------------|---------------|---------------------------|----------|
| 7. Apis mellifera (Apidae) | Liden (dioula) | Honey | NA | Oral | Constipation | Terminalia avicenniodes roots decoction | Houët |
| | | | | | | Acacia nilotica bark | Kadiogo |
| | | | NA | Topical | Burn | NA | Houët |
| | | | | | Decoction of Lannea acida bark decoction | Kadiogo |
| | | | NA | Oral | Hemorrhage in women | NA | Houët |
| | | | | | Decoction of Lannea acida bark decoction | Kadiogo |
| | | | | | Cassia sibiriana | Kadiogo |
| | | | | | NA | Houët |
| | | | | | Decoction of Lannea acida bark decoction | Kadiogo |
| | | | | | Zingiber officinale crushed bulb + Diospyros mespiliformis bark decoction | Kadiogo |
| | | | | | Allium sativum or Annona senegalensis + Annona squamosa or Citrus aurantifolia or Khaya senegalensis or Striga sp. | Houët |
| | | | – | Oral | Stomach aches | Mangifera indica leaves decoction | Houët |
| | | | | | Crushed wax | Lagenaria siceraria leaves decoction | Houët |
| | | | Crushed wax | Oral | Gonorrhea | Ocimum basilicum leaves or Acacia nilotica fruit or striga sp. (whole) or Cochlospermum vitatum roots decoction | Kadiogo |
| | | | Crushed wax | Oral | Ulcer | Acacia nilotica bark and leaves decoction | Houët |
| | | | Crushed wax | Topical | Itching | Khaya senegalensis bark decoction | Kadiogo |
| | | | Crushed wax | Anal | Anal bleeding | NA | Houët |
| | | | Crushed wax | Oral | Amenorrhea | Ficus sycomorus | Houët |
| | | | | | Ficus gnaphalocarpa leaves decoction | Kadiogo |
Table 3 (continued)

| Insect species (family) | Vernacular name   | Insect or product | Preparation | Application | Disease cured                  | Used in combination with | Province |
|-------------------------|-------------------|-------------------|-------------|-------------|-------------------------------|--------------------------|----------|
| 7. Apis mellifera (Apidae) | Liden (dioula)   | Beeswax          | NA          | Oral        | General infertility           | NA                       | Kadiogo  |
| 8. Camponotus maculatus (Formicidae) | goetgoega (mooré) | Adult insect and pupae | NA          | Oral        | Azoospermia                  | NA                       | Houët    |
| 9. Camponotus sp. (Formicidae) | folonfolonba (dioula) | Adult insect | Powder | Topical    | Foot pain               | Guiera senegalensis     | Houët    |
| 10. Pachycondyla sp. (Formicidae) | Gûuri (mooré) | Nest              | Powder | Oral        | Retention of acute urinary   | Guiera senegalensis     | Houët    |
| 11. Tetramorium sp. (Formicidae) | Kaya (mooré)    | Nest              | Powder | Oral        | Stomach aches              | Cassia sieberiana (roots) or Guiera senegalensis | Houët    |
|                         |                   |                   |            |             |                               | + Ficus polita (roots) decoction | Kadiogo  |
|                         |                   |                   |            |             |                               | Khaya senegalensis bark decoction | Houët    |
|                         |                   |                   |            | Oral        | Retention of acute urinary   | Annona senegalensis roots | Houët    |
|                         |                   |                   |            | Topical    | Neurological problems        | Balanites aegyptiaca roots | Kadiogo  |
|                         |                   |                   |            | Oral        | Varicella                     | NA                       | Kadiogo  |
|                         |                   |                   |            | Topical    | Inflammation                  | Combretum molle         | Houët    |
|                         |                   |                   |            | Oral        | Cyst                           | Guiera senegalensis leaves decoction | Houët    |
|                         |                   |                   |            | Topical    | Hip pain                      | NA                       | Kadiogo  |
|                         |                   |                   |            | Topical    | Headache                      | NA                       | Houët    |
|                         |                   |                   |            | Topical    | Neurological problems         | Khaya senegalensis dead bark decoction | Houët    |
|                         |                   |                   |            | Oral        | Retention of acute urinary   | Annona Senegalensis roots decoction | Houët    |
|                         |                   |                   |            | Oral        | Gynecological problems       | NA                       | Kadiogo  |
|                         |                   |                   |            | Oral        | Chronic cough                 | NA                       | Kadiogo  |
| Insect species (family) | Vernacular name or product | Preparation | Application | Disease cured | Used in combination with | Province |
|------------------------|---------------------------|-------------|-------------|---------------|-------------------------|----------|
| 12. *Sceliphron* sp. (*Sphecidae*) | Vûnunvûnga (mooré) Nest | Powder | Topical | Inflammation | *Xanthoxylum* Zanthoxyloides leaves decoction | Houët |
|                         | Nest Powder Oral Vomiting | Tamarindus indica fruit juice Kadiogo | |
|                         | Oral Vomiting | Xanthoxylum zanthoxyloides leaves decoction |
|                         | Topical | Allergy due to stings | Kadiogo |
|                         | Oral Sprain | Water |
|                         | Oral Hiccups NA | |
|                         | Oral Female infertility | |
|                         | Oral | Skin infection | NA |
|                         | Oral | Sore throat | NA |
|                         | Oral | Heart diseases | Lion fat |
|                         | Oral | Whitlow | NA |
|                         | Oral | Painful urination | NA |
| 13. *Vespula vulgaris* (*Vespidae*) | Kânenkâaga (mooré) Nest | Powder | Topical | Lipoma | Cassia sieberiana roots decoction | Houët |
| Coleoptera | Gutungulungu (mooré) Rolled dung | NA | Oral | Painful urination | NA |
| 14. *Scarabaeus laticollis* (*Scarabaeidae*) | | | | | |
| Insect species (family) | Vernacular name | Insect or product | Preparation | Application | Disease cured | Used in combination with | Province |
|------------------------|----------------|------------------|-------------|-------------|--------------|--------------------------|----------|
| Lytta sp.              | Pusgn-waag-ma (mooré) | Adult insect     | NA          | Oral        | Sickle cell anemia | Ficus sycomorus, Ficus Gnaphalocarpa bark and roots decoction | Houët |
| 16. Coccinella septempunctata | – | Adult insect | Burnt insect powder | Topical | Retention of acute urinary Wound | NA | Kadiogo |
| 17. Unidentified specie (Cerambycidae) | Ti-gënengenga (mooré) | Insect gnawed wood | Ash of wood | Topical | Breast crack | NA | Kadiogo |
| 18. Cirina butyrospermi (Saturniidae) | Pilimpiu (mooré) | Larvae | Cooked larvae | Oral | Asthma, Arterial hypertension, Avitaminosis | Parkia biglobosa cooked seed | Kadiogo |
| 19. Musca domestica (Muscidae) | Limaga (dioula) | Adult insect | NA | Oral | Sickle cell anemia, Male infertility | Cassia sieberiana bark and Roots decoction | Houët |
| Larvae | | NA | Oral | | | | 

NA: not applicable
list of the therapeutic species [11, 14, 18]. Thus, insect and insect-derived products provide ingredients that have been a staple in traditional medicine for centuries in many parts of the world. In fact, their immunological, antiviral, analgesic, antibacterial, anti-cancer, diuretic, anesthetic, antioxidant, anti-inflammatory, anti-rheumatic and immunomodulatory properties are well recognized [12, 27, 28]. The use of medicinal insects varied from one locality to another and also from one country to another. Then, the adult house cricket, *Acheta domesticus* (Gryllidae), is used for the treatment of deafness in Burkina Faso while in Latin American, it is used for the treatment of scabies, asthma, eczema, lithiasis, earache, oliguresis, rheumatism, urine retention, urinary incontinence and ophthalmological problems [29]. As for locus *Schistocerca gregaria* (Acrididae), it is used by the traditional healers in Burkina Faso to treat wound. This insect is known to have antiproliferative activity [30–32] The Blattodae, *Periplaneta americana*, is used by the traditional healers in Burkina Faso to treat ear pain, but the same species has been used to treat asthma, toothaches and bronchitis by the Amerindians of the Amazon [33]. It is also used for an asthma treatment in Latin American folk medicine [29]. This property to treat pain is probably due to the presence of molecules isolated from the brains of these insects known to be excellent antibiotics v[34]. The therapeutic practice to use blister beetle *Lytta vesicatoria* for the treatment of urinary retention has also been reported in other studies undertaken by Read et al. [35] and Tsuneo et al. [36]. These common uses are probably certainly due to the presence of cantharidin, a compound with notable effects on the urogenital system of vertebrates. In the past, it was prescribed as a remarkable aphrodisiac, but now it is used to induce mating in some domestic animals and as a therapy for some disorders of the urinary tract [14]. Furthermore, a longhorned beetle

**Fig. 6** Distribution of medicinal insects according to the medical category in the PCA plan

are used to treat diarrhea, fractures and used for its
spp. nests of termite Trinervitermes Macrotermes spp. and
been shown to have therapeutic properties as regard-
secretions of these insects. Indeed, insect secretions have
peutic benefits. This transformation could come from the
insects can impact certain materials and give them thera-
products known to medicinal insects, the study showed that
linked to foraged flowers [8]. In addition to these prod-
content of mineral and organic constituents are strongly
on the region. Indeed, the composition of honey and its
variation in the composition of honey depending
on the region. Indeed, the composition of honey and its
content of mineral and organic constituents are strongly
linked to foraged flowers [8]. In addition to these prod-
known to medicinal insects, the study showed that
insects can impact certain materials and give them thera-
peutic benefits. This transformation could come from the
secretions of these insects. Indeed, insect secretions have
been shown to have therapeutic properties as regard-
secretions from larvae of Lucia sericata [42, 43]. The
ests of termite Macrotermes spp. and Trinervitermes spp. are used to treat diarrhea, fractures and used for its
toning effect and those of Nasutitermes spp. is used as an
anti-inflammatory activity. Healing properties of termite
mounds could be explained by the fact that they contain
xyloglucan, a hemicellulose in the wall of dicotyledons
that reduces the frequency and duration of diarrhea [44].
Undegraded sugars present in termite droppings could
explain their use as plaster to immobilize fractured limbs
[45]. Interestingly, Apis mellifera, Vespuca vulgaris, Sce-
liphron sp belonging to Hymenoptera are listed among
medicinal insects and their products are used to treat dif-
ferent diseases around the world. Thus, the nest of Sce-
liphron sp. is used to treat mumps. As to Apis mellifera,
besides honey used to treat asthma, burn, constipation,
difficulty breathing, voice extinction, general fatigue,
insomnia, intestinal helminthiasis, bladder lithiasis, heart
diseases, and hip pain, other bee products are highly
prized as medicines. Pollen (collected by bees), larvae
and pupae have medicinal properties, i.e., pollen is used
for the treatment of bleeding gastric ulcer and chronic
prostatitis [46–48]. Propolis, which is a resinous sub-
stance collected from the buds of some trees and flowers
by bees to repair damage to their hives, is used in Eastern
Europe as an antiseptic and an anti-inflammatory agent
for the treatment of wounds and burns [49].

Stage of development of medicinal insects’ use
Overall insects are used at different stages of develop-
ment. However, in our study, the egg stage was not cited.
Larvae, pupae and adults’ stage have nutritional and
medicinal qualities [39]. These authors point out that in
general, the protein content was found to be higher along
with the more mature developmental stages. Honeybee
larvae were used for the treatment of male impotence
and for raising libido in men. These are usually consumed
directly within the wax combs. The use of larvae for
treating infertility is probably due to their high protein
content of mature larvae (15.4% of fresh weight) [40]. For
Musca domestica, larvae are used in treating male infe-
tility whereas in Japan, it is used in treating snake bites
and fever, gut and stomach problems and eye disorders
[12].

Insect products used in therapy
The insect products cited in our study are the nests
of termite and honey and wax of bee. However, other
results suggest, in addition to the bee products men-
tioned above, propolis and royal jelly [41]. Honey is the
most widely used as bee product in traditional medicine
and its use varies by region. This could be explained by
the variation in the composition of honey depending
of individuals of this class. Also, we can think
of a great variability of the active molecules that can be
contained in these different insects and products. PCA
revealed a strong positive correlation between Cirina
butyrospermi larvae and nutritional diseases. Indeed,
shea caterpillars are very rich in protein (63%), but also
in omega 3, iron, zinc, magnesium, phosphorus (5%) and
vitamins A, D, E [50]. PCA has also shown that honey
from bees is widely used in the treatment of gastroenter-
ological pathologies. Indeed, it has been revealed that bee
products can regulate digestive disorders (diarrhea, colit-
is, peptic ulcer) induced by the bacterium Helicobacter
pylori [51]. Honey can be a complementary treatment for
bacterial gastroenteritis in children [52]. This same PCA
testified the use of Macrotermes sp. particularly its nest
in the treatment of pathologies of rheumatology and gyn-
ecology. Other studies have also shown the implication of
this insect’s nest in the treatment of disorders related to
human reproduction. Indeed, Zborowski [53] confirmed
in his study that the queens of Macrotermes sp. were
believed to have the power to treat female infertility and
male impotence. This nest is also used against inflamma-
tory diseases as it has been shown in Mahdi et al. [54].
Association between medicinal insects and plants
As for the association between insects and plants for the treatment of pathologies in the two study areas exhibits many variabilities. This fact could be explained by the different floristic knowledge of traditional healers in the different study areas. Here, plants (flowers, fruits, leaves, barks and roots) were added to insect and their products, either or advauntag and therapeutic.

Conclusion
Insects or their products have therapeutic virtues affecting several categories of modern classical medicine. The predominant order cited in this current study is Orthoptera, Blattodea (exopterygota) and Hymenoptera, Coleoptera, Lepidoptera, and Diptera (endopterygota). Also, insects and products are used alone or in combination with ash, fat or with various organs of flowering or non-flowering plants. The predominantly used insect products are termite nests and bee honey in the two study areas. Honey is mainly used in the therapy of gastroenteritis and termite nests in the treatment of inflammatory and trauma diseases. The treatment of pathology in which an insect is used depends on the product with which it is combined and on the region. In fact, insects are used differently in most cases in the different survey areas. This study provides a new insight of medicinal insects and open new avenues for their putative valorization in Burkina Faso.

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Author contributions
MO, RR, SFD and OG conceived and performed the study. MO, RR, SFD and OG analyzed the data. MO, RR, SFD, NO and OG wrote the paper. All authors read and approved the final manuscript.

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The authors declare that they have no competing interests.

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