Nutritional Composition of Edible Insects Consumed in Africa: A Systematic Review

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Abstract: Edible insects are an important protein rich natural resource that can contribute to resilient food security. Edible insects not only play an important role in traditional diets, but are also an excellent source of protein in traditional dishes in Africa. We systematically searched Web-of-Science and Google Scholar from year 2000–2019 for studies on the consumption of insects and their nutritional composition in Africa, resulting in 98 eligible papers, listing 212 edible insect species from eight orders. These insects were rich in protein, fats, and fibre. The highest protein content was reported for Lepidoptera (range: 20–80%). Coleoptera had the highest carbohydrate content (7–54%), while Lepidoptera had the highest fat content (10–50%). Considering the excellent source of nutrition, and potential socio-economic benefits, from edible insects, they can contribute strongly to improved food security, and rural development in developing countries. In addition, edible insects can be used as a sustainable food source to combat food shortages in the future, for example, providing resilience during times of drought or other climate stressors.

Keywords: entomophagy; Africa; edible insects; nutrition; food security

1. Introduction

Consumption of insects has recently received more attention because of their promising potential for contributing to livelihoods and mitigating food security problems around the world [1–3]. Food security problems are caused by an enormous increase in the global human population, which is estimated to increase to approximately 9 billion people by 2050 [1], resulting in a 70% increase in food demand, and an increase in food prices [1,4,5]. The increase in food prices will prompt the search for cheap alternative sustainable protein sources [1]. Entomophagy, which refers to the consumption of insects by humans, is an environmentally friendly approach to increasing food for consumption, and contributing to food security across the world [2,5–7].

Edible insects might be a solution to food shortages, owing to their promising potential in contributing to livelihoods and mitigating food security problems around the world [1–3]. Insects are consumed as food in Thailand [8,9], China [10,11], Mexico [12–15], Latin America [16], Japan [17], and Africa [18]. According to van Huis [1], approximately 2 billion people worldwide regularly consume insects as part of their diets. The consumption of insects is not a new phenomenon, as it dates back to before the development of agriculture when humans relied on gathering plants and hunting wild animals [4,11,19].

Edible insects have played a very important traditional role in nutritious diets in various countries in Africa [18,20]. In addition, edible insects are an important natural resource that is used as a coping strategy, particularly in months of food shortage [21–23]. Unfavourable climatic conditions experienced in Africa affect small scale animal husbandry and reduce animal protein production, so diets are then supplemented with edible insect protein [22]. Edible insects provide significant socio-economic and ecological benefits for developing countries [24,25]. Approximately 500 species of edible insects are
consumed in Africa and form part of traditional diets [18]. Of these 500 species, 256 species were consumed in the Central African region, 164 in southern Africa, 100 species in eastern Africa, 91 in western Africa, and only eight species in northern Africa [18]. Insects are consumed among different African cultures because of their taste, cultural importance, and nutritive value, and as a supplementary food when staple food is limited [1,3,25–27].

Various studies in Africa have focused on studying the nutritional content of a single species, group, or genus [28–32]. Little is known about the diversity and nutritional content of various insects consumed in Africa. Therefore, the current study will review the existing literature on the diversity of insects, and their nutritional status in Africa, and, therefore, compile information on the nutrient composition of edible insects consumed in Africa. This will be done by asking the following questions: (1) What is the nutritional value of edible insects consumed in Africa, (2) what are the most consumed, and (3) the most studied insect species, in terms of nutrition, in Africa?

2. Materials and Methods

2.1. Search Strategy

To explore the diversity and nutritional status of edible insects in Africa, we followed the PRISMA guidelines for a systematic review. Peer-reviewed literature was obtained using the Thomson Reuters’ Web of Science database (https://apps.webofknowledge.com) and google scholar (https://scholar.google.co.za/) looking for publications that researched entomophagy in Africa, edible insects, diversity, nutrient content of edible insects, and consumption of insects. To source information, the following key words and phrases were used, “entomophagy”, “edible insects”, “diversity of edible insects”, “entomophagy in Africa”, “edible insects in eastern Africa”, “edible insects in north Africa”, “edible insects in western Africa”, “edible insects in Central Africa”, “edible insects in southern Africa” and “nutrient content of edible insects”. We also screened references included in selected articles in order to identify studies that might be relevant but did not appear in our search. We limited the search to literature published from 2000 to 2019. We started in the year 2000 because it was a starting point where most researchers began investigating the use of edible insects as a food source and as a solution to combat food insecurity problems [33,34].

2.2. Data Collection

Data from the selected articles were independently screened and extracted by a single author (Z.T.H). The search result was done by reading the title and abstract of the retrieved papers to determine if the article was relevant to the study. Once it was determined that the article was relevant, the full text of the selected articles was further analysed to extract relevant information. The information that was collected and extracted after full text reading from each article included year, study area and country, study insect species, reported nutrient composition of insects, consumption stage of an insect, main research findings, and conclusions. Collected articles were categorised by country and insect order.

2.3. Inclusion and Exclusion Criteria

2.3.1. Inclusion Criteria

- Original research articles and review papers focusing on entomophagy, nutrient composition of single or multiple edible insect species.
- Articles published in English.
- Articles of work done in African countries.
- Articles that reported nutrient composition of edible insects.

2.3.2. Exclusion Criteria

- Conference papers, editorial material, book chapters
• Articles on insect rearing and farming.

2.4. Data Quality

To evaluate the quality of studies included in this systematic review, we assessed quality based on the following criteria: (1) A clear food description (scientific name(s) of insects studied or genus), (2) a clear description on the part of the insects used for analysis, e.g., whole, head, abdomen, indication of geographic origin of the insects, and the country where it is used as food in Africa, (3) analytical method used, number of analytical samples, (4) clear indication of whether the nutritional composition was based on the dry weight. Studies were included if they meet all the above criteria.

2.5. Data Analysis

The methods and data sources used in the included studies were highly heterogeneous and a statistical meta-analysis was not possible. Instead, a more narrative synthesis approach was used, and data from each study were tabulated. We synthesised the results according to study species and mean values of all insect species belonging to the same insect order were calculated and represented in bold, the nutritional composition of consumed species were presented in the table, most consumed species in different countries were presented graphically.

3. Results and Discussion

A total of 428 papers were identified for potential inclusion; after checking the title and abstract, 300 articles were excluded because they did not meet the inclusion criteria. From here, 128 articles were selected for full-text reading; from these, 29 articles were further excluded because they were not relevant or not conducted in Africa. After reading the full-text, 89 studies met all inclusion criteria, and a further nine articles were identified through screening references and confirming inclusion criteria were met. In total 98 articles were included in a systematic review (Figure 1).

Figure 1. Flow chart of the study selection process for systematic review of the nutritional composition of edible insects.
3.1. Consumption of Insect Patterns in Africa

For the research articles published since 2000, a total of 212 edible insect species from nine orders were recorded and are potentially consumed in different African countries (Appendix A). Of these, 41% were Lepidoptera, 23% Orthoptera, 15% Coleoptera, 12% Blattodea (including both cockroaches and termites as recently classified), 4% Hemiptera, and Hymenoptera, Diptera, Blattodea, and Mantodea each contributed <1%. Rhynchophorus phoenicis (African palm weevil) and Cirina forda (Pallid emperor moth) were the most studied species in Africa, with 32 publications from 12 countries, and 18 publications from 10 countries, respectively (Figure 2). Most research has been done in the western African countries, particularly in Nigeria, mainly on Rhynchophorus phoenicis and Cirina forda, which are the most consumed species in West Africa. However, southern African countries (Zimbabwe, South Africa, and Botswana) have the highest number of consumed species, but little research has been done on nutritional content and consumption patterns of edible insects.

3.2. Nutrient Composition of Edible Insects

A compilation of nutrient composition of 54 edible insects based on the dry matter is presented in Table 1. Percentage of fat, protein, moisture, and ash content were calculated based on dry weight of the insect when ready for preparation to eat, noting that, in some cases, the insects had been processed since collecting. The highest protein was reported in Lepidoptera (range: 12–79%) and Orthoptera (12–73%), while the lowest protein content ranging from (0–39%) was reported for Blattodea.
Table 1. Nutritional composition of edible insects, based on dry matter, from six orders consumed by people in Africa.

| Scientific Name | Stage of Consumption | Protein (%) | Crude Fibre (%) | Moisture (%) | Ash (%) | Carb (%) | Vitamin A (mg/100 g) | Vitamin B2 (mg/100 g) | Vitamin C (mg/100 g) | Fe (mg/100 g) | Ca (mg/100 g) | Zn (mg/100 g) | P (mg/100 g) | Mg (mg/100 g) | Fats (mg/100 g) | Reference |
|-----------------|----------------------|-------------|-----------------|--------------|---------|----------|----------------------|----------------------|----------------------|--------------|--------------|--------------|-------------|-------------|----------------|----------|
| Blattodea (termites and cockroaches) | | 33.2 ± 14.5 | 4.7 ± 3.9 | 2.9 ± 0.1 | 5.2 ± 2.5 | 23.2 ± 0 | 2.7 ± 0.2 | 1.8 ± 0.2 | 3.2 ± 0.2 | 86 ± 96.8 | 54.1 ± 42.6 | 13.8 ± 3.5 | 125 ± 11 | 0.2 ± 0.1 | 22.2 ± 9.8 |
| Periplaneta Americana Adult | | 39.6 | 13.1 | 6.2 | | | | | | | | | | | | | | | [35] |
| Macrotermes nigeriensis Adult | | 35.9 | 5.5 | 5.8 | | | | | | | | | | | | | | | | [35] |
| Macrotermes bellicosus Adult | | 20.4 | 2.7 | 2.8 | 11.3 | 23.2 | 2.9 | 2.0 | 3.4 | 27.0 | 21.0 | | 136.0 | 0.2 | 36.1 | | | [36] |
| Macrotermes bellicosus Adult | | 22.1 | 2.2 | 3.0 | 4.1 | 2.6 | 1.5 | 3.0 | 29.0 | 18.0 | | 114.0 | 0.3 | 21.4 | | | | | [36] |
| Pseudacathotermes spiniger Adult | | 6.8 | | | | | | | | | | | | | | | 332.0 | 84.7 | 11.9 | | [37] |
| Macrotermes spp. Adult | | 2.4 | | | | | | | | | | | | | | | 93.9 | 83.7 | 8.1 | | [37] |
| Macrotermes herus Adult | | 6.8 | | | | | | | | | | | | | | | 161.0 | 132.0 | 14.3 | | | [37] |
| Macrotermes bellicosus Adult | | 40.7 | | 5.7 | | | | | | | | | | | | | | 42.7 | 16.9 | 8.4 | | | [38] |
| Macrotermes bellicosus Adult | | 20.4 | 2.7 | 2.8 | 2.9 | 2.9 | 2.0 | 3.4 | 27.0 | 21.0 | | 136.0 | 0.2 | | | | | | | | [36] |
| Syntermes soldiers Adult | | 64.7 | | 4.2 | | | | | | | | | | | | | | 32.5 | 17.6 | 23.0 | | | [38] |
| Macrotermes natalensis Adult | | 22.1 | 2.2 | 3.0 | 1.9 | 2.6 | 1.5 | 3.0 | 29.0 | 18.0 | | 114.0 | 0.3 | | | | | | | | | [36] |
| Coleoptera (beetles) | | 32.8 ± 11.5 | 6.2 ± 7.8 | 7.6 ± 15.7 | 4.7 ± 2.7 | 22.6 ± 13.2 | 11.2 ± 1.4 | 1.9 ± 0.9 | 5.4 ± 1.2 | 14.1 ± 8.9 | 43.6 ± 14.3 | 14.4 ± 12.1 | 109.6 ± 48.5 | 10.1 ± 4.2 | 29.1 ± 16.6 | | | | | | |
| Anoplophora trifasciata Larvae | | 20.1 | 2.0 | 2.2 | 5.1 | 12.5 | 2.6 | 5.4 | 18.2 | 61.2 | | 136.4 | 18.2 | | | | | | | | | [36] |
| Oryctes hupe Larvae | | 26.0 | 1.5 | 1.9 | 1.5 | | | | | | | | | | | | | | | | | [6,36] |
| Oryctes monacensis Larvae | | 26.4 | 4.7 | 7.8 | 51.6 | | | | | | | | | | | | | | | | | [39] |
| Aphidius rutipilus Larvae | | 22.4 | 28.1 | 3.3 | 2.7 | 13.1 | | | | | | | | | | | | | | | | [36] |
| Rhynchophorus phoenicis Larvae | | 28.4 | 2.8 | 2.7 | 2.7 | | | | | | | | | | | | | | | | | [6] |
| Oryctes rhinoceros Larvae | | 50.5 | | 4.5 | | | | | | | | | | | | | | | | | [6] |
| Oryctes olivaceus Larvae | | 50.6 | 8.4 | 7.7 | 14.3 | | | | | | | | | | | | | | | | | [40] |
| Scientific Name | Stage of Consumption | Protein (%) | Crude Fibre (%) | Moisture (%) | Ash (%) | Vitamin A (mg/100 g) | Vitamin B2 (mg/100 g) | Vitamin C (mg/100 g) | Fe (mg/100 g) | Ca (mg/100 g) | Zn (mg/100 g) | P (mg/100 g) | Mg (mg/100 g) | Fats (mg/100 g) | Reference |
|-----------------|---------------------|-------------|----------------|--------------|--------|---------------------|----------------------|---------------------|-------------|-------------|-------------|-------------|--------------|----------------|------------|
| Eulopida mashona Larvae | 46.3 | 14.8 | 10.9 | 16.2 | | | | | | | | | | | 11.8 | [41] |
| Heteroligus melus Larvae | 38.1 | 3.0 | 1.0 | 5.8 | 20.1 | | | | | | | | | | 32.0 | [42] |
| Rhynchophorus phoenicis Larvae | 50.0 | 2.6 | 1.2 | 4.9 | 20.2 | | | | | | | | | | 21.1 | [42] |
| Rhynchophorus phoenicis Larvae | 28.4 | 2.8 | 2.7 | 2.7 | 11.3 | 2.2 | 4.3 | 12.2 | 39.6 | | | | | | | [36] |
| Analeptes trifasciata Larvae | 29.6 | 2.0 | 2.2 | 4.2 | 12.5 | 2.6 | 5.4 | 18.2 | 61.3 | | | | | | | [36] |
| Oryctes boas Larvae | 28.4 | 2.8 | 2.7 | 2.7 | 11.3 | 2.2 | 4.3 | 12.2 | 39.6 | | | | | | | [36] |
| Aponecynia parumpunctata Larvae | 16.8 | 5.4 | 59.4 | 3.0 | | | | | | | | | | | | | [43] |
| Hemiptera (bugs) Larvae | 39.3 ± 4.0 | 5.3 ± 0 | 4.9 ± 0 | 1.7 ± 0 | 6.3 ± 1.3 | 0.2 ± 0 | 0.9 ± 0 | 20.2 ± 0 | 91.0 ± 0 | 46.0 ± 0 | 57 ± 0 | 109 ± 0 | | | | [43] |
| Encosternum delegorguei Larvae | 43.3 | 5.3 | 4.9 | 1.7 | 5.0 | 0.2 | 0.9 | 20.2 | 91.0 | | | | | | | [4] |
| Encosternum delegorguei Larvae | 35.2 | 4.9 | 1.7 | 7.6 | | | | 20.2 | 91.0 | 46.0 | | | | | | [28] |
| Hymenoptera (bees and ants) Larvae | 33.9 ± 9.2 | 7.7 ± 4.6 | 3.9 ± 0.1 | 4.1 ± 3.2 | 12.4 ± 0 | 3.2 ± 0 | 10.3 ± 0 | 17.8 ± 6.6 | 21.6 ± 6.3 | 7.5 ± 2.5 | 115.6 ± 9.6 | 7.8 ± 2.6 | 42.9 ± 4.7 | | | |
| Apis mellifera Adult | 21.0 | 2.0 | 3.8 | 2.2 | 12.4 | 3.2 | 10.3 | 25.2 | 15.4 | | | | | | | | | [36] |
| Carebara vidua Adult | 42.5 | 9.1 | 8.6 | | | | | 10.4 | 22.3 | 5.7 | 106.0 | 10.4 | | | | | [6] |
| Componotus spp. Adult | 40.1 | 14.1 | 9.6 | | | | | | | | | | | | | | | [35] |
| Oecophylla longinoda Adult | 37.8 | 12.3 | 7.3 | | | | | | | | | | | | | | | [35] |
| Ceratogaster tumida Adult | 1.7 | | | 17.7 | 32.6 | 11.1 | | | | | | | | | | | [37] |
| Carebara vidua Smith Adult | 40.8 | 6.9 | 3.9 | 1.6 | 10.7 | 22.2 | 5.7 | 106.0 | 10.4 | | | | | | | | | | [44] |
| Apis mellifera Adult | 21.0 | 2.0 | 3.8 | 2.2 | 12.4 | 3.2 | 10.3 | 25.2 | 15.4 | | | | | | | | | | [36] |
| Lepidoptera (caterpillars) Larvae | 46.3 ± 21.7 | 5.9 ± 5.4 | 29.3 ± 36.5 | 4.6 ± 2.2 | 18.0 ± 13.0 | 3.1 ± 0.2 | 1.7 ± 0.6 | 2.8 ± 1.0 | 15.4 ± 22.2 | 9.4 ± 2.3 | 10.6 ± 2.2 | 320.7 ± 367.9 | 18.9 ± 45.5 | 18.3 ± 14.8 | | | |
| Anaphe venata Larvae | 60.0 | 3.2 | 3.3 | 3.1 | 1.3 | 2.2 | 2.0 | 8.6 | | | | | | | | | | [6] |
| Anaphe infracta Larvae | 20.0 | 2.4 | 2.7 | 3.0 | 2.0 | 4.5 | 1.8 | 8.6 | | | | | | | | | | [6,36] |
| Anaphe recticulata Larvae | 23.0 | 3.1 | 3.2 | 3.4 | 2.0 | 2.2 | 2.2 | 10.5 | | | | | | | | | | [6,36] |
| Scientific Name | Stage of Consumption | Protein (%) | Crude Fibre (%) | Moisture (%) | Ash (%) | Carb (%) | Vitamin A (mg/100 g) | Vitamin B2 (mg/100 g) | Vitamin C (mg/100 g) | Fe (mg/100 g) | Ca (mg/100 g) | Zn (mg/100 g) | P (mg/100 g) | Mg (mg/100 g) | Fats (mg/100 g) | Reference |
|-----------------|----------------------|-------------|-----------------|--------------|--------|-----------|----------------------|----------------------|---------------------|-------------|--------------|--------------|------------|-------------|----------------|-----------|
| *Cirina forda*  | Larvae               | 20.2        | 1.8             | 4.4          |        |           | 3.0                  | 2.2                  | 2.0                 | 64.0        | 15.4         | 8.6          | 110.0      | 1.9         |                | [6,36]    |
| *Imbrasia cyanea* | Larvae               | 73.1        | 79.8            |              |        |           |                      | 13.0                 |                     | 11.1        | 402.0        |              |            |             |                | [36]      |
| *Imbrasia obscura* | Larvae               | 62.3        | 83.0            |              |        |           |                      |                      |                     | 12.2        |              |              |            |             |                | [45]      |
| *Gomimbrasia* (Nudaurelia) *alpina* | Larvae               | 62.3        | 85.7            |              |        |           |                      |                      |                     | 1.9         |              |              |            |             |                | [45]      |
| *Gomimbrasia* (Nudaurelia) *diones* | Larvae               |            |                 |              |        |           |                      |                      |                     |             |              |              |            |             |                | [45]      |
| *Pseudanthepis discrepans* | Larvae               | 48.9        | 72.2            |              |        |           |                      |                      |                     |              |              |              |            |             |                | [45]      |
| *Anaphe panda* | Larvae               | 53.2        | 83.4            |              |        |           |                      |                      |                     |              |              |              |            |             |                | [46]      |
| *Cirina butyrospermi* | Larvae               | 62.7        | 5.0             | 5.1          |        |           |                      |                      | 13.0                |              |              |              |            |             |                | [46]      |
| *Imbrasia helina* | Larvae               | 55.3        | 16.0            | 8.3          | 8.2    |           |                      | 31.0                 | 14.0                | 543.0       | 160.0        |              |            |             |                | [6,47]    |
| *Gynanisa muta* | Larvae               | 51.1        | 16.2            | 7.7          | 14.1   |           |                      |                      |                     |              |              |              |            |             |                | [47]      |
| *Loba leopoldina* | Larvae               | 25.8        | 14.7            | 6.6          | 40.2   |           |                      |                      |                     |              |              |              |            |             |                | [47]      |
| *Imbrasia macrodactylus* | Larvae               | 75.4        |                 |              |        |           |                      |                      |                     |              |              |              |            |             |                | [48]      |
| *Nudaurelia macrophthalmus* | Larvae               | 75.4        |                 |              |        |           |                      |                      |                     |              |              |              |            |             |                | [48]      |
| *Gomimbrasia richenmaini* | Larvae               | 79.6        |                 |              |        |           |                      |                      |                     |              |              |              |            |             |                | [48]      |
| *Cirina spp.* | Larvae               | 64.0        | 7.0             | 8.6          | 1090.0 | 32.4      |                      |                      |                     |              |              |              |            |             |                | [49]      |
| *Hemijana variigata Rothschild* | Larvae               | 62.7        | 5.0             |              |        |           |                      |                      |                     |              |              |              |            |             |                | [46]      |
| *Anaphe infracta* | Larvae               | 20.0        | 2.4             | 2.7          | 1.6    |           |                      | 3.0                  | 2.0                  | 4.5         | 1.8          | 8.6          | 111.3      | 1.0         |                | [36]      |
| *Anaphe recticulata* | Larvae               | 25.0        | 3.1             | 3.2          | 2.5    |           |                      | 3.4                  | 2.0                  | 2.2         | 10.5         |              | 102.3      | 2.6         |                | [36]      |
| *Anaphe spp.* | Larvae               | 18.9        | 1.7             | 2.5          | 4.1    |           |                      | 2.8                  | 0.1                   | 3.2         | 1.6          | 7.6          | 122.2      | 1.0         |                | [36]      |
| *Anaphe venata* | Larvae               | 25.7        | 2.3             | 3.3          | 3.2    |           |                      | 3.1                  | 1.3                   | 2.2         | 8.6          |              | 100.5      | 1.6         |                | [36]      |
| Orthoptera (grasshoppers, locusts and crickets) | | 39.8 ± 21.1 | 6.4 ± 4.8 | 3.5 ± 1.7 | 5.5 ± 4.0 | 26.8 ± 14.5 | 3.0 ± 3.5 | 0.2 ± 0.4 | 2.9 ± 4.0 | 120.1 ± 208.8 | 17.3 ± 15.8 | 91.1 ± 99.8 | 119.7 ± 12.7 | 2.8 ± 3.8 | 20.8 ± 18.9 |                | [36]      |
Table 1. Cont.

| Scientific Name | Stage of Consumption | Protein (%) | Crude Fibre (%) | Moisture (%) | Ash (%) | Carb (%) | Vitamin A (mg/100 g) | Vitamin B2 (mg/100 g) | Vitamin C (mg/100 g) | Fe (mg/100 g) | Ca (mg/100 g) | Zn (mg/100 g) | P (mg/100 g) | Mg (mg/100 g) | Fats (mg/100 g) | Reference |
|-----------------|----------------------|-------------|-----------------|--------------|---------|---------|----------------------|----------------------|---------------------|----------------|--------------|--------------|-------------|-------------|--------------|-----------|-----------|
| Brachytrupes membranaceus | Adult | 53.4 | 15.0 | 3.4 | 6.0 | 15.1 | 0.0 | 0.0 | 0.0 | 0.7 | 9.2 | 126.9 | 0.1 | 53.0 | [6,47] |
| Cytacanthacris naeruginosus unicolor | Adult | 12.1 | 2.1 | 2.6 | 1.0 | 0.1 | 1.0 | 0.4 | 4.4 | 100.2 | 0.1 | [6,36] |
| Zonocerus variegatus | Adult | 26.8 | 2.4 | 2.6 | 6.8 | 0.1 | 8.6 | 910.0 | 42.2 | 131.2 | 8.2 | [6,36] |
| Gryllotalpa africana | Adult | 22.0 | 7.5 | 12.6 | 47.2 | 10.8 | [47] |
| Henicus whelani | Adult | 53.6 | 10.6 | 14.0 | 4.3 | [50] |
| Caradepatopis taeoniata | Adult | 40.6 | 13.3 | 6.9 | [35] |
| Zulus cyaneperta | Adult | 33.7 | 13.3 | 6.6 | [51] |
| Ornithacris bispinata | Adult | 42.7 | 2.0 | 4.5 | 18.2 | 2.0 | [47] |
| Rasposus differens | Adult | 72.7 | 6.3 | 4.6 | 1.2 | 0.1 | 13.0 | 24.5 | 12.4 | 121.0 | 33.1 | 46.2 | [6] |
| Anacridium melanorhodon melanorhodon (Walker) | Adult | 66.2 | 8.4 | 7.5 | 12.4 | [52] |
| Zonocerus variegatus | Adult | 62.7 | 3.6 | 1.2 | 8.9 | 0.1 | 9.8 | 2.0 | 29.0 | [6] |
| Brachytrupes membranaceus L | Adult | [53] |
| Zonocerus variegatus | Adult | 26.8 | 2.4 | 2.6 | 1.2 | 2.0 | 42.2 | 131.2 | 8.2 | [36] |
| Brachytrupes spp | Adult | 65.4 | 4.9 | 33.6 | 232.0 | 16.9 | [38] |
| Brachytrupes spp | Adult | 6.3 | 1.0 | 3.4 | 1.8 | 0.0 | 0.0 | 0.0 | 0.7 | 9.2 | 126.9 | 0.1 | [36] |
| Cytacanthacris naeruginosus unicolor | Adult | 12.1 | 1.5 | 2.6 | 2.1 | 1.0 | 0.1 | 1.0 | 0.4 | 4.4 | 100.2 | 0.1 | [36] |

*Recommended daily intakes (mg/day) for adults:

| Nutrient | Amount |
|----------|--------|
| Protein  | 45.0   |
| Vitamin A| 7.5–58.8 |
| Vitamin B2| 1300.0 |
| Vitamin C| 3.0–14.0 |
| Fe        | 700.0 |
| Ca        | 220–260 |

Note the mineral abbreviations are Fe: Iron; Zn: Zinc; Ca: Calcium; P: Phosphorus; Mg: Magnesium. * Source [37]. Mean ± standard deviation of insects belonging to the same insect order are highlighted in bold and species names are in italics.
The crude fibre was reported to be higher in Coleoptera (2–28%) and Lepidoptera (2–16%), while the crude fibre content was reported to be lowest in Hemiptera (0–5%). Lepidoptera had the highest moisture content (3–86%), while Blattodea had the lowest moisture content (2.8–3%) (Table 1).

The highest carbohydrate content was recorded in Coleoptera (13–52%) and Orthoptera (15–47%), while the lowest carbohydrate content was recorded in Blattodea (0–32%). Fat content was the highest in Lepidoptera (2–55%) and lowest in Orthoptera (2–16%) (Table 1).

Orthoptera had the highest iron content (0.3–910 mg/100 g) followed by Blattodea (27–332 mg/100 g), while Hemiptera had the lowest iron content (0–20 mg/100 g). Calcium content was higher in Blattodea (18–132 mg/100 g) and lowest in Lepidoptera (8–15 mg/100 g). The highest Phosphorus was recorded in Lepidoptera (100–730 mg/100 g) and the lowest in Orthoptera (106–125 mg/100 g). Magnesium content was the highest in order Lepidoptera (1–160 mg/100 g), while Blattodea had the lowest magnesium content (0.1–0.3 mg/100 g) (Table 1).

Edible insects are widely consumed in Africa, and play an important role in nutritious diets. However, the preference and consumption of insects vary with species and orders. Lepidoptera caterpillars were the most consumed order, and they are the most preferred species because of their nutritional value, they are rich in protein, fats, and essential micronutrients [6,54]. In addition, several caterpillar species play an important role in income generation in rural areas in southern Africa, Uganda, and Nigeria [18,22,55].

Studies from western and Central Africa indicated that Rhynchophorus phoenic (palm weevil), and Cirina forda (pallid emperor moth) were the commonly consumed species [18,24,56]. The palm weevil and pallid emperor moth are a delicacy in western and Central Africa, and, in addition, these species were of economic importance in Nigeria, Cameroon, Benin, and Ghana [57]. In southern Africa, the literature indicates that the most consumed or preferred species were Imbrasia belina (mopane worm), Macrotremes natalensis, fuliger, and bellicosus (termites) [28,50,58]. While in eastern Africa, the most consumed species were Ruspolia nitidula and differens (grasshoppers), [22,59–61]. Mopane worms, and termites are an important part of food culture in different ethnic groups in southern Africa [18,59]. Moreover, the trade of mopane worms and termites plays an important role in rural food security and income generation, as it provides rural people with household income [28,50,57,58].

Edible insects are a good source of protein content, which ranges from 12–79% of dry matter, which is consistent with studies from China, Germany, and Asia [6,10]. The protein content reported in edible insects is higher than protein found in chicken (43%) or beef (54%) [28,62]. The high protein content found in edible insects could help to combat protein deficiency in Africa. Protein deficiency is a major contributor to human malnutrition [63], and, in Africa, protein deficiency is the most common form of malnutrition, which needs to be addressed to halt starvation [64]. Therefore, including edible insects in daily diets might help reduce malnutrition rates.

Moisture content ranged from 1–7.5%, which is relatively low, such that most edible insects have longer preservation periods, and the risk of microbial deterioration and spoilage is minimal [29,42,65]. Unlike beef or chicken, which are prone to decay (unless refrigerated), edible insects can be stored for longer periods, especially during the dry season when food shortage is higher [42]. However, three caterpillars (Gonimbrasia (Nudaurelia) aloipia, Anaphe panda, and Pseudontheraea discrepans) had higher moisture (>60%), meaning they are prone to spoilage and their preservation period is shorter unless processed in some manner. Siulapwa et al. [29] reported similar results, where caterpillars Imbrasia belina and Gynanisa maja had higher moisture content than other species. To increase shelf life, caterpillars are usually degutted, washed in boiling salt water, or roasted before drying in the sun, then packed in large sacks and containers [23,66].

Edible insects contain fat content ranging from 1–67%. The fat content of edible insects are higher in the larval stage. For example, a palm weevil, which is a beetle larva that is consumed as a delicacy in western Africa, contained the highest fat content of 67%. These results are consistent with Bukkens [67], who reported that Lepidopteran caterpillars and palm weevil larvae contain higher fat than any other insect species. Edible insects can be used to provide essential fatty acids required by the
human body [10,68]. In addition, fat plays an important role in providing the human body with energy, which means that consuming insects such as *Rhynchophorus phoenicis*, *Imbrasia belina*, *Anaphe panda*, and *Brachytrupes membranaceus*, may help provide people with energy, thereby reducing malnutrition associated with energy deficiencies in developing countries [4,10,69].

Carbohydrates play a very important role in human nutrition as they are the primary source of energy. Carbohydrates found in edible insects varied from 5–51% [19,70]. Therefore, edible insects can be used as a source of carbohydrates, as they contain relatively high amounts of polysaccharides, which play an important role in enhancing the immune system of the human body [10]. In addition, carbohydrates are an essential nutritive element in the human body [29]. Species such as *Oryctes monoceros* and *Gryllotalpa africana*, reported in the current study, contained a high amount of carbohydrates; therefore, edible insects can be included in human diets to provide a good source of carbohydrates [29].

Excellent source of iron and zinc found in some edible insects indicate that edible insects could be used to combat malnutrition deficiencies such as zinc and iron deficiency anemia, which is prevalent in Africa [37]. Species such as *Zonocerus variegatus*, *Pseudacathotermes spinige*, and *Macrotermes herus* contained high iron content of 910, 332, and 161 mg/100 g respectively, which means that these species can be used as a good source of Iron. Zinc content was notably high in insects such as *Zonocerus variegatus* (29 mg/100 g) and *Rhynchophorus phoenicis* (26.5 mg/100 g) the Zinc content found in these insects exceed the daily recommended intake of 3.0–14 mg/100 g. Rumpold and Schluter [6] reported that Iron and Zinc content found in edible insects is generally higher than the Zinc and Iron content found in pork, beef, or chicken; therefore, edible insects might be a solution in fighting Iron and Zinc deficiency. Zinc and Iron deficiency are one of the health problems faced by many women of reproductive age and children in developing countries [37]. Therefore, consumption of edible insects might provide a solution to Iron deficiency health problems, such as anemia, reduced physical activity, and maternal mortality [37,71].

Edible insects reported in the current study contained a low amount of Vitamin A, B2, and C. The 100 g dry matter of edible insects reported in this study did not contain enough daily recommended Vitamin A (500–600 mg) or C (45 mg). As such, Chen et al. [10] reported that to meet the daily recommended amount of Vitamin C, insect tea derived from the excrement of insects is an option. This tea contains up to 15.04 mg of Vitamin C per 100 g, and the consumption of 300 mL of insect tea per day makes 45 mg of Vitamin C, which is the daily recommended amount of vitamin C for adults [10]. Contrary to findings reported in this study, Bukkens [67] reported that Vitamin B1, B2, and B3 content found in an edible house fly is richer than the Vitamin B1, B2, and B3 found in chicken, beef, or salmon. In addition, edible crickets contain twice more Vitamin B12 than the beef [69]. Igwe et al. [72] found that *Microtermes nigeriensis* contain a favourable high source of Niacin, Thiamine, Vitamin A, and C. Vitamins play an important role in human nutrition, as Vitamin C is important for human growth, development, and repair of various body tissues [73]. The excellent source of Vitamins found in some edible insects shows that insects have a great potential of being used as a healthy food supplement for malnourished people, or to prevent malnutrition [24].

There were several limitations to this review, which included studies reported in English only and excluded studies published in other languages used in Africa. There were significant gaps in data available on the nutritional composition of edible insects consumed in Africa. Most publications focused on a single macronutrient content, especially protein, carbohydrates, fats and fibre, and other nutrients, especially minerals, are not included in analyses. In addition, research focused on reporting the nutritional composition of economically important species such as *Imbrasia belina*, *Macrotermes natalensis*, *bellicosus* and *falciger*, *Rhynchophorus phoenicis*, and *Cirina forda*. Strengths of this review incudes the robust approach to combine the nutritional composition of consumed insects in Africa, previous studies have focused on documenting the nutritional composition of single, or a group of, insects that are consumed in Africa.

This review reported combined nutritional data of consumed insects in Africa; this information can be useful to policy makers in the health and nutrition sector by including insects in food and
nutrition policies. Health officials need to motivate people to include insects in their daily diets, particularly the most vulnerable groups such as elderly people, women, and children, with the aim to improve the quality of life for people. In addition, farming and rearing of insects by the agricultural sector need to be adopted to ensure that insects are easily accessible and available all year even when they are out of season in nature. Insects can be included as an ingredient in other food products such as bread, maize powder, chocolate, and biscuits to overcome discomfort and fear associated with eating whole insects in some groups of people. Future studies are required to research sustainable ways of farming and rearing insects in Africa and the implication that might have on the environment.

4. Conclusions

Meeting global food demand and halting poverty in Africa are among the greatest challenges, and these challenges are expected to continue if sustainable and innovative measures are not put into place. In 2017, approximately 256 million people were reported to be undernourished in Africa [74]. There is no doubt that Africa is far from achieving Sustainable Development Goal 2, which is to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture by 2030. Edible insects are widely consumed in Africa, and they play an important socio-economic role for rural communities in Africa, by providing nutritious diets (this review), and income opportunities to traders and harvesters [22,75,76]. In addition, edible insects are a traditional delicacy, and are used as an emergency food source during times of food shortage [57]. They are rich in protein, carbohydrates, amino acids, and micronutrients such as Zinc and Iron. This implies that edible insects have a potential of contributing in sustainable diets, while assuring food security, and improving livelihoods of African people.

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Table A1. Edible insects consumed in different African countries.

| Order       | Scientific Name/Morpho Species | Common Name               | Country                                                                 | Consumption Stage                  | References         |
|-------------|--------------------------------|---------------------------|-------------------------------------------------------------------------|-----------------------------------|--------------------|
| Blattodea   | Periplaneta americana          | Common cockroach          | Nigeria                                                                  | Adult                             | [35]               |
| Coleoptera  | Analeptes trifasciata          | Stem girdler              | Nigeria, Ivory Coast, Sierra Leone, Liberia, Democratic Republic of Congo, South Africa, Botswana, Namibia, Guinea Bissau | Larvae                            | [24,36,77]         |
| Coleoptera  | Oryctes boas Fabr              | Rhinoceros beetle         | Nigeria, Ivory Coast, Sierra Leone, Liberia, Democratic Republic of Congo, South Africa, Botswana, Namibia, Guinea Bissau | Larvae                            | [18,24,33,36,78,79] |
| Coleoptera  | Oryctes monoceros              | Rhinoceros beetle         | Nigeria                                                                  | Larvae                            | [24,33,36,39,56,79] |
| Coleoptera  | Aphodius rufipes               | Dung beetle               | Nigeria, Angola, Burkina Faso, Cameroon; Ghana, Cote D’ivoire, Democratic Republic of Congo, Liberia, Niger, Sao Tome, Togo, Benin, Guinea Bissau | Larvae                            | [24,36,80]         |
| Coleoptera  | Rhynchophorus phoenicis        | Palm weevil               | Nigeria                                                                  | Larvae, pupa and adult            | [18,24,33,36,39,42,56,57,77,79,81–98] |
| Coleoptera  | Heteroligus meles              | Yam beetle                | Nigeria                                                                  | Larvae, pupa, adult               | [24,36,42,77,79,91,99,100] |
| Coleoptera  | Eulepida mashona               | Beetle                    | Zimbabwe                                                                | Larvae/adult                      | [51,58]            |
| Coleoptera  | Carbula marginella            | Beetle                    | Burkina Faso                                                            | Adult                             | [98]               |
| Coleoptera  | oryctes sp.                    | Beetle                    | Burkina Faso                                                            | Larvae                            | [98]               |
| Coleoptera  | Oryctes rhinoceros larva       | Beetle                    | Nigeria; Cote D’ivoire                                                  | Larvae                            | [79,81,99,101,102] |
| Coleoptera  | Stenocera orissa Buq           | Giant jewel beetle        | Botswana, Zimbabwe                                                      | Winged adult                      | [58,78]            |
| Coleoptera  | Eulepida anatine               | Beetle                    | Zimbabwe                                                                | Larvae                            | [58]               |
| Coleoptera  | Eulepida nitidicollis         | Beetle                    | Zimbabwe                                                                | Larvae                            | [58]               |
| Coleoptera  | Aponecyna parumpunctata        | African longhorned beetle | Cote D’ivoire, Democratic Republic of Congo, South Africa, Angola, Malawi, Botswana, Mozambique, Zambia, Zimbabwe, Nigeria, Ivory Coast, Sierra Leona, Guinea, Ghana, Equatorial Guinea, Guinea Bissau | Larvae                            | [43]               |
| Coleoptera  | Oryctes ovariensis             | Beetle                    | Mozambique, Zambia, Zimbabwe, Nigeria, Ivory Coast, Sierra Leona, Guinea, Ghana, Equatorial Guinea, Guinea Bissau | Adult                             | [18,33,40]         |
| Coleoptera  | Rhinoceros oryctes             | Beetle                    | Nigeria                                                                  | Larvae, pupa, adult               | [91]               |
| Coleoptera  | Sitophilus oryzae              | Rice weevil               | Nigeria                                                                  | Larvae, pupa, adult               | [91]               |
| Order     | Scientific Name/Morpho Species | Common Name          | Country     | Consumption Stage          | References   |
|-----------|-------------------------------|----------------------|-------------|---------------------------|--------------|
| Coleoptera | *Callosobruchus maculatus*    | Bean beetle          | Nigeria     | Larvae, pupa, adult       | [91]         |
| Coleoptera | *Dermestes maculatus*         | Beetle               | Nigeria     | Larvae, pupa, adult       | [91]         |
| Coleoptera | *Cotinis nitida*              | Beetle               | Nigeria     | Adult/larvae              | [79]         |
| Coleoptera | *Eulopida mashona*            | Beetle               | Zimbabwe    | Adult/larvae              | [47]         |
| Coleoptera | *Sternocera funebris*         | Beetle               | Zimbabwe    | Adult/larvae              | [47]         |
| Coleoptera | *Oryctes spp*                 | Beetle               | Nigeria     | Larvae                    | [77]         |
| Coleoptera | *Augosoma centaurus*          | Beetle               | Cameroon    | Adult, larvae             | [57]         |
| Coleoptera | *Phyllophaga nebulosa* (Harris) | Beetle larvae       | Ghana       | Larvae                    | [94,103]     |
| Coleoptera | *Sitophilus zeamais*          | Beetle               | Ghana       | Larvae, adult             | [104]        |
| Coleoptera | *Polyceis aequatus*           | Weevil               | South Africa| Adult                     | [33]         |
| Coleoptera | *Polyceis plumbeus*           | Weevil               | South Africa| Adult                     | [33]         |
| Coleoptera | *Sipalis aloysii-sabaudiae*   | Beetle               | South Africa| Larvae                    | [33]         |
| Coleoptera | *Teralobus flabellicornis*    | Beetle               | South Africa| Larvae                    | [33]         |
| Coleoptera | *Sterocera orissa*            | Beetle               | South Africa| Larvae                    | [33]         |
| Diptera    | *Chaoborus eulis*             | Beetle               | Malawi      | Adult                     | [33]         |
| Hemiptera  | *Nezara viridula*             | Southern green stink bug | Nigeria     | Adult                     | [24,36,99]   |
| Hemiptera  | *Encosternum delegorgui*      | Stink bug            | South Africa, Zimbabwe, Namibia, Mozambique | Adult | [18,28,33,47,58,105] |
| Hemiptera  | *Monomotapa insingnisis*      | Cicada               | Botswana    | Adult                     | [78]         |
| Hemiptera  | *Aspongubus viduatus*         | Melon bug            | Sudan       | Adult                     | [106]        |
| Hemiptera  | *Agonoscelis pubescens*       | Sorghum bug          | Sudan       | Adult                     | [106]        |
| Hemiptera  | *Rynchophorus spp.*           | May bug              | Nigeria, Cameroon | Larvae | [79,107] |
| Hemiptera  | *Brevisana brevis*            | African cicada       | Zimbabwe    | Adult                     | [47]         |
| Hemiptera  | *Ugada limbalis*              | Cicada               | Uganda      |                          | [108]        |
| Hemiptera  | *Pediculus capita*            |                     | Angola, Malawi, South Africa, Zambia, Zimbabwe, Mozambique, Namibia, Botswana | | [33]         |
| Order            | Scientific Name/Morpho Species | Common Name | Country                                                                 | Consumption Stage          | References                  |
|------------------|-------------------------------|-------------|-------------------------------------------------------------------------|----------------------------|-----------------------------|
| Hymenoptera      | Apis mellifera                | Honey bee   | Nigeria, Botswana, Cote D’ivoire, Cameroon, Zambia, Zimbabwe, Botswana, Angola, Mozambique, Tanzania, Senegal, Ghana, Lesotho, Benin, South Africa Botswana, Zimbabwe; Kenya Burundi, South Africa, Malawi, Zambia, Sudan, Namibia, Mozambique | Egg, larva, pupa            | 2,18,33,36,38,77,78,91,107,109,110 |
| Hymenoptera      | Carebara vidua                | African thief ant | Botswana, Zimbabwe; Kenya Burundi, South Africa, Malawi, Zambia, Sudan, Namibia, Mozambique | Winged adult               | 18,33,44,47,58,78,81,108   |
| Hymenoptera      | Plebeina hildebrandti Friese  | Stingless bee | Botswana | Adult | 78 |
| Hymenoptera      | Hypotrigona gribodoi Magretti | Stingless bee | Botswana | Adult | 78 |
| Hymenoptera      | Cossus cossus                | Capenter ant | Cote D’ivoire | Adult | 102 |
| Hymenoptera      | Componotus spp.              | Ant         | Nigeria | Adult | 35 |
| Hymenoptera      | Oecophylla longinoda         | African weaver ant | Nigeria, Cameroon, Zambia, South Africa, Democratic Republic of Congo, Zimbabwe, Botswana, Mozambique, Namibia, Mozambique | Adult | 35,93,107 |
| Hymenoptera      | Carebara lignata             | Ant         | Botswana, Mozambique, Namibia, Sudan | Adult | 18 |
| Blattodea        | Macrotermes nigeriensis      | Termite     | Nigeria, Kenya, Uganda, Democratic Republic of Congo, Cameroon, Cote D’ivoire, Sao Tome, Togo, Liberia, Burundi, Ghana, Zimbabwe, Zambia, South Africa, Zimbabwe | Winged adult, queen        | 24,33,36,72,111,112 |
| Blattodea        | Macrotermes bellicosus       | Termite     | Cameroon, Cote D’ivoire, Sao Tome, Togo, Liberia, Burundi, Ghana, Zimbabwe, Zambia, South Africa, Zimbabwe | Winged adult, queen        | 24,33,36,59,77,79,82,94,109,111,113–115 |
| Blattodea        | Macrotermes natalensis       | Termite     | Cameroon, Democratic Republic of Congo, Burundi, Malawi, Democratic Republic of Congo; South Africa, Zimbabwe, Burundi, Zambia, Burkina Faso, Benin | Winged adult, queen        | 24,33,36,47,58,75,99 |
| Blattodea        | Macrotermes falciger         | Termite     | South Africa, Zimbabwe, Burundi, Zambia, Burkina Faso, Benin | Winged adult               | 18,33,58,108,115–117 |
| Blattodea        | Macrotermes michaelensi      | Termite     | South Africa | Winged adult | 75 |
| Blattodea        | Macrotermes subhyalinus      | Termite     | Burkina Faso Zimbabwe, Cote D’ivoire, Rwanda, Uganda, Angola, Togo, Kenya | Adult                      | 18,33,58,98,102,108,118 |
| Order   | Scientific Name/Morpho Species | Common Name | Country | Consumption Stage       | References |
|---------|--------------------------------|-------------|---------|-------------------------|------------|
| Blattodea | Hodotermes mossambicus (Hagen) | Harvester termite | Botswana | Larvae | [78] |
| Blattodea | Macrotermes sp. | Termite | Nigeria, Uganda | Adult queen, soldiers | [35,38,91] |
| Blattodea | Syntermes soldiers Pseudacanthotermes militaris | Termite | Uganda | Adult | [38] |
| Blattodea | Pseudacanthotermes sp. | Termite | Kenya, Uganda | Winged adult | [59,108,115] |
| Blattodea | Odontotermes kibarensis | Termite | Uganda | Winged adult | [108] |
| Blattodea | Pseudacanthotermes sp.1 | Termite | Uganda | Winged adult | [108] |
| Blattodea | Pseudacanthotermes sp.2 | Termite | Uganda | Winged adult | [108] |
| Blattodea | Pseudacanthotermes sp.5 | Termite | Uganda | Winged adult | [108] |
| Blattodea | Macrotermes spp. | Termite | Burundi | Adult | [108] |
| Blattodea | Macrotermes sasvae | Termite | Rwanda, Cameroon | Winged adult | [93,107,108] |
| Blattodea | Microhodotermes viator | Termite | South Africa | Winged adult | [33] |
| Blattodea | Ternes badius | Termite | South Africa | Winged adult | [33] |
| Lepidoptera | Anaphe venata | African silkworm | Nigeria, Zambia, Cote D’Ivoire, Sierra Leona, Guinea, Liberia, Guinea Bissau, Angola | Larvae | [18,24,36,77,96] |
| Lepidoptera | Anaphe infraacta | African silkworm | Nigeria | Larvae | [24,33] |
| Lepidoptera | Anaphe reticulata | African silkworm | Nigeria | Larvae | [24,33,36] |
| Lepidoptera | Bunaca alcinoe | Emperor moth | Cameroon, Zambia, South Africa, Democratic Republic of Congo, Tanzania | Larva, pupa and adult | [18,24,36,77,79,87,93,99,117] |
| Lepidoptera | Lepidoptuia litoralia | Caterpillar | Nigeria, Angola, Democratic Republic of Congo, Botswana, Zimbabwe, Togo, Zambia, Mozambique, Ghana, Namibia | Larvae | [24,36,119] |
| Lepidoptera | Cirina forda | Pallid emperor | Nigeria, Angola, Democratic Republic of Congo, Botswana, Zimbabwe, Togo, Zambia, Mozambique, Ghana, Namibia | Larvae | [18,24,30,31,33,36,48,56,58,78,96,112,117,120–123] |
## Table A1. Cont.

| Order          | Scientific Name/Morpho Species | Common Name       | Country                                | Consumption Stage | References       |
|----------------|--------------------------------|-------------------|----------------------------------------|-------------------|------------------|
| Lepidoptera    | *Imbrasia epimeethe*           | Caterpillar       | Angola, Democratic Republic of Congo   | Larvae            | [18,33,45]       |
| Lepidoptera    | *Imbrasia obscura*             | Caterpillar       | Angola                                 | Larvae            | [96]             |
| Lepidoptera    | *Imbrasia truncata*            | Caterpillar       | Angola                                 | Larvae            | [96]             |
| Lepidoptera    | *Gonimbrasia (Nudaurelia) alepia* | Caterpillar   | Angola                                 | Larvae            | [96]             |
| Lepidoptera    | *Gonimbrasia (Nudaurelia) dione* | Caterpillar     | Angola                                 | Larvae            | [96]             |
| Lepidoptera    | *Pseudanthera discrepans*      | Caterpillar       | Angola, Democratic Republic of Congo   | Larvae            | [96]             |
| Lepidoptera    | *Micragone cana*               | Caterpillar       | Angola, Democratic Republic of Congo   | Larvae            | [33,96]          |
| Lepidoptera    | *Anaphe panda*                 | Bagnest moth     | Angola, Democratic Republic of Congo, Nigeria, Tanzania | Larvae            | [18,33,47,58,124] |
| Lepidoptera    | *Notodontidae sp. 1*           | Caterpillar       | Angola                                 | Larvae            | [96]             |
| Lepidoptera    | *Notodontidae sp. 2*           | Caterpillar       | Angola                                 | Larvae            | [96]             |
| Lepidoptera    | *Notodontidae sp. 3*           | Caterpillar       | Angola                                 | Larvae            | [96]             |
| Lepidoptera    | *Notodontidae sp. 4*           | Caterpillar       | Angola                                 | Larvae            | [96]             |
| Lepidoptera    | *Gastroplakaeis rubroanalis*   | Caterpillar       | Angola                                 | Larvae            | [96]             |
| Lepidoptera    | *Sciatta inconcisa*            | Caterpillar       | Angola                                 | Larvae            | [96]             |
| Lepidoptera    | *Elaphrodes lactea Gaede*      | Caterpillar       | Democratic Republic of Congo          | Larvae            | [33,117]         |
| Lepidoptera    | *Lobobunaea saturnus*          | Caterpillar       | Democratic Republic of Congo, Zimbabwe | Larvae            | [33,58,117]      |
| Lepidoptera    | *Cinia brachyptera*            | Caterpillar       | Democratic Republic of Congo          | Larvae            | [33,117]         |
| Lepidoptera    | *Gonimbrasia richelmanni*      | Caterpillar       | Democratic Republic of Congo          | Larvae            | [33,117]         |
| Lepidoptera    | *Antherea insignata*           | Caterpillar       | Democratic Republic of Congo          | Larvae            | [33,117]         |
| Lepidoptera    | *Imbrasia rubra*               | Caterpillar       | Democratic Republic of Congo          | Larvae            | [117]            |
| Lepidoptera    | *Athletes semiata*             | Caterpillar       | Democratic Republic of Congo, Zimbabwe, Zambia, South Africa, Namibia, Mozambique | Larvae            | [33,58,117]      |
| Order | Scientific Name/Morpho Species | Common Name | Country | Consumption Stage | References |
|-------|--------------------------------|-------------|---------|-------------------|------------|
| Lepidoptera | *Cirina butyrospermi* | Caterpillar | Burkina Faso, Cote D’Ivioire, Zambia, Zimbabwe, South Africa, Nigeria, Mali, Ghana | Larvae | [18,46,102,103,118,125] |
| Lepidoptera | *Hemijana variegata* | Caterpillar | South Africa | Larvae | [49] |
| Lepidoptera | *Imbrasia belina* | Mopane worm | Namibia, South Africa, Malawi, Zambia, Angola, Mozambique | Larvae | [18,33,34,47,58,76,78,91,109,126–129] |
| Lepidoptera | *Isoberlina paniculata* | Caterpillar | Zambia | Larvae | [127] |
| Lepidoptera | *Urota sinope* | Caterpillar | Zambia, Botswana | Larvae | [78,130] |
| Lepidoptera | *Gonimbrasia zambesina* | Caterpillar | Zambia; Zimbabwe, Democratic Republic of Congo | Larvae | [33,58,130] |
| Lepidoptera | *Lophostethus dumolii* | Angas | Botswana | Larvae | [78] |
| Lepidoptera | *Daphnis nerii L* | Oleander hawk moth | Botswana | Larvae | [78] |
| Lepidoptera | *Heniocha spp.* | Marbled emperor moth | Botswana | Larvae | [78] |
| Lepidoptera | *Imbrasia tyrrhea* | Willow emperor moth | Botswana | Larvae | [78] |
| Lepidoptera | *Sphingomorpha chlorea* | Sundown emperor moth | Botswana | Larvae | [78] |
| Lepidoptera | *Hippotion celerio L.* | Silver striped hawk | Botswana | Adult | [78] |
| Lepidoptera | *Agrius convolvuli L.* | Convulvulus hawk moth | Botswana, South Africa, Angola, Zimbabwe, Zambia, Malawi, Mozambique, Namibia, Zimbabwe, Botswana, Malawi | Larvae | [78] |
| Lepidoptera | *Gonanisa maia* | Caterpillar | Democratic Republic of Congo, South Africa | Larvae | [33,47,58] |
| Lepidoptera | *Anthoacra zambezina* | Caterpillar | Zambia, Botswana, Malawi, Namibia, Zambia, South Africa, Mozambique, Angola | Larvae | [33,58] |
| Lepidoptera | *Athletes gigas* | Caterpillar | Namibia, Zambia, South Africa, Mozambique, Angola | Larvae | [33,58] |
| Lepidoptera | *Bombycomorpha pallida* | Moth | Zimbabwe, South Africa | Larvae | [33,58] |
Table A1. Cont.

| Order       | Scientific Name/Morpho Species | Common Name | Country                                      | Consumption Stage | References         |
|-------------|--------------------------------|-------------|----------------------------------------------|-------------------|-------------------|
| Lepidoptera | Bunaeacaffra                    | Moth        | Zimbabwe, Zambia, South Africa, Namibia, Botswana, Mozambique, Angola | Larvae            | [33,58]           |
| Lepidoptera | Bunacopsis aurantica            | Moth        | Zimbabwe, Democratic Republic of Congo       | Larvae            | [33,58]           |
| Lepidoptera | Gonometa postica                | Moth        | Zimbabwe, South Africa                       | Larvae            | [33,58]           |
| Lepidoptera | Heniocha dyops                  | Moth        | Zambia, Malawi, Namibia, Mozambique, Angola   | Larvae            | [33,58]           |
| Lepidoptera | Imbrasia epimethea              | Moth        | Zimbabwe, Democratic Republic of Congo, South Africa, Angola, Malawi, Namibia | Larvae            | [33,58]           |
| Lepidoptera | Imbrasia eurili                 | Caterpillar | Zimbabwe, South Africa, Democratic Republic of Congo, Angola, Zimbabwe, Botswana, Angola | Larvae            | [18,33,58]       |
| Lepidoptera | Nudaurelia belina               | Moth        | Mozambique, Namibia, Zambia, South Africa    | Larvae            | [33,58]           |
| Lepidoptera | Pseudobunaea irius              | Moth        | Zimbabwe, South Africa, Zambia, Angola, Malawi, Namibia | Larvae            | [33,58]           |
| Lepidoptera | Loba leopardina                 | Moth        | Zimbabwe                                     | Larvae            | [58]              |
| Lepidoptera | Imbrasia oyemensis              | Caterpillar | Cote D’Ivoire                                | Adult             | [102]             |
| Lepidoptera | Imbrasia spp.                   | Caterpillar | Cameroon                                     | Larvae            | [93]              |
| Lepidoptera | Eumeta spp.                     | Caterpillar | Cameroon                                     | Larvae            | [107]             |
| Lepidoptera | Anaphe spp.                     | Caterpillar | Cameroon                                     | Larvae            | [107]             |
| Lepidoptera | Dactyloceras spp.               | Caterpillar | Cameroon                                     | Larvae            | [107]             |
| Lepidoptera | Bunaca spp.                     | Caterpillar | Democratic Republic of Congo, Zambia, South Africa, Cameroon, Angola, Gabon, Sierra Leone, Equatorial Guinea, Sao Tome, Zambia, Democratic Republic of Congo, Sierra Leone, Rwanda, Burundi, Equatorial Guinea, Sao Tome, | Larvae            | [18]              |
| Lepidoptera | Platysphinx stigmatica          | Caterpillar |                                            | Larvae            | [18]              |
| Order | Scientific Name/Morpho Species | Common Name | Country | Consumption Stage | References |
|-------|-------------------------------|-------------|---------|-------------------|------------|
| Lepidoptera | *Epanaphe carteri* | Caterpillar | Democratic Republic of Congo, Angola, Gabon, Sierra Leone, Sao Tome, Equatorial Guinea | Larvae | [18] |
| Lepidoptera | *Gynanisa ata* | Caterpillar | Democratic Republic of Congo, Zambia, Malawi, Sudan Democratic Republic of Congo, Cameroon, Angola, Gabon, Sierra Leone, Sao Tome, Equatorial Guinea, Rwanda, Burundi, Liberia Democratic Republic of Congo, | Larvae | [18] |
| Lepidoptera | *Eumeta cervina* | Caterpillar | Democratic Republic of Congo, Cameroon, Angola, Gabon, Sierra Leone, Sao Tome, Equatorial Guinea, Rwanda, Burundi, Liberia Democratic Republic of Congo, | Larvae | [18] |
| Lepidoptera | *Urota sinope* | Caterpillar | South Africa, Zimbabwe, Botswana, Gabon, Mozambique, Namibia | Larvae | [18,33] |
| Lepidoptera | *Anthoeca caffaria* | Caterpillar | Angola, Malawi, South Africa, Zambia, Zimbabwe, Mozambique, Namibia, Botswana Angola, Malawi, South Africa, Zambia, Zimbabwe, Mozambique, Namibia, Botswana | Larvae | [33] |
| Lepidoptera | *Anthoeca menippe* | Caterpillar | Angola, Malawi, South Africa, Zambia, Zimbabwe, Mozambique, Namibia, Botswana | Larvae | [33] |
| Lepidoptera | *Bunaea caffaria* | Caterpillar | Democratic Republic of Congo Democratic Republic of Congo | Larvae | [33] |
| Lepidoptera | *Drapetides uniformis* | Caterpillar | Democratic Republic of Congo Democratic Republic of Congo | Larvae | [33] |
| Lepidoptera | *Gonimbrasia lecata* | Caterpillar | Democratic Republic of Congo Democratic Republic of Congo | Larvae | [33] |
| Lepidoptera | *Goodia kuntzei* | Caterpillar | Democratic Republic of Congo Angola, Malawi, South Africa, Angola, Malawi, South Africa, | Larvae | [33] |
| Lepidoptera | *Heniocha apollonia* | Caterpillar | Zambia, Zimbabwe, Mozambique, Namibia, Botswana Zambia, Zimbabwe, Mozambique, Namibia, Botswana Angola, Malawi, South Africa, Angola, Malawi, South Africa, | Larvae | [33] |
| Lepidoptera | *Heniocha marnois* | Caterpillar | Zambia, Zimbabwe, Mozambique, Namibia, Botswana Zambia, Zimbabwe, Mozambique, Namibia, Botswana | Larvae | [33] |
| Lepidoptera | *Herse convolvuli* | Caterpillar | South Africa | Larvae | [33] |
| Lepidoptera | *Imbrasia dione* | Caterpillar | Democratic Republic of Congo Democratic Republic of Congo | Larvae | [33] |
| Lepidoptera | *Imbrasia macrothyris* | Caterpillar | Democratic Republic of Congo Democratic Republic of Congo | Larvae | [33] |
| Lepidoptera | *Imbrasia rubra* | Caterpillar | Democratic Republic of Congo Democratic Republic of Congo | Larvae | [33] |
| Lepidoptera | *Lobobunaea phaedusa* | Caterpillar | Democratic Republic of Congo Democratic Republic of Congo | Larvae | [33] |
Table A1. Cont.

| Order       | Scientific Name/Morpho Species | Common Name          | Country                                      | Consumption Stage | References            |
|-------------|--------------------------------|----------------------|----------------------------------------------|-------------------|-----------------------|
| Lepidoptera | *Melanocera parva*             | Caterpillar          | Democratic Republic of Congo                | Larvae            | [33]                  |
| Lepidoptera | *Microgene cana*               | Caterpillar          | Democratic Republic of Congo                | Larvae            | [33]                  |
| Lepidoptera | *Nudaurelia macrotomus*        | Caterpillar          | Democratic Republic of Congo                | Larvae            | [33]                  |
| Lepidoptera | *Nyodes prasinodes*            | Caterpillar          | Democratic Republic of Congo                | Larvae            | [33]                  |
| Lepidoptera | *Rohaniella pygmaea*           | Caterpillar          | Democratic Republic of Congo                | Larvae            | [33]                  |
| Lepidoptera | *Rheneae mediata*              | Caterpillar          | Democratic Republic of Congo                | Larvae            | [33]                  |
| Lepidoptera | *Tagoropsis flavinata*         | Caterpillar          | Democratic Republic of Congo                | Larvae            | [33]                  |
| Lepidoptera | *Usta terpisichore*            | Caterpillar          | Democratic Republic of Congo                | Larvae            | [33]                  |
| Lepidoptera | *Usta wallengre*               | Caterpillar          | Democratic Republic of Congo                | Larvae            | [33]                  |
| Mantodea    | *Mantis religiosa*             | African mantis       | Nigeria, South Africa, Nigeria, Angola       | Adult             | [33,79]               |
| Orthoptera  | *Brachytrupes membranaceus*    | Giant African cricket| Democratic Republic of Congo, Burkina Faso,| Adult             | [18,24,33,36,45,53,58,77,79,91,93,96,99,108,124]|
| Orthoptera  | *Gymnogryllus lucens*          | Cricket              | Nigeria                                      | Adult             | [24,36,116]           |
| Orthoptera  | *Cytacanthacris naeruginosus*  | Short horned grasshopper| Nigeria, Cameroon, Ghana, Guinea             | Adult             | [24,36]               |
| Orthoptera  | *Zonocerus variegatus*         | Grasshopper          | Democratic Republic of Congo, Cote D’ivoire,| Adult             | [18,24,35,36,38,77,79,85,94,99,110,116,131]|
| Orthoptera  | *Gryllotalpa africana*         | Mole cricket         | Nigeria, Zimbabwe, Malawi, Kenya, Tanzania,  | Adult             | [24,33,36,47,77,79,99,124]|
| Orthoptera  | *Ruspolia differens*           | Grasshopper          | Democratic Republic of Congo, Uganda, Rwanda,| Adult             | [33,58–60,108,112,115,117,132]|
| Orthoptera  | *Melanoplus foedus*            | Grasshopper          | Nigeria                                      | Adult             | [112]                 |
| Orthoptera  | *Gryllus assimilis*            | Cricket              | Nigeria, Ghana                               | Adult             | [94,112]              |
| Order       | Scientific Name/Morpho Species | Common Name          | Country                                      | Consumption Stage         | References                  |
|-------------|--------------------------------|----------------------|----------------------------------------------|---------------------------|----------------------------|
| Orthoptera  | *Henicus whellani*             | Cricket              | Zimbabwe                                    | Adult                     | [50,51]                    |
| Orthoptera  | *Kraussaria ongulifera*        | Grasshopper          | Burkina Faso                                | Adult                     | [98,118]                   |
| Orthoptera  | *Gryllus campestris*           | Field cricket        | Burkina Faso; Cameroon, Malawi              | Adult                     | [98,107,124]               |
| Orthoptera  | *Ruspolia nitidula*            | Grasshopper          | Uganda                                       | Larvae and adult          | [22,133]                   |
|             |                                 |                      | Botswana; Uganda; Zambia, South Africa, Democratic Republic of Congo, Zimbabwe, Botswana, Uganda, Malawi, Mozambique |                           |                            |
| Orthoptera  | *Normadacris septemfasciata*   | Red locust           | Botswana, South Africa, Zimbabwe, Malawi, Libya | Adult                     | [18,78,108]               |
| Orthoptera  | *Locustana pardalina*          | Brown locust         | Botswana, South Africa, Zimbabwe, Malawi, Libya | Adult                     | [18,33,78]               |
| Orthoptera  | *Schistocerca gregaria*        | Desert locust        | Botswana, South Africa, Zimbabwe, Malawi, Libya | Adult                     | [18,78,116]               |
| Orthoptera  | *Cyrtacanthacris tatarica*     | Brown-spotted locust | Botswana                                    | Adult                     | [78]                       |
| Orthoptera  | *Acrida acuminata*             | Common stick         | Botswana                                    | Adult                     | [78]                       |
| Orthoptera  | *Zonocerus elegans*            | Elegant grasshopper  | Botswana, South Africa                      | Adult                     | [35,78]                    |
| Orthoptera  | *Acrotylus spp.*               | Burrowing grasshopper| Botswana, South Africa                      | Adult                     | [78]                       |
| Orthoptera  | *Hemorocoryphus nitidulus*     | Cricket              | Cameroon, Democratic Republic of Congo, Zimbabwe, Burkina, Faso, Malawi, Mali, Niger, Togo, Benin | Adult                     | [18,78,116]               |
| Orthoptera  | *Gynanisa maia*                | Cricket              | Zimbabwe, Malawi, South Africa              | Larvae                    | [35,58]                    |
|             |                                 |                      | Botswana, Cote D’ivoire; Nigeria; Republic of Congo, Sudan, Ghana | Larvae                    | [18,33,79,94,102,134,135] |
| Orthoptera  | *Acheta domesticus*            | Cricket              | Cote D’ivoire; Nigeria, Ghana               | Adult                     | [79,94,102]               |
| Orthoptera  | *Cartartropsis taeniolatus*     | Grasshopper          | Nigeria                                      | Adult                     | [35]                       |
| Orthoptera  | *Zalua cyanoptera*             | Grasshopper          | Nigeria                                      | Adult                     | [35]                       |
| Orthoptera  | *Brachytrupes spp.*            | Cricket              | Uganda, Cameroon                             | Adult                     | [107,110]                  |
| Orthoptera  | *Cyrtacanthacris aeruginosa*   | Grasshopper          | Uganda                                       | Adult                     | [110]                      |
| Orthoptera  | *Zonocerus sp.*                | Grasshopper          | Nigeria                                      | Adult                     | [91]                       |
| Orthoptera  | *Daraba (Scolioidea) laisalis* | Locust               | Nigeria                                      | Larvae, pupa, adult       | [91]                       |
| Orthoptera  | *Ornithacris turbida*          | Grasshopper          | Zimbabwe                                    | Adult                     | [47]                       |
| Order       | Scientific Name/Morpho Species | Common Name | Country                                                                 | Consumption Stage | References |
|------------|--------------------------------|-------------|-------------------------------------------------------------------------|-------------------|------------|
| Orthoptera | *Acanthoplus discoidalis*      | Cricket     | Zimbabwe, Uganda, Zambia, South Africa, Cameroon, Democratic Republic of Congo, Zimbabwe, Burkina Faso, Malawi, Mali, Niger, Togo, Benin | Adult             | [47]       |
| Orthoptera | *Acanthacris ruficornis*       | Garden locust | Uganda, Zambia, South Africa, Cameroon, Democratic Republic of Congo, Zimbabwe, Burkina Faso, Malawi, Mali, Niger, Togo, Benin | Adult             | [18,108]   |
| Orthoptera | *Schistocerca spp.*           | Grasshopper  | Cameroon                                                               | Adult             | [107]      |
| Orthoptera | *Acanthacris spp.*            | Grasshopper  | Cameroon                                                               | Adult             | [107]      |
| Orthoptera | *Gastrimargus spp.*           | Locust      | Cameroon                                                               | Adult             | [107]      |
| Orthoptera | *Phymateus spp.*              | Locust      | Cameroon                                                               | Adult             | [107]      |
| Orthoptera | *Anacridium spp.*             | Locust      | Cameroon                                                               | Adult             | [107]      |
| Orthoptera | *Pyrgomorpha spp.*            | Locust      | Cameroon                                                               | Adult             | [107]      |
| Orthoptera | *Gastrimargus africanus*      | Locust      | Cameroon, Democratic Republic of Congo, Niger, Lesotho, Liberia, Zambia, South Africa, Democratic Republic of Congo, Zimbabwe, Botswana, Mozambique, Namibia, Togo, Nigeria, Guinea Bissau, Sierra Leone, Liberia, Benin, Democratic Republic of Congo, Kenya, Sudan, Zambia | Adult             | [18]       |
| Orthoptera | *Phymateus viridipes brunneri* | Bolivar     | Republic of Congo, Zimbabwe, Botswana, Mozambique, Namibia, Togo, Nigeria, Guinea Bissau, Sierra Leone, Liberia, Benin, Democratic Republic of Congo, Kenya, Sudan, Zambia | Adult             | [18]       |
| Orthoptera | *Gryllus bimaculatus*         | Cricket     | Cameroon                                                               | Adult             | [18]       |
| Orthoptera | *Anacridium melanorhodon melanorhodon* | Cricket | Cameroon, Sudan, Niger                                               | Adult             | [18,52]    |
| Orthoptera | *Paracinema tricolor*         | Cricket     | Cameroon, Malawi, Lesotho                                              | Adult             | [18]       |
| Orthoptera | *Acheta spp.*                | Cricket     | Zambia, Zimbabwe, Kenya                                               | Adult             | [18]       |
| Orthoptera | *Scapteriscus vicinus*        | Field cricket | Ghana                                                               | Adult             | [94,103]   |
| Orthoptera | *Gryllotalpa gryllotalpa*     | Mole cricket | Malawi                                                               | Adult             | [124]      |
| Orthoptera | *Homorocoryphus vicinus*      | Cricket     | Uganda                                                                | Adult             | [33]       |
| Orthoptera | *Nomadacris septemfasciata*   | Cricket     | South Africa                                                          | Adult             | [33]       |
| Orthoptera | *Schistocerca gregaria*       | Cricket     | Zimbabwe                                                             | Adult             | [33]       |
| Blattodea   | *Pseudacathotermes spiniger*  | Termite     | Kenya                                                                | Adult             | [37]       |
| Blattodea   | *Macrotermes spp.*            | Termite     | Kenya                                                                | Adult             | [37]       |
| Blattodea   | *Macrotermes subhyalinus*     | Termite     | Kenya                                                                | Adult             | [37]       |
| Hymenoptera | *Crematogaster mimosae*       | Ant         | Kenya                                                                | Adult             | [37]       |
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