

*Full Length Research Paper*

# Indigenous knowledge on host tree preference of the wild edible *Gynanisa maja* (Lepidoptera: Saturniidae) matches with the laboratory test results in western Zambia

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***Gynanisa maja* is an edible caterpillar and contributes significantly towards household food security. The linkage between indigenous and scientific knowledge influencing *G. maja* forage preference is not yet clear, and therefore the study aimed at determining this linkage regarding host preferences for *G. maja* in western Zambia. A household survey was conducted to determine people's perception on the most preferred host plants and in order to compare with the laboratory tests, phytochemical and proximate analyses on host plants were conducted. Local people (100% of the respondents) mentioned that *G. maja* frequently feed on *Julbernardia paniculata* than on any other tree in the area. Both phytochemical and proximate analyses showed that *J. paniculata* had significantly high amount of total ash ( $F_{2,15} = 557.0$ ,  $p < 0.001$ ) and crude protein ( $F_{2,15} = 77.6$ ,  $p < 0.001$ ) and low content of total fat. The presence of terpenoids and lack of saponins and phenols in *J. paniculata* provided further support that *J. paniculata* is the most preferred host for *G. maja*. Study findings lays a foundation for embarking on farming *G. maja* using *J. paniculata* which will consequently enhance household food security.**

**Key words:** Edible caterpillar, Forage preference, plant nutrients, phytochemicals, indigenous knowledge.

## INTRODUCTION

Indigenous communities play significant role in reporting traditional uses of flora and can be used as a tool to conserve and maintain biodiversity and could be further match with scientific findings (Mishra, 2013; Aziz et al.,

2018). It plays an important role in the documentation of diverse plant species that are utilised by local communities for treating a broad spectrum of disorders (Shah et al., 2016) and also for the discovery and

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development of novel, safe and affordable medicines (Süntar, 2020). Also the preservation, protection and promotion of the indigenous knowledge is encouraged as it plays a critical role in health and food security among other areas (UNCTAD, 2004).

Trees do not only serve a purpose of being host of edible insects but through indigenous knowledge they are used in several ways such as medicines for treating ailments, for apiculture among others and therefore, it is prudent to encourage communities to conserve these plants in order to protect habitats for edible insects like caterpillar species (Kusia et al., 2021). Considering the threat of climate change (Kalantary, 2010) and poor harvesting methods of trees (Chungu et al., 2007), the need to protect the forests is greater now than before.

Insects are the dominant class of organisms in terms of species number on a global level and almost half of them feed on living plants (Schoonhoven et al., 2005). The chemical constitution of a plant is the prime factor in its interaction with the insect world (Schoonhoven et al., 2005). The nutrition of plants may have an impact on the growth, survival and general performance of the insects that feed on plants (Shah, 2017). The main groups of primary plant metabolites; proteins, carbohydrates, and lipids involved in fundamental plant physiological processes form essential nutrients for herbivores. Therefore, qualitative and quantitative variation in primary plant compounds can have profound effects on insect preference and performance (Berenbaum, 1955).

The choice of host plants is determined both at the egg-laying and larval-feeding stages (Nishida, 2014). The food quality of a given host plant tissue will influence the performance and preference behaviour of herbivorous animals (Tremmel and Müller, 2013). Insects lay most eggs on host plants that provide the best larval performance (Griese et al., 2020). In an event that the parent lay eggs on an unsuitable plant, larvae have the capacity to find a suitable food source (Zhou et al., 2020). This is why female herbivores try to lay eggs where their offspring can develop successfully (Li and Liu, 2015).

Plant palatability which is the preference an animal has for a particular feed when offered a choice (Heath et al., 1985; Kochare et al., 2018) plays a major role in host selection which in turn is affected by different plant factors such as seasonal availability of plant, degree of maturity, growth stage, phenology, morphological and chemical nature (Muhammad et al., 2014; Kochare et al., 2018). Food quality is important for all caterpillar instars (Arriens et al., 2021) and the community composition of insect herbivores is largely shaped by host-plant phylogeny and functional traits (Abe et al., 2021). Caterpillar species and the host plant on which they feed, have an important effect on the host acceptance and performance (Traine et al., 2021).

Plant volatiles are an important component of the wide-ranging classes of plant compounds that influence

herbivory as many insects detect their host plants through volatile chemical signaling (Carroll et al., 2008; Magalhaes et al., 2012; Massad et al., 2017). Therefore, chemical composition of plants determines the relationship between phytophagous insects and their host plants (Kant et al., 2015). For instance, in the case of phytochemical compounds, they serve several purposes such as to repel or attract phytophagous insects (Kant et al., 2015). Phytophagous insects recognise the host plant through multiple sensory modalities, including visual, olfactory, gustatory, and tactile cues (Nishida, 2014). Herbivorous insects are known to possess mechanisms which enable them to detect and reject plants that contain harmful secondary compounds as ingestion of these compounds can result in death (Hennessy, 2020). Host plant odour is an important cue in recognising hosts suitable for oviposition (Cao et al., 2014).

Currently, there is limited knowledge on plant chemicals that influence *Gyanisa maja* forage preference. The aim of this study was to test whether indigenous knowledge was in accordance with the results of laboratory tests regarding the preference of the commonly consumed caterpillar *G. maja* (Lepidoptera: Saturniidae). In order to achieve this, we first conducted a survey to determine people's observation on the most preferred host plants for *G. maja* then secondly, phytochemical and proximate contents in the host plants were analysed.

## MATERIALS AND METHODS

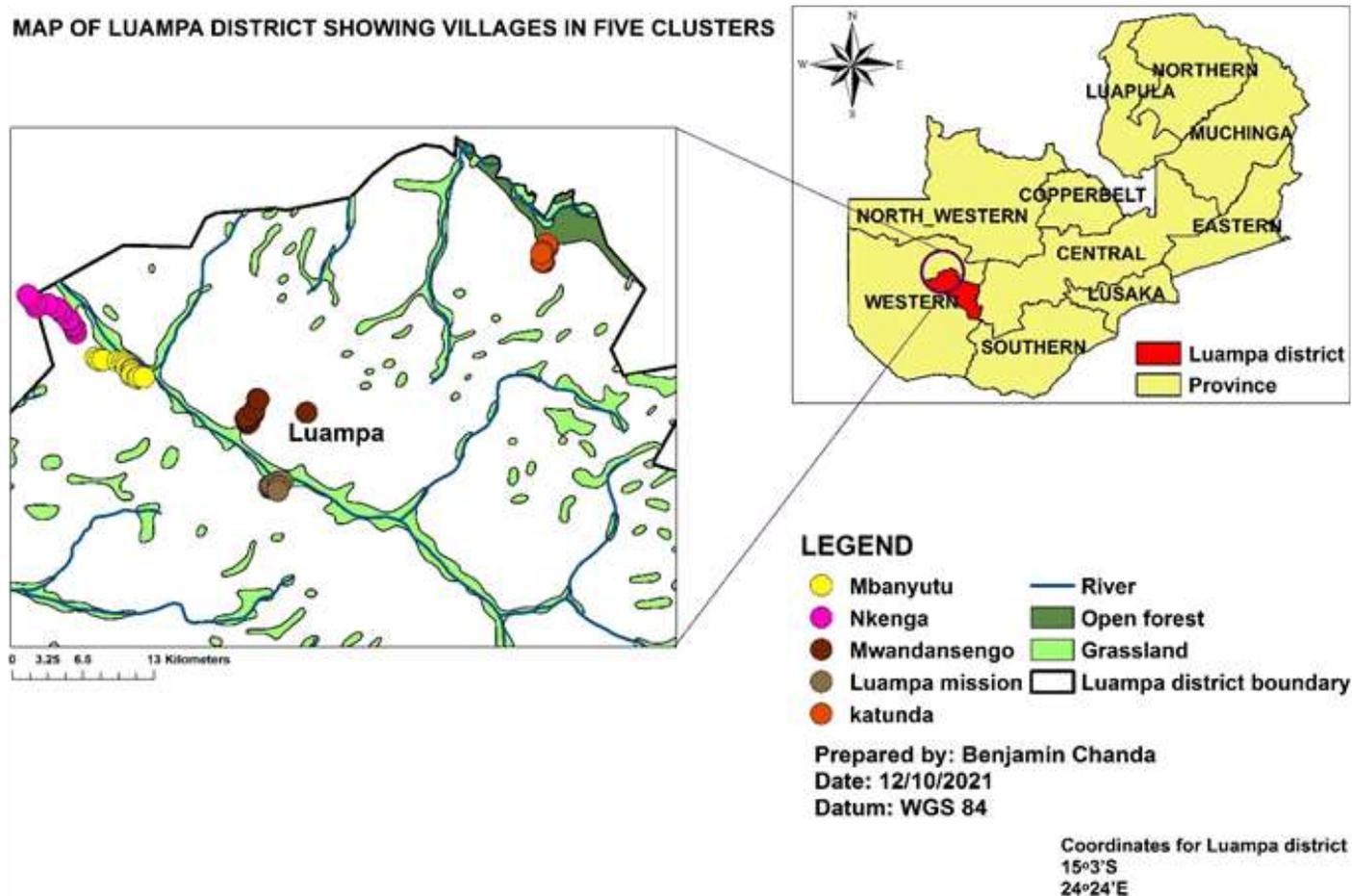
### Study site

The study was conducted in Luampa district, Western province of Zambia (15° 3' S and 24° 24' E, 1119 m asl) in five clusters namely: Katunda, Mwandansengo, Mbanyutu, Luampa Mission and Nkenga as shown in Figure 1. According to the information obtained at Luampa District Health Office (unpublished data), Luampa has a tropical savannah climate with a hot-wet season (November to April), cold dry season (May to July) and a hot dry season (August to October). The average annual rainfall is 1000 mm. The average temperature ranges from 10 to 38°C. The main vegetation type found in this district is mixed forest commonly referred to as miombo woodland which is characterized by the dominant tree species of the genera *Brachystegia*, *Julbernardia* and *Isoberlinia* (Gumbo et al., 2018). This vegetation type is an important habitat for lepidopterans and other insects (Ghaly, 2010) as forest cover prove to be influential for insect communities (González et al., 2017). Soils in this area are dominated by acidic arenosols and podzols type with sandy textures and pH less than 4.0 (JAICAF, 2008).

### Sampling and data collection

#### Household survey

To determine people's observation on the most preferred host plants for *G. maja*, household survey was conducted using a



**Figure 1.** The map showing the study site.

questionnaire. The survey focused on description of caterpillar morphological features, social-economic value, harvesting sites and the preferred host plants. The targeted sample include 80 randomly sampled participants per cluster who had lived in the area for 15 years or more, because these people might have harvested *G. maja* for a couple of years and could provide valid and sufficient information about the preferred food plants of *G. maja* in the area.

#### **Tree sampling and leaf sample collection**

Tree species mentioned during household survey were recorded in each cluster that is, Katunda, Mwandansengo, Mbanyutu, Luampa Mission and Nkenga. Trees ( $n=3$ ) that were commonly mentioned in all the clusters were further studied in the field by collecting leaves for laboratory analysis. With the help of a key informant, one tree species per cluster was randomly sampled from farms where respondents harvest *G. maja* and about one thousand to two thousand moderately young leaves per tree species per cluster were collected. The leaves were randomly selected based on the information obtained from the respondents who indicated that *G. maja* larvae prefer moderately young leaves to old ones as they harvest more of it from moderate young leaves than old. The leaf samples were plucked from their respective tree branches,

packaged in well labeled polyethene bags. Thereafter, they were air dried under the shade and stored in zip lock bags for proximate and phytochemical analyses following the method by Banu and Cathrine (2015) and Sithara et al. (2016).

#### **Proximate and phytochemical analysis**

To determine proximate chemical analysis, three host plants were analysed and the following parameters were assessed: moisture content, total ash, crude protein, fat, carbohydrate and calorific value following the methods recommended in the literature (Egan et al., 1981; AOAC, 1990; Zaklouta et al., 2011). Moisture content was determined by keeping the samples in a moisture oven at 105°C for overnight and then cooling in desiccator. The loss in weight was regarded as a measure of moisture. To determine ash content, samples were heated in a muffle furnace at 600°C, until white or greyish-white ash was obtained, and the weight of the ash was recorded directly. Nitrogen content was estimated using micro Kjeldahl method and crude protein was calculated by multiplying the measured nitrogen by a factor 6.25 (Zaklouta et al., 2011). The calorific value was calculated by multiplying the values of total carbohydrate, fat and protein by the factors 4, 9 and 4 respectively and the summation was expressed as kilocalories. For

phytochemical analysis, the following contents were qualitatively assessed using ethanol and methanol as solvents: the tannins, saponins, flavonoids, phenols, terpenoids, and alkaloids following the method by Jayaramu et al. (2016) with minor modifications. Salkowski reaction was used to determine the presence of steroids (Kumar et al., 2010). Therefore, general reactions in these analyses revealed either the presence or absence of these compounds in different leaf extracts.

### Statistical analysis

The survey data on people's observations on the preferred host plant species of *G. maja* were related to the results of quantitative proximate and qualitative phytochemical laboratory analyses. Shapiro-Wilk test was conducted on proximate data to test normality and in order to achieve normality and stabilize homogeneity of variances between treatments, the moisture data was square root transformed while ash, protein, fat and energy data were log transformed before performing one-way analysis of variance (ANOVA). The ANOVA was applied to determine whether differences in moisture content, total ash, crude protein, fat, carbohydrate, or calorific value were due to tree species and/or clusters). In order to determine where exactly the significant difference occurs between groups, Tukey's honestly significant difference (HSD) test was used. Generally proximate data were reported as mean  $\pm$  standard deviation. Data were analysed in R version 4.1.1 software.

## RESULTS

### People's observations of tree hosts for *G. maja*

Five host plants were mentioned as preferred hosts for *G. maja*, namely; *Julbernardia paniculata* (Benth.) Troupin, *Brachystegia longifolia* Benth, *Erythrophleum africanum* (Welw. ex Benth.) Harms and *Albizia antunesiana* Harms. Out of these, *J. paniculata*, *E. africanum* and *B. longifolia* were mentioned consistently in all the five clusters in this study. Across all clusters, 100% of the participants mentioned *J. paniculata* as the first host choice for *G. maja*, while 57.5% of the participants in Katunda, 51.3% in Luampa and 38.8% in Mbanyutu mentioned *B. longifolia* as the second preferred host for the caterpillar but *E. africanum* was mentioned as the second most preferred host only in Mwandansengo (63.8%) and in Nkenga (56.3%). On the other hand, only 17.5 and 26.3% of the participants in Katunda mentioned that *B. spiciformis* and *A. antunesiana* respectively as hosts for *G. maja*. Overall, three host plants were mentioned in all the clusters namely; *J. paniculata* (100%), *E. africanum* (50.3%) and *B. longifolia* (49.8%) (Figure 2).

### Proximate composition of the preferred host tree species for *G. maja*

Tables 1 and 2 shows proximate composition of the preferred host plants for *G. maja* and ANOVA table

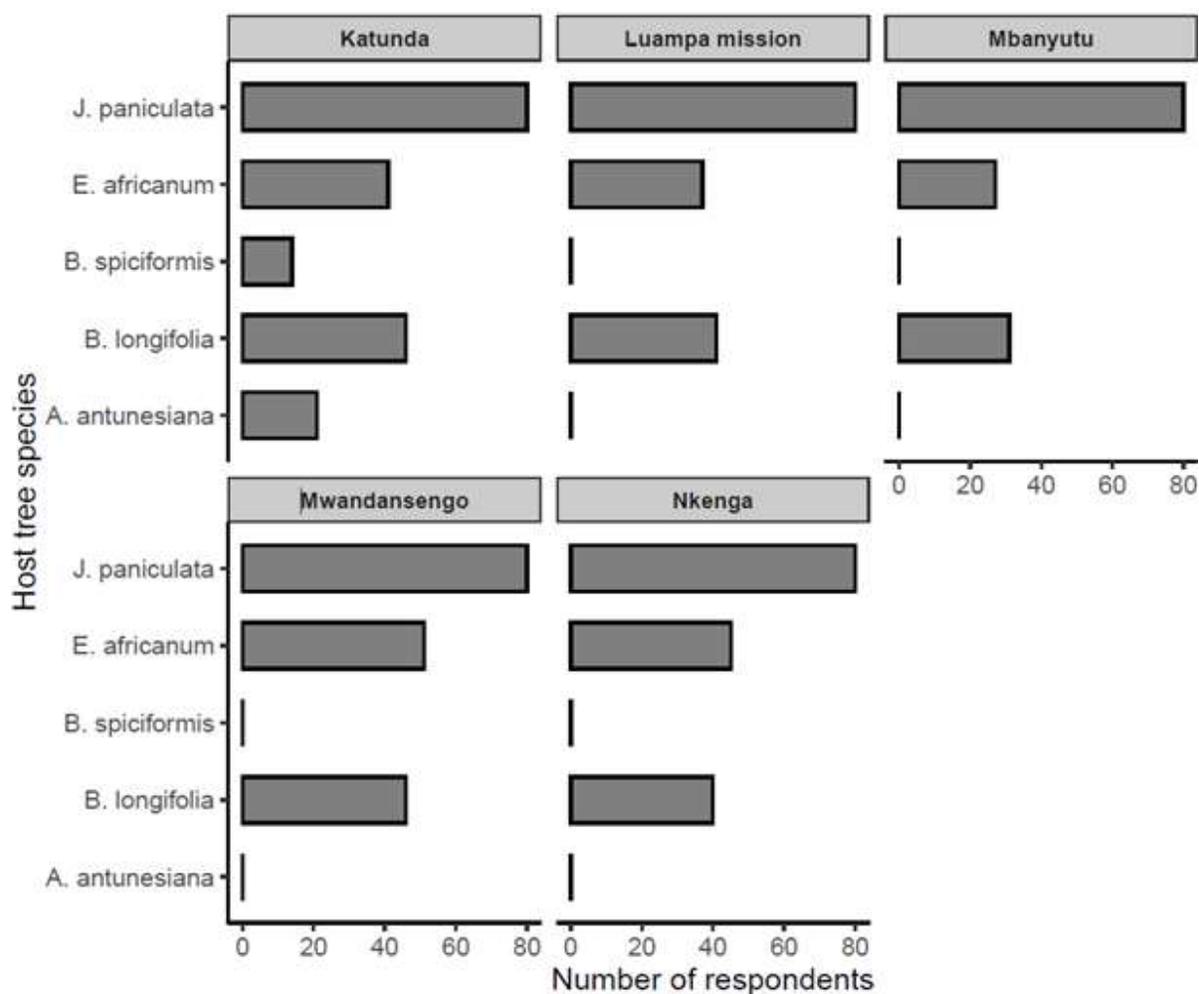
respectively. The proximate composition of three host tree species for *J. paniculata*, *E. africanum* and *B. longifolia* commonly found in all clusters are presented in Table 1. The highest content of moisture ( $11.62 \pm 0.02\%$ ) was found in *E. africanum* and the least amount ( $2.40 \pm 0.07\%$ ) was found in *J. paniculata*. Total ash also varied between tree species with the highest content ( $4.33 \pm 0.007\%$ ) observed in *J. paniculata*, and the least content ( $1.0 \pm 0.12\%$ ) observed in *E. africanum* (Table 1). The differences in moisture content and total ash observed between tree species was significant (Moisture content:  $F_{2,15} = 494.8$ ,  $p < 0.001$ , Total ash:  $F_{2,15} = 557.0$ ,  $p < 0.001$ , Table 2).

Crude protein content was significantly different among the top three plant species ( $F_{2,15} = 77.6$ ,  $p < 0.001$ , Table 2). *J. paniculata* had the highest crude protein content ( $12.44 \pm 0.07\%$ ) and the least content ( $0.31 \pm 0.19\%$ ) was found in *E. africanum* (Table 1). The observation that *J. paniculata* scored highest crude protein content was consistent across all clusters. The highest fat content ( $13.54 \pm 0.21\%$ ) was found in *E. africanum* and the least content ( $1.07 \pm 0.55\%$ ) was detected in *J. paniculata* across clusters (Table 1), and the differences across species was highly significant ( $F_{2,15} = 77.9$ ,  $p < 0.0001$ , Table 2). Furthermore, the highest content of carbohydrate ( $84.63 \pm 0.77\%$ ) was found in *B. longifolia* and the least content ( $66.94 \pm 0.29\%$ ) was detected in *E. africanum*. Although the least content of carbohydrate was found in *E. africanum*, this tree species significantly scored the highest energy content ( $427.66 \pm 1.22$  Kca/100 g) while *B. longifolia* was found to have the least energy content ( $366.78 \pm 2.48$  Kca/100 g) ( $F_{2,15} = 187.9$ ,  $p < 0.001$ , Table 2).

In fact, carbohydrate content negatively correlated with fat content ( $r = -0.61$ ) and energy ( $r = -0.59$ ) suggesting that carbohydrates decreased with fats and energy across tree species studied (Table 3). But fat content was highly correlated ( $r = 0.90$ ) with energy (Table 3) suggesting that fats were more important than carbohydrates for deducing the energy content in host tree species. Furthermore, protein content negatively correlated with moisture ( $r = -0.59$ ) and carbohydrates ( $r = -0.74$ ). But the strengths of the relation between protein and fat ( $r = 0.03$ ), protein and energy ( $r = 0.24$ ), protein and ash ( $r = 0.29$ ) were weak.

### Phytochemical analysis

Results for the qualitative analysis of phytochemicals of *J. paniculata*, *E. africanum* and *B. longifolia* leaf samples are presented in Table 4. Alkaloids and flavonoids were detected in all samples, suggesting that all three host tree species for *G. maja* contain alkaloids and flavonoids. Saponins and phenols were detected in *B. longifolia* and *E. africanum* but not in *J. paniculata*. The presence of



**Figure 2.** Indigenous people's observations per cluster on the preferred host tree species for edible caterpillars *Gyanisa maja* in western Zambia.

both saponins and phenols was strongest in *E. africanum* than in any other tree species tested (Table 4). Saponins were not the only phytochemicals that were absent in *J. paniculata*, phenols and steroids were also absent. But steroids were only detected in *B. longifolia* and *E. africanum*. Tannins were however, not detected in all three host tree species. Furthermore, different extraction methods produced different results. The extraction method based on ethanol did not detect saponins and phenols compared to the methanol-based method (Table 4), suggesting that methanol-based extraction method is a better method for detecting these phytochemicals than ethanol-based method.

## DISCUSSION

The proximate composition and phytochemical analysis

of host trees for the edible caterpillar, *G. maja*, in this study matches with local people's observation on the host preference of this caterpillar. This is so as the local people mentioned that when *G. maja* translocate to any other host tree species from *J. paniculata*, the caterpillar become stunted, changes in colour from greenish to brownish and also the taste is not as good as that of *G. maja* that completes its entire life cycle on *J. paniculata* (Chanda et al., 2020).

The relatively high level of total ash detected in *J. paniculata*, indicates that it is rich in minerals (Ogbe and Affiku, 2011) but the quantitative profiling of minerals in the preferred hosts is still not clear. The high protein and moderately low carbohydrate content were detected in *J. paniculata*. This is not surprising considering that tree species with high carbohydrate and fat contents are generally low in protein (Lykke and Padonou, 2019). The growth of insect larvae and the length of the larval stage

**Table 1.** Proximate composition of the preferred host tree species for *G. maja* expressed as mean  $\pm$ SD per cluster in western Zambia.

Cluster	Tree species	Moisture content (%)	Total ash (%)	Crude protein (%)	Total fat (%)	Carbohydrates (%)	Energy (kcal/100 g)
Katunda	<i>J. paniculata</i>	6.75 $\pm$ 0.33 <sup>a</sup>	3.74 $\pm$ 3.0 <sup>e-5</sup> <sup>a</sup>	2.51 $\pm$ 0.09 <sup>a</sup>	3.44 $\pm$ 0.02 <sup>a</sup>	83.56 $\pm$ 0.40 <sup>a</sup>	375.27 $\pm$ 1.46 <sup>a</sup>
	<i>B. longifolia</i>	9.13 $\pm$ 0.33 <sup>b</sup>	3.21 $\pm$ 0.13 <sup>b</sup>	1.44 $\pm$ 0.19 <sup>b</sup>	5.16 $\pm$ 0.03 <sup>b</sup>	81.07 $\pm$ 0.05 <sup>b</sup>	376.42 $\pm$ 0.63 <sup>a</sup>
	<i>E. africanum</i>	8.27 $\pm$ 0.18 <sup>b</sup>	1.82 $\pm$ 16 <sup>c</sup>	2.07 $\pm$ 0.09 <sup>a</sup>	7.65 $\pm$ 0.46 <sup>c</sup>	80.18 $\pm$ 0.35 <sup>b</sup>	397.88 $\pm$ 2.41 <sup>c</sup>
Luampa Mision	<i>J. paniculata</i>	7.21 $\pm$ 0.02 <sup>a</sup>	3.72 $\pm$ 0.31 <sup>a</sup>	12.44 $\pm$ 0.07 <sup>a</sup>	2.29 $\pm$ 0.10 <sup>a</sup>	74.34 $\pm$ 0.13 <sup>a</sup>	367.69 $\pm$ 1.67 <sup>a</sup>
	<i>B. longifolia</i>	10.13 $\pm$ 0.17 <sup>b</sup>	2.63 $\pm$ 0.41 <sup>a</sup> <sup>b</sup>	3.14 $\pm$ 0.12 <sup>b</sup>	3.56 $\pm$ 0.31 <sup>b</sup>	80.54 $\pm$ 0.20 <sup>b</sup>	366.78 $\pm$ 2.48 <sup>a</sup>
	<i>E. africanum</i>	7.45 $\pm$ 0.08 <sup>a</sup>	1.48 $\pm$ 0.14 <sup>b</sup>	11.69 $\pm$ 0.13 <sup>c</sup>	4.20 $\pm$ 0.07 <sup>b</sup>	75.18 $\pm$ 0.12 <sup>c</sup>	385.27 $\pm$ 0.59 <sup>c</sup>
Mwandansengo	<i>J. paniculata</i>	8.52 $\pm$ 0.05 <sup>a</sup>	3.16 $\pm$ 0.003 <sup>a</sup>	11.00 $\pm$ 0.13 <sup>a</sup>	4.40 $\pm$ 0.08 <sup>a</sup>	72.92 $\pm$ 0.003 <sup>a</sup>	375.28 $\pm$ 0.23 <sup>a</sup>
	<i>B. longifolia</i>	7.45 $\pm$ 0.20 <sup>b</sup>	3.06 $\pm$ 0.002 <sup>b</sup>	9.30 $\pm$ 0.18 <sup>b</sup>	7.23 $\pm$ 0.01 <sup>b</sup>	72.96 $\pm$ 0.37 <sup>a</sup>	394.11 $\pm$ 0.84 <sup>b</sup>
	<i>E. africanum</i>	8.41 $\pm$ 0.05 <sup>a</sup>	1.60 $\pm$ 0.003 <sup>c</sup>	9.52 $\pm$ 0.13 <sup>b</sup>	13.54 $\pm$ 0.21 <sup>c</sup>	66.94 $\pm$ 0.29 <sup>c</sup>	427.66 $\pm$ 1.22 <sup>c</sup>
Nkenga	<i>J. paniculata</i>	6.95 $\pm$ 0.01 <sup>a</sup>	3.60 $\pm$ 0.003 <sup>a</sup>	11.22 $\pm$ 0.06 <sup>a</sup>	2.95 $\pm$ 0.72 <sup>a</sup>	75.28 $\pm$ 0.67 <sup>a</sup>	372.51 $\pm$ 3.59 <sup>a</sup>
	<i>B. longifolia</i>	8.43 $\pm$ 0.01 <sup>b</sup>	2.04 $\pm$ 0.04 <sup>b</sup>	1.48 $\pm$ 0.12 <sup>b</sup>	3.42 $\pm$ 0.85 <sup>a</sup>	84.63 $\pm$ 0.77 <sup>b</sup>	375.21 $\pm$ 4.04 <sup>a</sup>
	<i>E. africanum</i>	11.62 $\pm$ 0.02 <sup>c</sup>	1.001 $\pm$ 0.12 <sup>c</sup>	0.31 $\pm$ 0.19 <sup>c</sup>	4.39 $\pm$ 0.35 <sup>a</sup>	82.69 $\pm$ 0.26 <sup>b</sup>	371.46 $\pm$ 1.36 <sup>a</sup>
Mbanyutu	<i>J. paniculata</i>	2.40 $\pm$ 0.07 <sup>a</sup>	4.32 $\pm$ 0.007 <sup>a</sup>	11.01 $\pm$ 0.12 <sup>a</sup>	1.07 $\pm$ 0.55 <sup>a</sup>	81.21 $\pm$ 0.75 <sup>a</sup>	378.46 $\pm$ 2.48 <sup>a</sup>
	<i>B. longifolia</i>	7.34 $\pm$ 0.006 <sup>b</sup>	3.35 $\pm$ 0.10 <sup>b</sup>	10.09 $\pm$ 0.06 <sup>b</sup>	6.84 $\pm$ 0.65 <sup>b</sup>	72.39 $\pm$ 0.68 <sup>b</sup>	391.43 $\pm$ 2.88 <sup>ab</sup>
	<i>E. africanum</i>	5.20 $\pm$ 0.33 <sup>c</sup>	1.38 $\pm$ 0.01 <sup>c</sup>	10.56 $\pm$ 0.12 <sup>a</sup>	6.99 $\pm$ 1.28 <sup>b</sup>	75.88 $\pm$ 1.09 <sup>b</sup>	408.64 $\pm$ 7.70 <sup>b</sup>

Different letters following data within the same columns indicate significant difference among nutrient in host plants at  $p < 0.05$  by Tukey's honestly significant difference (HSD) test.

are critically dependent on food quality particularly those that are rich in proteins, in fact, juvenile insects require relatively large amounts of protein in their diets (Speight et al., 2008). Low fat content in *J. paniculata* relative to *E. africanum* and *B. longifolia* also provide a potential reason why it is most commonly observed as a preferred host. Eigenbrode and Espelie (2019) highlighted that fats in plants play an important role as epicuticular lipids on plant surfaces. The physical structure of plant surface lipids may affect insect herbivore attachment, locomotion and deter oviposition and feeding.

The presence of phytochemicals (alkaloids and flavonoids) in the host trees in this study might also explain why the three species (*J. paniculata*, *E. africanum* and *B. longifolia*) seem to be preferred by the caterpillar. In fact, several studies have shown that although alkaloids play a role in chemical defence against insects, they also serve as precursors for biosynthesis of male courtship pheromone components (Ackery and Vane-Wright, 1984; Schulz, 1998; Lawson et al., 2021) which attracts females in most Lepidoptera as oviposition cue (Macel, 2011). Although, alkaloids are possibly used as a general cue to recognize host trees amongst other tree species, selection depends on other factors such as nutrients (Van der Meijden et al., 1989; Macel, 2011).

The presence of alkaloids and superior nutritional value of *J. paniculata* probably make this tree the most preferred among the trees studied. Similarly, flavonoids were observed in *J. paniculata* and these phytochemicals are crucial for pollen development and provide a visual and volatile cues to attract pollinators and seed dispersers (Dar et al., 2017).

Terpenoids were only observed in *J. paniculata* and its been reported that most monoterpenoids are volatile compounds, found mainly as components of essential oils (Schoonhoven et al., 2005), and some terpenoids act as chemo-attractants to herbivores (Boncan et al., 2020). Considering that terpenoids also function prominently in host location by herbivorous insects (Miller and Strickler, 1984; Visser, 1986; Niogret et al., 2011). It is well known that other phytochemicals such as saponins are not desirable to insects and trees with high content of saponins and tannins are more likely to be avoided as hosts by several insects including Lepidoptera (Adel et al., 2000; Singh and Kaur, 2018; Qasim et al., 2020). When ingested, saponins increase mortality levels by lowering food intake and affecting movement of food in the insect gut due to toxicity and lower digestibility (Adel et al., 2000; Singh and Kaur, 2018; Qasim et al., 2020). Among all host trees tested, *J. paniculata* was

**Table 2.** Analysis of variance showing the effect of tree species and clusters on the variation in proximate chemical content in preferred host plants for *Gyanisa maja* in western Zambia.

Proximate chemical content	Response	df	SS	MS	F-value	P-value
Moisture content	Tree species	2	1.07	0.54	494.84	<0.001
	Cluster	4	2.46	0.62	567.59	<0.001
	Tree species: Cluster	8	1.45	0.18	167.67	<0.001
	Residuals	15	0.02	0.001		
Total Ash	Tree species	2	0.90	0.45	556.97	<0.001
	Cluster	4	0.09	0.02	28.65	<0.001
	Tree species: Cluster	8	0.06	0.01	10.01	<0.001
	Residuals	15	0.01	0.001		
Crude protein	Tree species	2	0.88	0.44	77.560	<0.001
	Cluster	4	3.74	0.93	164.98	<0.001
	Tree species: Cluster	8	2.24	0.28	49.49	<0.001
	Residuals	15	0.08	0.01		
Total fat	Tree species	2	5.03	2.51	77.85	<0.001
	Cluster	4	3.01	0.75	23.29	<0.001
	Tree species: Cluster	8	2.45	0.31	9.47	0.001
	Residuals	15	0.48	0.03		
Carbohydrate	Tree species	2	23.30	11.65	45.09	<0.001
	Cluster	4	436.46	109.12	422.31	<0.001
	Tree species: Cluster	8	258.86	32.36	125.23	<0.001
	Residuals	15	3.88	0.26		
Energy	Tree species	2	0.004	0.002	187.92	<0.001
	Cluster	4	0.004	0.001	97.82	<0.001
	Tree species: Cluster	8	0.002	0.0002	24.45	<0.001
	Residuals	15	0.0002	0.00001		

df=degrees of freedom, SS=Sum of the Square, MS= Mean Squares.

**Table 3.** Correlation matrix on proximate composition of the most preferred host tree species of *G. maja* across all the clusters in western Zambia.

	Moisture	Ash	Protein	Fat	Carbohydrate	Energy
Moisture	1.00					
Ash	-0.49	1.00				
Protein	-0.59	0.29	1.00			
Fat	0.22	-0.49	0.03	1.00		
Carbohydrate	0.09	0.03	-0.74	-0.61	1.00	
Energy	-0.18	-0.44	0.24	0.90	-0.59	1.00

found with little or no saponins, this might be another reason why this host is preferred by *G. maja*. Furthermore, phenols were absent in *J. paniculata* but present in *B. longifolia* and *E. africanum*. This group of

phytochemicals in a tree act as protective agent and inhibitor against invading herbivores (Lattanzio et al., 2006; Dar et al., 2017). "These findings can provide a potential explanation for the fact that 100% respondents

**Table 4.** Presence and absence of phytochemicals in the most preferred host tree species for *Gynanisa maja* expressed as + for presence and – for absence per cluster in western Zambia.

Cluster	Tree species	Alkaloids		Flavonoids		Saponins		Tannins		Terpenoids		Phenols		Steroids	
		E	M	E	M	E	M	E	M	E	M	E	M	E	M
Katunda	<i>J. paniculata</i>	+	+	+	+	-	-	-	-	+	+	-	-	-	-
	<i>B. longifolia</i>	+	+	+	+	-	+	-	-	-	-	-	+	+	+
	<i>E. africanum</i>	+	+	+	+	-	++	-	-	-	-	-	++	+	+
Luampa Mission	<i>J. paniculata</i>	+	+	+	+	-	-	-	-	+	+	-	-	-	-
	<i>B. longifolia</i>	+	+	+	+	-	+	-	-	-	-	-	+	+	+
	<i>E. africanum</i>	+	+	+	+	-	++	-	-	-	-	-	++	+	+
Mwandansengo	<i>J. paniculata</i>	+	+	+	+	-	-	-	-	+	+	-	-	-	-
	<i>B. longifolia</i>	+	+	+	+	-	+	-	-	-	-	-	+	+	+
	<i>E. africanum</i>	+	+	+	+	-	++	-	-	-	-	-	++	+	+
Nkenga	<i>J. paniculata</i>	+	+	+	+	-	-	-	-	+	+	-	-	-	-
	<i>B. longifolia</i>	+	+	+	+	-	+	-	-	-	-	-	+	+	+
	<i>E. africanum</i>	+	+	+	+	-	++	-	-	-	-	-	++	+	+
Mbanyutu	<i>J. paniculata</i>	+	+	+	+	-	-	-	-	+	+	-	-	-	-
	<i>B. longifolia</i>	+	+	+	+	-	+	-	-	-	-	-	+	+	+
	<i>E. africanum</i>	+	+	+	+	-	++	-	-	-	-	-	++	+	+

- = Negative, + = Positive, ++ = Strong positive, E= Ethanol and M=Methanol.

in this study mentioned that *G. maja* larvae prioritise *J. paniculata* as a more preferred host than *E. africanum* and *B. longifolia*. This provides an opportunity to preserve this tree species so as to prevent *G. maja* from going into extinction which may have serious consequences on household food security particularly for the local people.

## Conclusion

The findings on indigenous knowledge on host

plants matched well with plant chemicals wherein chemical analyses provided a potential explanation why *J. paniculata* was observed as a primary host of the wild edible *G. maja* as it contained high amounts of total ash (rich in mineral content) and crude proteins but low-fat content. These are major nutrients that influence the selection of a host as they play an important role in the growth, development, and survival of herbivorous insects. In addition to nutrients, the phytochemical presence of alkaloids, flavonoids and terpenoids as well as the absence of tannins, saponins, phenols and in *J. paniculata*, also

supports the respondent's observation as these phytochemicals play significant role of repelling or attracting herbivorous insects such as *G. maja*. However, future studies should focus on profiling phytochemicals beyond detecting whether they are present or absent in order to enhance the chemical ecology of *G. maja*. It is evident that *J. paniculata* is the most preferred host tree for this caterpillar, this provides an opportunity to preserve this tree species so as to avoid sending *G. maja* into extinct which may have serious consequences on household food security particularly for the local people.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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