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Biogeographic Distribution and Host Specificity of Hymenopteran Parasitoids of Tephritids (Diptera) Infesting Mangoes in Cameroon, Central Africa

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Abstract

Tephritid fruit flies (Diptera) represent a major threat to mango production and food security across Sub-Saharan Africa. Up to date, the species diversity and ecological roles of their natural enemies remain underexplored. This study provides the first comprehensive analysis of hymenopteran parasitoid communities associated with tephritids infesting mangoes in two agroecological zones (AEZs) of Cameroon: the Sudano-Sahelian savannah (AEZ 1) and the High Guinean savannah (AEZ 2). From 2,795 mangoes sampled between 2020 and 2021 across seven orchards, a total of 27,654 tephritids (representing four species) and 1,008 parasitoids (belonging to six species from three families) adults emerged. A marked biogeographic partitioning of parasitoid communities was observed: Braconidae (*Fopius caudatus*, *Diachasmimorpha fullawayi*, *Psyttalia concolor*) were exclusively recorded in AEZ 1, particularly in the orchard of Lagdo which belong to the dry zone, whereas Figitidae (*Ganaspis* sp., *Ealata saba*) and Diapriidae (*Trichopria* sp.) dominated in the more humid AEZ 2 orchards. Notably, *Ganaspis* sp. was found in both AEZs. Host specificity varied: *Ganaspis* sp. and *Trichopria* sp. exhibited a broad host range, primarily parasitizing *Bactrocera dorsalis*, while *E. saba* showed a high specificity for *Ceratitis cosyra*. Importantly, the exotic parasitoid *Fopius arisanus*, previously introduced as a biological control agent, was not detected.

Parasitism rates were high in cultivar with thin pericarp (e.g., 'Palmer'). However, in Djefatou and Ngong (AEZ 1), premature fruit harvesting for livestock feed limited parasitism assessment, as fruits were removed from the orchards before parasitoid infestation could occur. These findings underscore the importance of managing indigenous parasitoids through the selection of suitable ecological conditions and plant resources. Indeed, elucidating host-parasitoid dynamics, as demonstrated in this study, could support the development of practical and sustainable strategies for mango pest management in Central Africa.

Keywords

Mango-Infesting Tephritids, Agroecological Zone, Parasitoid Diversity, Host-Parasitoid, Cameroon

1. Introduction

Mango (*Mangifera indica* L.; Sapindales: Anacardiaceae), the third most cultivated fruit crop worldwide after banana and pineapple [1], is an essential resource for food security and livelihoods, particularly in rural areas of Sub-Saharan Africa. Smallholder farmers, who account for over 90% of total production, depend on mango cultivation for both income and nutrition [2] [3]. Cameroon, one of the leading mango producers in Central Africa, produced approximately 891,000 tons in 2023 [4], supported by a rich diversity of cultivars [5].

However, tephritid fruit flies (Diptera), particularly the invasive species *Bactrocera dorsalis* Hendel and native *Ceratitis* species, pose a major threat to mango yield and commercial quality [3] [6]-[12]. In orchards lacking pest management practices, fruit losses can exceed 50% due to high infestation levels [13] [14]. Female preferentially oviposit in ripening fruits, where larval development within the pulp renders the fruit unmarketable, leading to serious phytosanitary restrictions on exports [15] [16].

Current management strategies for tephritids largely rely on the use synthetic insecticides, field sanitation through the burial or incineration of attacked fruits, male lures, and protein baits [16]-[18]. However, the excessive use of chemical pesticides leads to environmental contamination, exposes farmers and the general population to health risks, causes mortality of non-target organisms, and promotes the development of insecticide resistance, highlighting the need for more ecologically sound and sustainable alternatives [19] [20]. Biological control, particularly through hymenopteran parasitoids, represents a promising solution within the framework of Integrated Pest Management (IPM), as it reduces pest populations while maintaining ecosystem balance [21]-[23].

Parasitoids belonging to the families Braconidae, Figitidae, Eulophidae, and Diapriidae target the immature stages of tephritids to ensure the continuation of their lineage. Through this interaction, they provide essential ecosystem services of natural regulation in fruit orchards [7] [24] [25]. For instance, the Asian parasitoid *Fopius arisanus* (Sonan), introduced to Hawaii, has led to the long-term suppression of *B. dorsalis* populations [26] [27], and has been successfully established in parts of East Africa [28] [29], Central Africa [30], and West Africa [31], offering a promising biological control strategy against this invasive pest. In contrast, indigenous parasitoids such as *Fopius caudatus* Szépligeti, *Diachasmimorpha fullawayi* Silvestri, and *Psyttalia cosyra* (Wilkinson) exhibit host-specific associations with *Ceratitis* spp. in West Africa [25] [32]-[34], although their ecological roles in Central Africa remain poorly studied.

Despite efforts by Cameroon to address the issue of tephritids [4], the species diversity and ecological dynamics of parasitoid communities associated with these pests remain poorly documented. To fill these knowledge gaps, the present study aims to characterize hymenopteran parasitoid wasps across two agroecological zones (AEZs), with the following objectives: (i) to identify the species composition and biogeographical distribution of parasitoids across AEZs; (ii) to assess their host specificity and their interactions with the main tephritid species and; (iii) to analyse the influence of mango cultivar type and anthropogenic practices, such as premature fruit harvesting, on parasitism rates.

2. Materials and Methods

2.1. Study Area

The study was conducted in mango orchards across two agroecological zones (AEZs) of Cameroon: the Sudano-Sahelian Savannah (AEZ 1) and the High Guinea Savannah (AEZ 2) [7]. These AEZs differ significantly in terms of altitude, climate, and dominant vegetation as documented in previously studies [7], thus providing a relevant ecological context for assessing the biological and ecological diversity of parasitoids and the biogeographic host-parasitoid associations.

AEZ 1 is characterized by a dry climate, with an average annual temperature of 28˚C, a prolonged dry season lasting seven months (from mid-November to mid-May), annual rainfall ranging from 500 to 900 mm, and altitudes between 250 and 500 meters above sea level [35]. The orchards studied in this zone included Mbé (E 13˚36'949"; N 7˚50'743"; 590 m), Ngong (E 13˚31'956"; N 9˚03'149"; 290 m), Lagdo (E 13˚40'985"; N 9˚04'138"; 200 m), and Djefatou (E 13˚31'452"; N 9˚09'434"; 260 m). All these orchards are located near areas of intensive cucurbit cultivation. At the time of the study, the vicinity of Mbé orchard experienced frequent pesticide use. The Djefatou and Ngong orchards were subjected to high anthropogenic pressure, particularly due to the systematic collection of attacked fruits for livestock feed.

AEZ 2 has a humid climate, with an average annual temperature of 23˚C, a prolonged rainy season from April to November, annual rainfall ranging from 1,500 to 1,800 mm, and altitudes between 500 and 1,500 meters above sea level [35]. The orchards selected in this zone included Malang (E 13˚32'948"; N 7˚27'233"; 1110 m) and Manwi (E 13˚32'835"; N 7˚22'760"; 1100 m), both characterized by seminatural vegetation and low pesticide use in the surrounding areas, as well as Marza (E 13˚35'227"; N 7˚16'290"; 1100 m), which presented conditions similar to those observed in Mbé. Orchard selection was based on mango production intensity, the absence of pesticide use, cultivar diversity, and documented history of tephritid infestation.

2.2. Fruit Collection and Sampling

Biweekly sampling was conducted during two mango fruiting seasons (2021-2022). A total of 2,795 fruits were collected from 26 cultivars, including 17 commercial cultivars: Alphonso, Alphonso Hawai, Amélie, Brooks late, Eldon, Ruby, Sabot, Julie, Valencia, Smith, Palmer, Kent, Keitt, Ifack 1, Ifack 5 Haden, Tommy Atkins and 9 local cultivars.

Fruits showing signs of tephritid infestation, such as oviposition punctures, larval exit holes, or premature fruit drop, were randomly sampled both from tree branches and the ground. To ensure cultivar representativity, 5 to 10 fruits per cultivar were collected during each sampling date, depending on fruit availability. Each fruit was labeled, assigned a reference code, and transported to the Laboratory at the Applied Zoology (LAZOA) at the University of Ngaoundéré for incubation and further analysis.

2.3. Fruit Incubation and Insect Emergence

Each sampled fruit was placed in a transparent plastic incubation box containing oven-sterilized sand, to facilitate larval pupation, and covered with a fine mesh screen to allow gas exchange while preventing the escape of emerging insects. One week after incubation, the pupae formed in each box were regularly collected, transferred to new incubation containers, and monitored until adult emergence [36]. Emerging tephritids and parasitoids were counted, sorted into morphospecies, and preserved in 70% ethanol for identification.

2.4. Taxonomic Identification

The tephritid specimens obtained were identified to the species level using morphological keys appropriate for economically important species [37]. These identifications were confirmed by Dr. Marc De Meyer of the Royal Museum for Central Africa (RMCA) in Tervuren, Belgium.

The parasitoids were identified, some to the species level, using a dichotomous key [38] and the online database by Wharton and Yoder, available at: http://paroffit.org. Identifications were verified by experts from the French Agency for Food, Environmental and Occupational Health and Safety (ANSES) in Montpellier, France.

Voucher specimens are preserved in 70% ethanol at LAZOA.

2.5. Data Analysis

2.5.1. α-Diversity

Parasitoid species abundance was assessed using the index of Dajoz [39], based on the relative abundance (p_i), calculated as follows:

$$p_i = \frac{n_i}{\sum n_i}$$

where n_i is the number of individuals of a given parasitoid species or hymenopteran wasp family, and $\sum n_i$ is the total number of individuals in the community. The value of p_i was classified as follows:

- most abundant if $p_i \geq 50\%$;
- abundant if $25\% \leq p_i < 50\%$;
- less abundant if $1\% \leq p_i < 25\%$, and;
- scarce if $p_i < 1\%$.

This classification was visualized using a heatmap. Color gradients (YlOrRd palette) were scaled from 0% to 100% to reflect dominance within the parasitoid community across the surveyed orchards.

Parasitoid species richness and diversity were assessed using three commonly applied ecological indices: the Shannon-Wiener index (H'), the Simpson index (1 – D), and Pielou's Evenness index (J').

The Shannon-Wiener index measures species diversity by incorporating both species richness and relative abundance. It is calculated as:

$$H' = -\sum_{i=1}^{N} pilnpi$$

The Shannon index ranges from 0 (low diversity) to ln(S) (maximum diversity); $0 \leq H' \leq \ln(S)$.

The Simpson index measures the probability that two individuals randomly selected from a sample belong to different species. It is calculated as:

$$D = \frac{1}{\sum p_i^2}$$

and expressed as $1 - D$, where higher values indicate greater diversity, while values closer to 0 reflect dominance by one or a few species.

Pielou's Evenness index quantifies the uniformity of individual distribution across species. It is derived from the Shannon-Wiener index and calculated as:

$$J' = \frac{H'}{\ln S}$$

where H' is the Shannon-Wiener index and S is species richness. Values of J' range from 0 to 1, with values near 1 indicating a more even species distribution.

2.5.2. *β*-Diversity

Community similarity between AEZs and orchards was assessed using the Jaccard similarity index, which quantifies the proportion of species shared between two sites. The index was calculated as follows:

$$J(A,B) = \frac{a}{a+b+c};$$

where:

- a is the number of species shared by both orchards A and B;

- *b* is the number of species present only in orchard A and;
- *c* is the number of species present only in orchard B.

Jaccard values range from 0 (no shared species) to 1 (identical species composition). The resulting similarity matrix was visualized as a heatmap to reveal patterns of community clustering. Color gradients (YlOrRd palette) were scaled from 0% (low similarity) to 100% (high similarity).

2.5.3. Parasitism Rate

Parasitism rate, expressed as a percentage (%), was calculated as the proportion of parasitoids that emerged from a fruit relative to the total number of emerged individuals (parasitoids + tephritids) [40]. Parasitism rates were compared across AEZs, orchards, and cultivars. Means were separated using Tukey's HSD post hoc test at a significance level of $\alpha = 0.05$.

2.5.4. Host Specificity

Host-parasitoid associations were recorded when individuals of a single parasitoid species and a tephritid host emerged from the same incubation box. These associations were visualized using heatmaps generated with Python libraries (*matplotlib* and *seaborn*), where relative parasitoid abundance (*pi*) was standardized by host species. Color gradients (YlOrRd palette) were scaled from 0% to 100% to reflect the intensity of parasitism. These visualizations highlighted the ecological dominance of parasitoid species across AEZs and tephritid hosts.

2.5.5. Software and Packages Used

All analyses were performed using both R (version 4.3.0) for statistical and ecological computations (*vegan*, *ggplot2*, *agricolae*) and Python (v3.9) for data manipulation and visualization (*pandas*, *scipy*).

3. Results

3.1. Composition of Tephritids and Their Associated Parasitoids Collected from Attacked Mangoes

From a total of 2,795 attacked mango fruits, collected from 26 cultivars across seven orchards located in agroecological zones (AEZs) 1 and 2, yielded 27,654 tephritids and 1,008 parasitoids (Supplementary Materials 1 and 2).

The tephritid community comprised four species, with *Ceratitis cosyra* being dominant in AEZ 1 and *Bactrocera dorsalis* in AEZ 2 (Supplementary Materials 1 and 2).

The parasitoids recovered belonged to three hymenopteran families: Braconidae, Figitidae, and Diapriidae, and represented a total of six species (**Figure 1**).

3.2. Parasitoid Richness and Biogeographic Distribution

In the orchards of Lagdo (AEZ 1) and Malang (AEZ 2), three parasitoid species emerged from mango fruits infested by tephritis. The orchard of Manwi (AEZ 2) yielded two species, while only one species was recorded at Marza (AEZ 2) and

Mbé (AEZ 1) (**Figure 1**). In contrast, at Djefatou and Ngong (AEZ 1), premature harvesting of fruits for livestock feeding resulted in a complete absence of tephritid parasitism, despite high levels of fruit fly emergence (Supplementary Material 1).

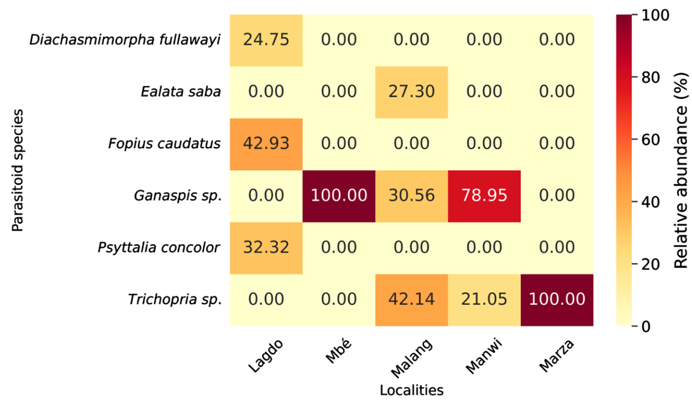

Figure 1. Abundance distributions (%) of six parasitoid species attacking tephritids across five orchards in the agroecological zones 1 and 2 of Cameroon, during two years 2021-2022.

Marked differences were observed between the parasitoid communities of the two AEZs. AEZ 1 was dominated by the Braconidae family, with the exclusive presence in Lagdo of *Fopius caudatus* (**Figure 2(a)**), *Diachasmimorpha fullawayi* (**Figure 2(b)**), and *Psyttalia concolor* (**Figure 2(c)**). In contrast, AEZ 2 was characterized by the presence of Figitidae, represented by *Ganaspis* sp. (**Figure 2(d)**) and *Ealata saba* (**Figure 2(e)**), as well as Diapriidae (*Trichopria* sp., **Figure 2(f)**). According to the Dajoz index, *Ganaspis* sp. emerged as the most abundant and broadly distributed parasitoid species across both AEZs.

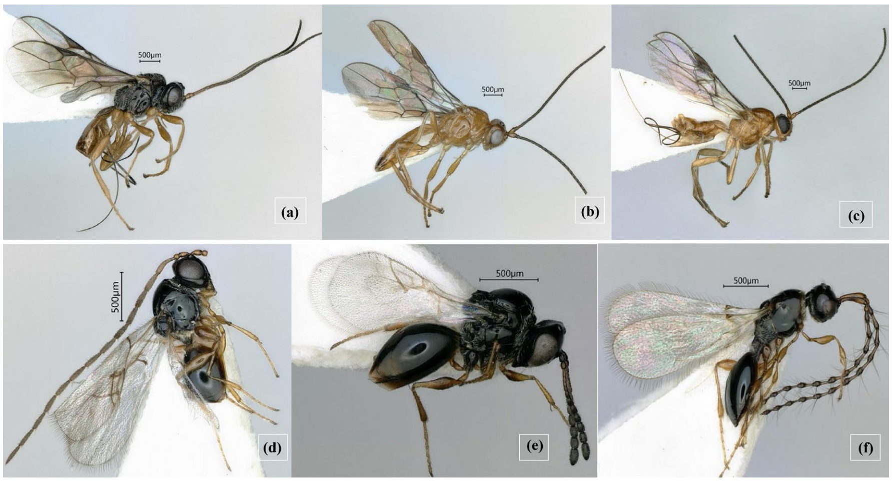

Figure 2. Six parasitoid species associated with mango infesting-tephritids collected during two years 2021-2022, in the agroecological zones 1 and 2 of Cameroon: *Fopius caudatus* (a), *Diachasmimorpha fullawayi* (b), *Psyttalia concolor* (c), *Ganapsis* sp (d), *Ealata saba* (e) and *Trichopria* sp. (f).

3.3. Diversity Indices between Orchards

The orchards of Lagdo and Malang exhibited the highest species diversity, reflecting a balanced abundance among the collected parasitoid species (**Figure 3**). Furthermore, in these orchards, evenness values were close to 1, while Shannon-Wiener index values approached maximum diversity (**Figure 3**), indicating an equitable distribution of parasitoid species. In contrast, the orchards of Marza and Mbé showed near-zero diversity (**Figure 3**), due to extreme dominance (100% of the abundance) by *Trichopria* sp. and *Ganaspis* sp., respectively (**Figure 1**).

The Jaccard similarity index between the two agroecological zones was low (> 0.5), indicating distinct community compositions between AEZs (**Figure 4**).

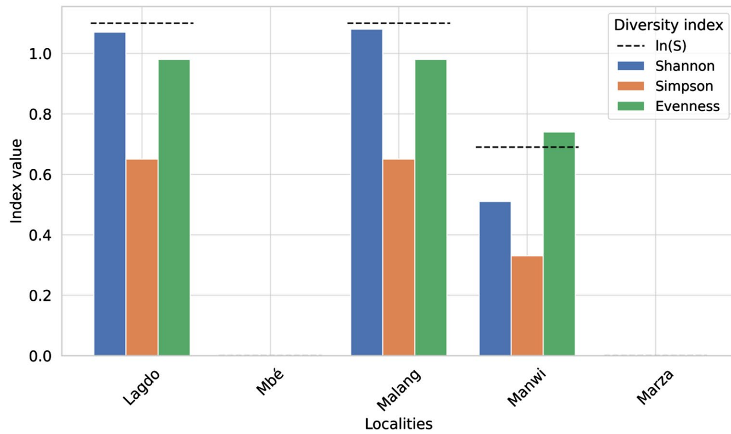

Figure 3. Diversity indices of parasitoid communities across five orchards in the agroecological zones 1 and 2 of Cameroon, during two years 2021-2022.

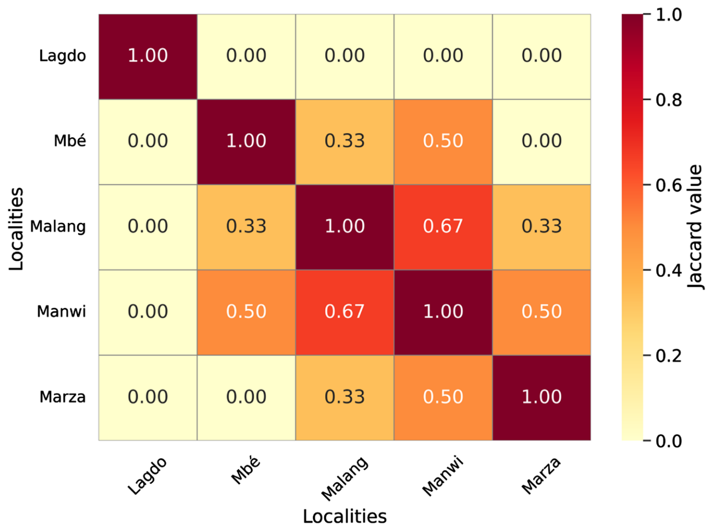

Figure 4. Jaccard similarity heatmap of parasitoid community across five orchards situated in the agroecological zones 1 and 2 of Cameroon, during two years 2021-2022.

3.4. Evaluation Parasitism Rates

Overall parasitism rates did not vary significantly between AEZs (**Figure 5(A)**) or between orchards (**Figure 5(B)**). However, notable differences were observed depending on the mango cultivar.

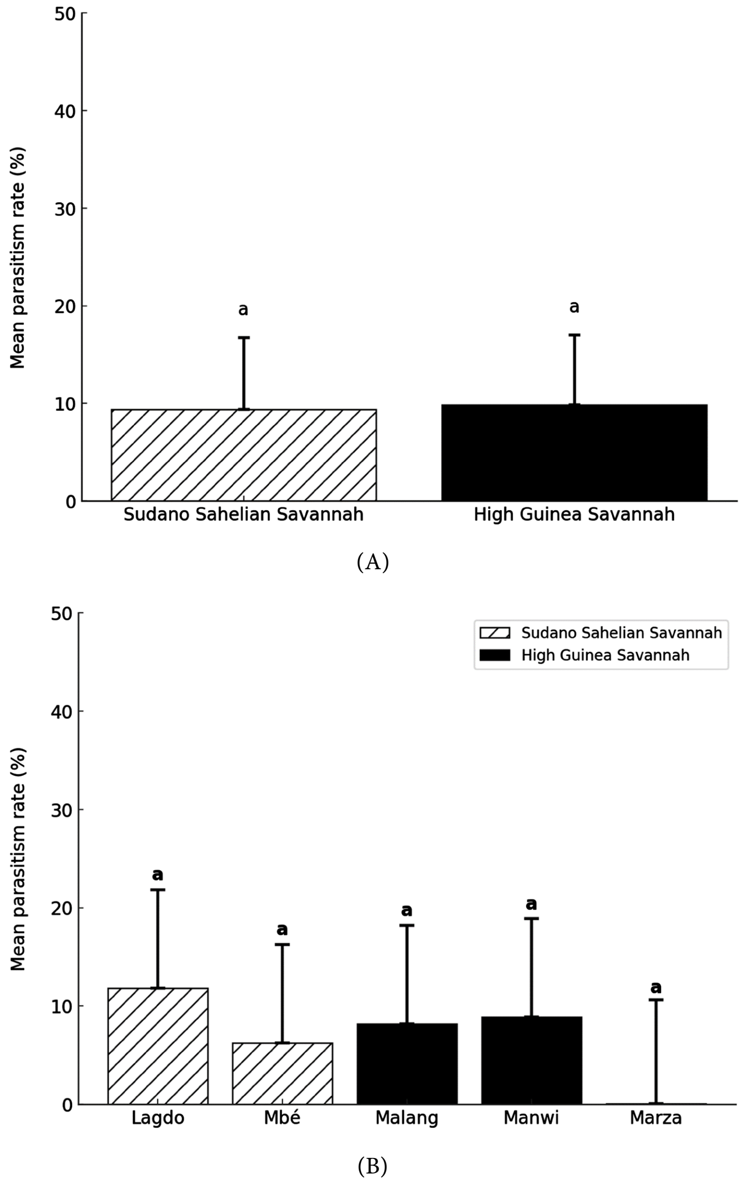

Figure 5. Parasitism rate of Hymenopteran parasitoids infesting mango tephritids in two AEZs (A) and five orchards (B) in Cameroon, during two years 2021-2022. Bars with the same letter indicate means are not statistically different at $P < 0.05$.

At Lagdo, the Palmer cultivar, characterized by a thin and soft pericarp, exhibited the highest parasitism rate ($F = 3.14$; $df = 3$; $p = 0.04$), which may be explained by greater accessibility of tephritid larvae to the parasitoid ovipositor. In contrast, cultivars with a thick pericarp, such as Kent and Smith, recorded the lowest parasitism rates (**Figure 6(A)**). In the Malang and Manwi orchards, no significant differences in parasitism rates were observed (**Figure 6(B)** and **Figure 6(C)**).

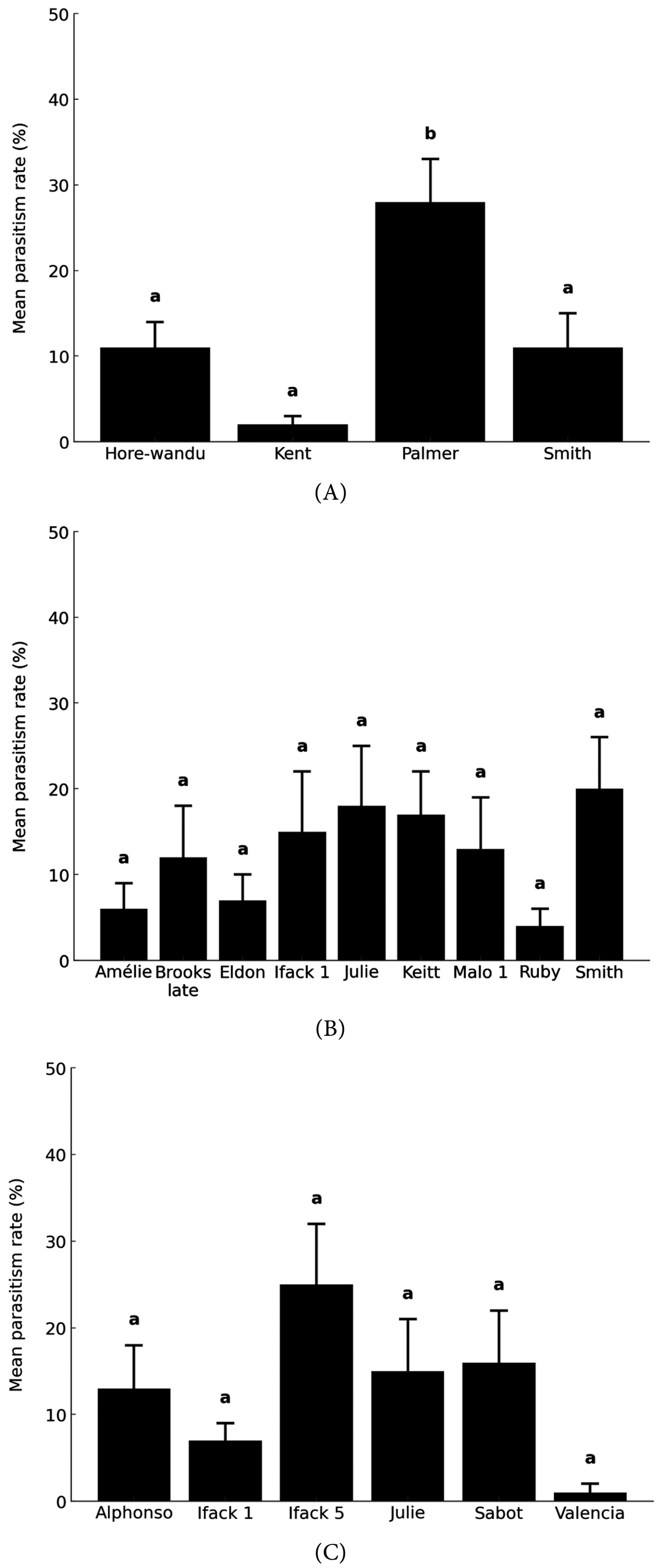

Figure 6. Parasitism rate of Hymenopteran parasitoids infesting tephritids on four, nine and six mango cultivars at Lagdo (A), Malang (B), and Manwi (C) locations respectively, during two years 2021-2022. Bars with different letters indicate that means are significantly different at $p < 0.05$.

3.5. Host Specificity in Parasitoid Community

Heatmap analysis revealed distinct host preferences. Generalist species *Ganaspis* sp. and *Trichopria* sp., parasitized multiple hosts, primarily *B. dorsalis* and, to a lesser extent, *Ceratitis* species, particularly at Malang and Manwi (**Figure 7**). *Ealata saba* showed a strong association with *C. cosyra* and a low occurrence on *B. dorsalis* at Malang (**Figure 7**), suggesting a higher level of host specificity. Additionally, *F. caudatus*, *D. fullawayi*, and *P. concolor* were predominantly associated with *C. cosyra* and, to a lesser extent, with *B. dorsalis* at Lagdo.

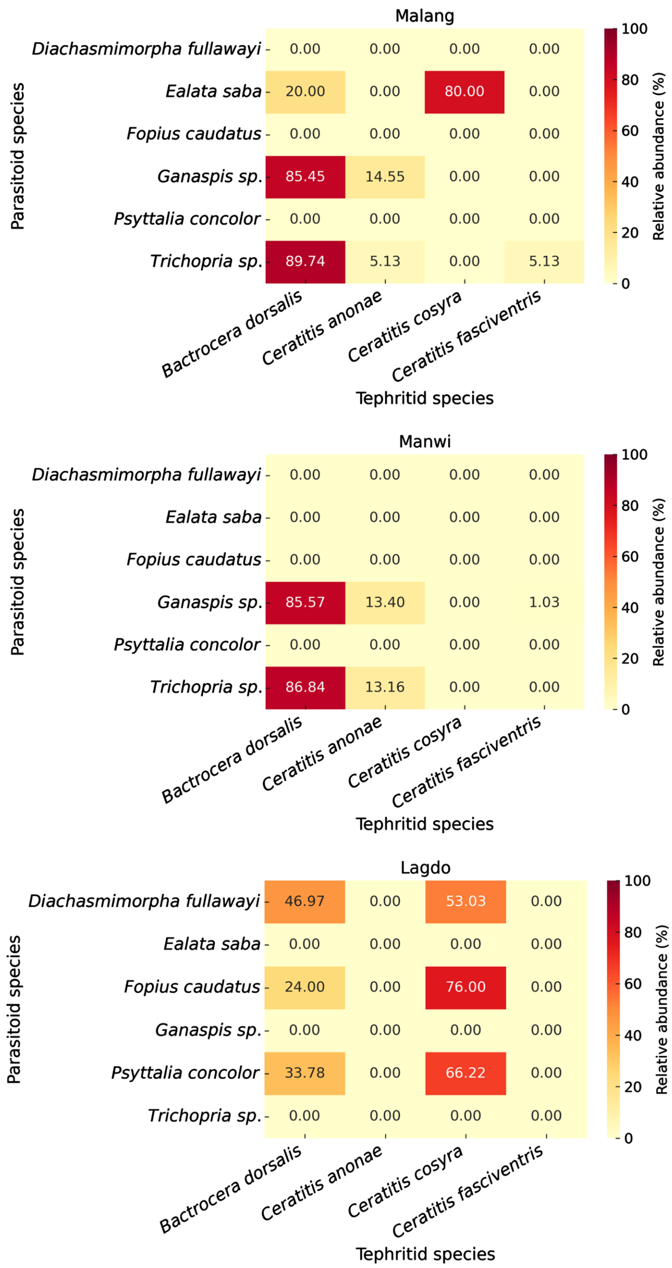

Figure 7. Host-parasitoid heatmaps of relative abundance across three orchards in Cameroon, during two years 2021-2022.

4. Discussion

Parasitoid communities associated with tephritids infesting mangoes in Sub-Saharan Africa remain understudied, despite their critical role in natural pest regulation of indigenous and introduced pest species. Our findings reveal pronounced differences in parasitoid communities consisting of six species across three Hymenopteran families, between seven orchards distributed in Cameroon's AEZ 1 and 2. These differences could be driven by tephritid host dominance and specificity, climatic gradients, and cropping systems [24] [25] [40]. In addition to these factors, pest management practices and human activities, such as collecting fallen fruits to feed animals instead of leaving them to rot, can have a significant impact on parasitoid abundance.

Previous studies in the same orchards reported differences in the dominance of two major mango pests: *Ceratitis cosyra* and *Bactrocera dorsalis* in Cameroon's AEZ 1 and AEZ 2 respectively [7]. Moreover, a clear biogeographic pattern emerged, with three braconid wasp species: *Fopius caudatus*, *Diachasmimorpha fullawayi*, and *Psyttalia concolor,* restricted to the orchard of Lagdo (AEZ 1). These parasitoids were documented on these tephritids, reflecting co-evolved trophic relationship similar to other African ecosystems [24] [25] [34] [41]-[43]. Their preference for *C. cosyra* aligns with its dominance (> 90%) in drier environments characteristic of Lagdo [7], in which temporal synchrony and host fruit volatiles provided a stable ecological niche [32] [44] [45]. The absence of these parasitoids in AEZ 2 aligns with reduced occurrence of *C. cosyra*, likely due to more diversified agroecologies, underscoring the critical role of host dominance in shaping parasitoid abundance distribution [46]. These findings highlight the potential of targeted parasitoid conservation in AEZ 1 to enhance *C. cosyra* biological control, reducing reliance on chemical insecticides [33], while captive breeding and periodic releases could further strengthen these efforts.

Additionally, the location of Lagdo is known for extensive cucurbit cultivation, potentially creating an ecological overlap between mango and cucurbit hosts. However, the dominant braconid wasp *Psyttalia perproximus* commonly associated with *Dacus* spp. in cucurbit systems in Cameroon's AEZ 4 and AEZ 5 [40], appears to have a more limited impact in mango systems [42]. This may be due to differences in host immune responses, duration of life cycle, or habitat preferences [33] [47] [48]. These contrasts emphasize the importance of crop-specific biological control strategies, for which conservation of native braconids in mango systems and targeted augmentation in cucurbit systems was reported to enhance pest suppression [33] [49] [50].

The absence of the exotic parasitoid *Fopius arisanus*, despite intentional releases in Cameroon at Nkolbisson (AEZ 5) [49] [50], contrasts with its establishment in other countries like Benin [31], Kenya [29], and Senegal [44]. This discrepancy suggests possible climatic incompatibility or competitive exclusion by native parasitoids, reinforcing the importance of prioritizing locally adapted biological control strategies. Additional factors such as market routes, seasonal variations, wind patterns, and surrounding vegetation may influence parasitoid dispersal.

In AEZ 2 characterized by humid environments (e.g., Malang and Manwi orchards), figitid and trichoprid parasitoids were exclusively recorded. The broad host range of *Ganaspis* sp. and *Trichopria* sp., primarily targeting *B. dorsalis* in this study, positions them as promising biocontrol agents for this invasive pest [25], and for other tephritids like *Ceratitis capitata*, *Ceratitis anonae* and *Dacus ciliatus* [41]. The absence of these parasitoids in AEZ 1, despite the presence of *B. dorsalis*, likely reflects the complex interplay between host availability, microclimate, and parasitoid life history traits.

Our results underscore the importance of integrating mango cultivar selection particularly favoring thin-pericarp, locally adapted varieties into IPM strategies to enhance natural pest control. However, this approach should be accompanied by a comprehensive evaluation of its socioeconomic and environmental implications within local agricultural systems. Notably, the Palmer cultivar, characterized by its thin pericarp, supported higher rates of parasitism, likely due to improved access for parasitoid ovipositors to host larvae [51] [52]. In contrast, firmer cultivars such as Smith and Kent exhibited lower parasitism levels. These observations are consistent with previous research highlighting the role of fruit physical and chemical properties in shaping parasitoid foraging behavior [51].

However, the absence of parasitoid in Djefatou and Ngong (AEZ 1) may stem from early fruit removal for livestock feeding. Thus, by removing infested fruits before parasitoids complete development, farmers inadvertently disrupt a critical ecosystem service. Whereas augmentoria could mitigate this, their efficacy depends on delayed sanitation to allow parasitoid emergence [53]-[55], highlighting the need to harmonize hygiene practices with biocontrol objectives.

Parasitoid diversity varied markedly across sites. Marza and Mbé, characterized by geographic isolation and high anthropogenic disturbance hosted depauperate communities dominated by a single species. Conversely, Malang and Manwi, embedded in interconnected natural landscapes, supported richer and more balanced assemblages. This underscores the importance of habitat connectivity and reduced anthropogenic pressure in sustaining parasitoid diversity.

5. Conclusion

The observed parasitoid community structure reflects a mosaic of generalist and specialist strategies shaped by host availability, microclimate, and anthropogenic factors. The prominence of indigenous species underscores the potential of conservation biological control through habitat management, pesticide reduction, and cultivar selection, over reliance on exotic introductions. Future research could be focused on prioritize molecular characterization of key species, long-term monitoring of introduced parasitoids, and field evaluations of local species' efficacy. Such efforts will refine strategies to enhance parasitoid-mediated pest regulation in mango agroecosystems, ensuring sustainable pest management across

Central Africa.

Data Available Statement

The data that supports the finding of this study are available from the corresponding author upon reasonable request.

Author Contributions

Ndakabo Atougour: data curation; investigation; methodology; writing-original draft. **Mokam Didi Gaëlle:** conceptualization; data curation; investigation; data analysis; visualization; supervision; writing-review and editing. **Ayuka T. Fombong:** visualization; review and editing. **Shepard Ndlela:** review and editing. **Awono Ezéchiel:** data collection and methodology. **Samira Mohamed:** review and editing. **Sunday Ekesi:** review and editing. **Djieto-Lordon Champlain:** conceptualization; supervision; visualization; writing-review and editing. **Aléné Désirée Chantal** and **Ngakou Albert**: visualization, writing, and editing

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Supplementary Table 1. Abundance distribution and occurrence of mango tephritids and associated parasitoids in the Sudano Sahelian Savannah agroecological zone of Cameroon from 2020 to 2022.

Localities	Mango's cultivars	Nb. fr. att.	Ab. Tephri + Para. spp.	*Bactrocera dorsalis*		*Ceratitis cosyra*		*Ceratitis fasciventris*		D. *fullawayi*		*Fopius caudatus*		*Ganaspis* sp.		*Psyttalia concolor*	
				Ab.	Oc.	Ab.	Oc.	Ab.	Oc.	Ab.	Oc.	Ab.	Oc.	Ab.	Oc.	Ab.	Oc.
Djefatou	Amélie	28	130	0	0	100	100	0	0	0	0	0	0	0	0	0	0
	Eldon	28	496	0	0	100	100	0	0	0	0	0	0	0	0	0	0
	Hore-wandu	33	391	0	0	100	100	0	0	0	0	0	0	0	0	0	0
	Ifack 1	30	135	0	0	100	100	0	0	0	0	0	0	0	0	0	0
	Julie	29	322	14.60	27.58	85.40	93.10	0	0	0	0	0	0	0	0	0	0
	Kent	70	1157	4.93	11.42	95.07	98.57	0	0	0	0	0	0	0	0	0	0
	Malo 2	30	339	0	0	100	100	0	0	0	0	0	0	0	0	0	0
	Smith	35	1267	18.94	65.71	81.06	77.14	0	0	0	0	0	0	0	0	0	0
	var. locale	40	289	0	0	100	100	0	0	0	0	0	0	0	0	0	0
Lagdo	Amélie	35	212	19.34	22.85	80.66	80	0	0	0	0	0	0	0	0	0	0
	Hore-wandu	75	874	9.15	37.33	82.84	80	0	0	0.69	5.33	4	13.33	0	0	3.32	16
	Kent	69	710	8.03	21.73	91.69	84.06	0	0	0	0	0.28	1.45	0	0	0	0
	Palmer	40	865	12.02	37.5	75.14	87.50	0	0	4.51	27.5	5.55	35	0	0	2.77	27.5
	Smith	36	250	34.40	58.33	59.60	55.56	0	0	1.60	5.56	0	0	0	0	4.40	11.11
Mbé	Alphonso Hawai	25	359	7.80	32	92.20	100	0	0	0	0	0	0	0	0	0	0
	Eldon	104	748	5.75	9.61	94.25	93.27	0	0	0	0	0	0	0	0	0	0
	Haden	40	187	0	0	98.40	97.50	0	0	0	0	0	0	1.60	2.5	0	0
	Ifack 1	39	350	0	0	93.43	92.31	0	0	0	0	0	0	6.57	7.69	0	0
	Julie	70	614	5.37	10	94.63	97.14	0	0	0	0	0	0	0	0	0	0
	Malo 1	40	205	0	0	100	100	0	0	0	0	0	0	0	0	0	0
	Malo 2	40	401	31.67	70	68.33	65	0	0	0	0	0	0	0	0	0	0
	Smith	70	816	18.26	47.14	81.74	90	0	0	0	0	0	0	0	0	0	0
	var. ind 2	40	179	0	0	100	100	0	0	0	0	0	0	0	0	0	0
	var. locale	40	238	13.03	25	86.97	87.50	0	0	0	0	0	0	0	0	0	0
Ngong	Greffé 1	50	451	9.09	20	90.91	86	0	0	0	0	0	0	0	0	0	0
	Greffé 2	45	235	86.38	88.88	13.19	17.78	0.43	2.22	0	0	0	0	0	0	0	0
	Julie	94	879	11.72	23.40	88.28	85.11	0	0	0	0	0	0	0	0	0	0
	Smith	30	395	6.84	26.66	93.16	93.33	0	0	0	0	0	0	0	0	0	0
	var. locale	48	307	0	0	100	100	0	0	0	0	0	0	0	0	0	0
Total	(16)	1353	13801	10.94	21.90	87.83	88.31	0.01	0.08	0.23	1.32	0.34	1.72	0.28	0.35	0.36	1.88

Note: Nb. fr. att. = Number of mango's cultivars attacked by tephritids; Ab. Tephri.+ Para. spp. = Abundance of tephritids and their associated parasitoids reared on mango's cultivars attacked by tephritids; Ab = Abundance; Oc = Occurrence; D. *fullawayi* = *Diachasmimorpha fullawayi*.

Supplementary Table 2. Abundance distribution and occurrence of mango tephritids and associated parasitoids in the High Guinea Savannah agroecological zone of Cameron from 2020 to 2022.

Localities	Mango's cultivars	Nb. Fr. att.	Ab tephri + Para. spp	*Bactrocera dorsalis*		*Ceratitis cosyra*		*Ceratitis anonae*		*Ceratitis fasciventris*		*Ealata saba*		*Ganaspis* sp.		*Trichopria* sp.	
				Ab.	Oc.	Ab.	Oc.	Ab.	Oc.	Ab.	Oc.	Ab.	Oc.	Ab.	Oc.	Ab.	Oc.
Malang	Amélie	58	804	86.94	77.58	3.98	15.52	4.73	27.59	2.11	8.62	0	0	2.24	3.45	0	0
	Brooks late	106	1632	85.60	82.07	6.43	17.92	1.53	8.49	1.35	6.60	0.43	2.83	2.33	8.49	2.33	8.49
	Eldon	111	1015	78.62	75.67	12.22	11.71	0.69	5.41	1.67	9.91	1.28	0.90	1.38	2.7	4.14	3.60
	Ifack 1	55	470	72.98	74.54	16.38	21.82	1.70	12.73	0	0	4.47	3.64	0.21	1.82	4.26	9.09
	Julie	60	561	90.73	86.66	2.14	10	0.36	3.33	0.71	3.33	0.89	3.33	1.96	6.67	3.21	8.33
	Keitt	20	224	63.84	45	24.55	50	2.23	15	0.45	5	5.36	5	3.13	15	0.45	5
	Malo 1	33	299	88.63	84.84	8.70	18.18	0.33	3.03	0	0	0.33	3.03	2.01	6.06	0	0
	Ruby	66	826	95.04	93.93	3.87	9.09	0.12	1.52	0	0	0	0	0.36	3.03	0.61	6.06
	Smith	49	323	70.90	55.10	8.36	26.53	0.93	6.12	2.79	10.20	10.22	2.04	1.55	6.12	5.26	8.16
	Tommy Atkins	64	840	92.50	79.68	6.79	37.50	0.24	3.13	0.48	4.69	0	0	0	0	0	0
Manwi	Alphonso	76	1179	94.06	88.15	0	0	0.76	9.21	0.08	1.32	0	0	5.09	13.2	0	0
	Ifack 1	69	1084	92.53	95.65	0.74	2.90	0	0	0	0	0	0	5.81	10.1	0.92	4.35
	Ifack 5	52	586	77.13	78.84	0	0	0.51	3.85	0	0	0	0	12.29	17.3	10.07	11.54
	Julie	49	322	49.69	63.26	9.32	20.41	4.97	8.16	0	0	0	0	34.78	10.2	1.24	4.08
	Sabot	53	218	55.05	54.71	0.92	3.77	17.89	37.74	1.38	5.66	0	0	16.06	11.3	8.72	5.66
	Valencia	60	726	99.59	100	0	0	0	0	0	0	0	0	0.41	1.67	0	0
Marza	Aku	50	258	65.89	42	34.11	58	0	0	0	0	0	0	0	0	0.0	0
	Alphonso	40	396	85.86	77.5	13.89	62.50	0	0	0	0	0	0	0	0	0.25	2.5
	Ifack 1	46	257	93	84.78	7	19.57	0	0	0	0	0	0	0	0	0	0
	Julie	45	191	64.92	51.11	35.08	48.89	0	0	0	0	0	0	0	0	0	0
	Kent	47	185	61.08	63.83	38.92	40.43	0	0	0	0	0	0	0	0	0	0
	Malo 1	39	242	85.12	82.05	12.81	20.51	0	0	2.07	5.13	0	0	0	0	0	0
	Smith	56	386	57.77	57.14	42.23	55.36	0	0	0	0	0	0	0	0	0	0
	Valencia	39	179	70.39	58.97	29.61	41.03	0	0	0	0	0	0	0	0	0	0
	var. ind 1	49	345	63.48	63.26	36.52	46.94	0	0	0	0	0	0	0	0	0	0
	var. locale	50	305	61.97	66	38.03	38	0	0	0	0	0	0	0	0	0	0
Total	(18)	1442	13853	77.05	72.40	15.10	26.02	1.42	5.59	0.50	2.33	0.88	0.80	3.45	4.51	1.59	2.96

Note: Nb. fr. att. = Number of mango's cultivars attacked by tephritids; Ab. Tephri. + Para. spp. = Abundance of tephritids and their associated parasitoids reared on mango's varieties attacked by tephritids; Ab = Abundance; Oc = Occurrence.