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ARTICLE

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Diversity of flower-visiting hoverflies (Diptera: Syrphidae) on ground cover vegetation from the market-gardening area of Meskine (Far-North Region, Cameroon)

Michelson Azo'o Ela[1] | **Bernard Bissou Wangbara**[2] | **Kurt Jordaens**[3]

[1]Department of Biological Sciences, Faculty of Science, University of Maroua, Maroua, Cameroon

[2]Department of Agriculture, Livestock and By-Products, National Advanced School of Engineering of Maroua, University of Maroua, Maroua, Cameroon

[3]Department of Biology–Invertebrates Unit, Royal Museum for Central Africa, Tervuren, Belgium

Correspondence
Michelson Azo'o Ela, Department of Biological Sciences, Faculty of Science, University of Maroua, P.O. Box 814 Maroua, Cameroon.
Email: azooela@yahoo.fr

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Abstract

We characterised the hoverfly (Diptera: Syrphidae) community on ground cover vegetation in the market garden of Meskine (Far-North region of Cameroon). Hoverflies were collected by hand-netting from flowers of ground cover vegetation in 20 grass strips from March to June in two consecutive years (2017–2018). In total, 15 hoverfly species were collected of which eight were new to Cameroon (subfamily Eristalinae: *Eristalinus megacephalus*, *Eristalinus tabanoides*, *Eristalinus* aff. *arvorum*, *Phytomia curta*, *Phytomia pallida*, *Phytomia incisa*, *Mesembrius caffer*; subfamily Syrphinae: *Asarkina* sp.). The subfamily Eristalinae was most abundant (74% of the specimens collected), while species of the subfamily Syrphinae accounted for 26% of the occurrences. Four species were extremely abundant (*M. caffer*, *E. tabanoides*, *E.* aff. *arvorum* and *Paragus borbonicus*) accounting for 70% of all flower visit observations, while the other species were rarer. Plant species with yellow or white flowers seemed to be most attractive. Hoverfly activity was high in the morning and evening and decreased at noon, most likely due to the higher air temperature and lower humidity during this period. The characterisation of hoverfly communities and the management of wild flower strips surrounding cultivated fields could be an important practice to improve crop pollination by hoverflies.

KEYWORDS
Africa, agriculture, Eristalinae, flower fly, pollination, Syrphinae

Résumé

Nous avons caractérisé la communauté de syrphes (Diptera: Syrphidae) en fonction de la couverture végétale des sols de la zone maraîchère de Meskine (située dans l'extrême-nord du Cameroun). Les syrphes ont été collectés au filet de piégeage entre mars juin sur les fleurs présentes dans la couverture végétale de 20 bandes enherbées pendant deux années consécutives (2017 et 2018). Au total, 15 espèces de syrphes ont été collectées. Huit d'entre elles étaient nouvelles au Cameroun (sous-famille Eristalinae: *Eristalinus megacephalus*, *Eristalinus tabanoides*, *Eristalinus* aff. *arvorum*, *Phytomia curta*, *Phytomia pallida*, *Phytomia incisa*, *Mesembrius caffer*; sous-famille Syrphinae: esp. *Asarkina*). La sous-famille Eristalinae était la plus abondante (74% des spécimens collectés), tandis que les espèces de la sous-famille Syrphinae représentaient 26% des syrphes présents. Quatre espèces étaient extrêmement abondantes (*M. caffer*, *E. tabanoides*, *E.* aff. *arvorum* et *Paragus borbonicus*) et représentaient 70% de toutes les visites de fleurs observées, tandis que les autres espèces étaient plus rares. Les espèces végétales à fleurs jaunes ou blanches semblaient être les plus attrayantes. L'activité des syrphes était élevée le matin et le soir et diminuait à midi, très probablement en raison de la température de l'air plus élevée et de l'humidité plus faible pendant cette tranche horaire. La caractérisation des communautés de syrphes et la gestion des bandes de fleurs sauvages entourant les champs cultivés pourraient devenir une pratique essentielle visant à améliorer la pollinisation des cultures par les syrphes.

1 | INTRODUCTION

Ecosystems provide humanity with goods and services known as ecosystem services (ES) (IPBES, 2019). Pollinators provide pollination ecosystem services (pollination ES) that are crucial for sexual reproduction of many flowering plants, including crops (Aizen et al., 2019). About two-thirds of all crop species benefit from cross-pollination by insect pollination and develop higher fruit set and/or higher fruit quality (Aizen et al., 2019; Klein et al., 2007). Also, pollination rises yield stability and maintains the genetic variability of crops, which counteracts inbreeding depression and facilitates resistance to environmental changes (Garibaldi et al., 2011). The study of pollination ES is thus crucial to safeguard food security.

On 22 February 2019, the Food and Agricultural Organization of the United Nations (FAO) published the first-ever report of its sort presenting mounting and worrying evidence that the biodiversity which underpins the world food systems is disappearing, putting the future of our food, livelihoods health and environment under severe threat. Indeed, man-made changes in land-use and climate change threaten the biodiversity and ES upon which humans depend, including crop pollination ES (Diaz et al., 2019). This is particularly problematic in tropical regions where many crop species that provide food security are highly pollinator-dependent (Aizen et al., 2019). However, for the Afrotropical Region, we have insufficient knowledge on insect pollinator communities, their habitat requirements, and the range and quality of pollination ES that they provide in agroecosystems.

One of the reasons for this lack of knowledge is that research efforts and funding on pollination networks are mainly concentrated in higher income countries (Bartholomée & Lavorel, 2019). As a result, the impact of pollination ES on crop pollination, food security and livelihood in general remains largely unknown in the least developed countries (LDC). Moreover, honeybees (*Apis mellifera*) are often assumed to provide the majority of pollination ES but other insect groups, such as hoverflies or flower flies (Diptera: Syrphidae; Figure 1) constitute important pollinators for crops as well (Doyle et al., 2020; Rader et al., 2016). A better knowledge of pollinator communities is a pivotal first step to characterise pollination ES especially since agricultural practices impact local animal and plant diversity.

In agroecology, ground cover vegetation is regarded as providing a range of ES, such as improved carbon sequestration, pest control and soil fertility, or increased diversity of beneficial insects (Lu et al., 2013; Winter, 2018). One approach is the management of flower strips around crop fields to attract insects which may serve as pollinators of the crops (e.g., Albrecht et al., 2020; Boetzl et al., 2021; Pétremand et al., 2017).

In sub-Saharan Africa, the study of plant–pollinator networks, and the relative contribution of non-honeybee pollinators in particular, remains in its infancy. In this study, we sampled flower-visiting hoverflies in grass strips in a market-gardening area in Meskine in northern Cameroon. More specifically, we (1) characterised the hoverfly community of the study area, (2) quantified the relative abundance of flower-visiting hoverflies and (3) related plant characteristics with flower preferences of hoverflies. The present study is a first step in the characterisation of the pollinator community in a typical agricultural landscape of Cameroon and provides important information for the management of this landscape in an agroecological context.

FIGURE 1 *Mesembrius caffer* foraging on *Tribulus terrestris* (picture by Azo'o E. Michelson)

2 | METHODS

2.1 | Study area

The study area is a market-gardening area in Meskine, in the vicinity of Maroua, the capital of the Far-North Region of Cameroon (10°34.346′N; 14°16.835′E; 420 m), West Africa. The area extends over a surface of about 508 ha from the Mayo Tsanaga Bridge to the experimental site of the Regional Center of the Agricultural Research for the Development of Maroua (Figure 2). The area is bordered by the main road which connects Maroua to Meskine and the Mayo Tsanaga River. The area consists of smallholder farms of different size which are characterised by a succession of various off-season crops of which the main crop species are Cucurbitae [*Citrullus lanatus* (Thunb.) Matsum. and Nakai and *Cucumis sativus* L.], Poaceae [*Zea mays* L. and *Sorghum bicolor* (L.) Moench], Amaranthaceae [*Amaranthus viridis* L.], Solanaceae [*Solanum nigrum* L.], Malvaceae [*Abelmoschus esculentus* (L.) Moench] and Brassicaceae [*Brassica oleracea* L.].

2.2 | Collection of hoverflies

In 2017 and 2018, 120 5 m^2 plots were randomly selected in the 508 ha study site to study flower visit behaviour of hoverflies. Because of the scattered distribution of the smallholder farms in the area, no fixed distance among the observational plots could be maintained, but the distance between adjacent observational plots varied between 10 and 20 m. Plots were chosen at the interface of different smallholder farms. Observations were made twice a week (Monday and Friday) for 15 consecutive weeks (March–June). For each day, observations were made at three time intervals: 06:00–10:00 AM, 11:00 AM–02:00 PM and 03:00–06:00 PM. The relative proportion of plant species was highly variable among plots. We did not quantify this and opted to observe each flowering plant species per plot for approximately 5 min per time interval and hoverflies visiting the flowers were counted. Since some specimens could have been observed more than once, counts were expressed as number of visits rather than number of individuals. For each flower visit, we noted whether either nectar or pollen was harvested. Nectar harvesting was assumed when the hoverfly was seen active at the nectary of the flower, while pollen harvesting was assumed when the hoverfly scratched the anthers with their mouthparts. Several specimens of each hoverfly species were captured with a hand net, killed with ethylacetate, pinned and labelled following procedures in Kirk-Spriggs (2017). Hoverfly species were thereafter identified by KJ (list of identification keys used available upon request). Voucher specimens were deposited in the entomological collections of the Royal Museum for Central Africa (Tervuren, Belgium), while all other specimens were stored at the Laboratory of Entomology (Department of Biological Sciences, Faculty of Science, University of Maroua, Cameroon).

The number of visits of each hoverfly species was counted and species richness, expressed as the number of hoverfly species, was determined. The relative abundance (*F*) or centesimal frequency, which corresponds to the percentage of total floral visits of a given hoverfly species compared to the total of the visits of all hoverfly species identified, was calculated as $F\ (\%) = [(ni/N) \times 100]$ where F (%) represents the relative abundance of flower visits of species i; ni the number of visits by individuals of the species and N the total number of visits by individuals of all species combined (Tchuenguem et al., 2002). We also calculated the frequency of occurrence (*C*), or frequency of appearance, which refers to the frequency of a species in the samples, that is in percentage, it is the ratio between the number of surveys during which the species was observed (*Pi*) to the total number of surveys (*P*): $C\ (\%) = [(Pi/P) \times 100]$ (Dajoz, 2006). Bigot and Bodot (1973) classified hoverflies into four categories of species

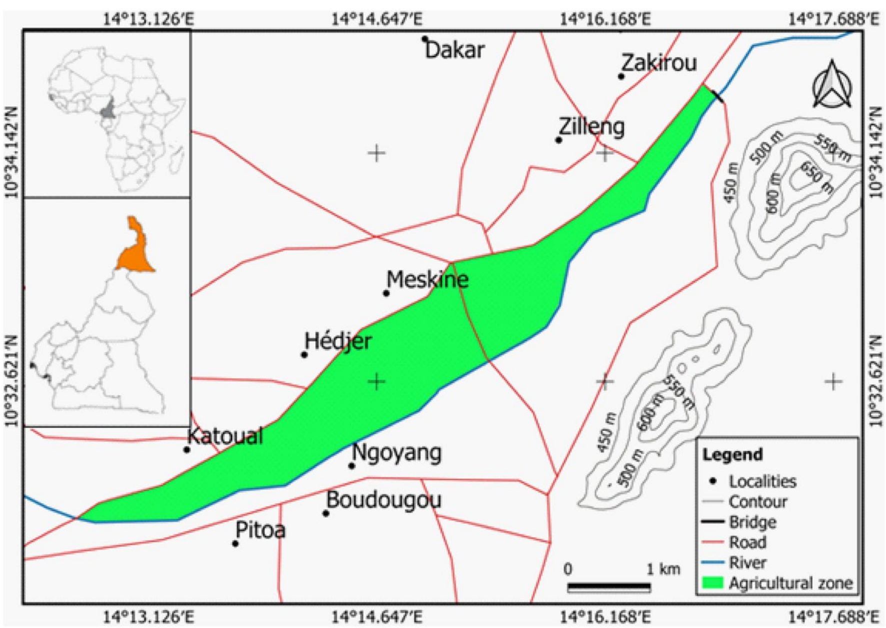

FIGURE 2 Study area of Meskine (Maroua, Far-North region, Cameroon)

as a function of the variation in *C*-values: very accidental or sporadic species ($C < 10\%$); accidental species ($10\% \le C \le 24\%$); accessory species ($25\% \le C \le 49\%$); and constant species ($C \ge 50\%$).

2.3 | Flowering plants

Prior to the field observations, the area was visited several times to select flowering plant species that seemed attractive to hoverflies. Then, in each plot, one individual of each plant species whose flowers were attractive to hoverflies was collected and dried. The colour of the flowers was noted, and the diameter of 10 flowers per plant species was measured using Vernier callipers (Aigo®, Japan). Plant species were identified by the Laboratory of Botany (Department of Biological Sciences) of the University of Maroua (Cameroon). All dried plant material is stored at the National Herbarium of Cameroon where identifications were confirmed by the Herbarium's staff members.

2.4 | Temperature and humidity

During each survey, mean temperature and humidity at each time interval were registered using an indoor/outdoor hygro-thermometer HT 9227. Each time, temperature and humidity were measured twice, and the mean of all measurements during one week was calculated and used in the regression analysis.

2.5 | Data analysis

SPSS v.20.0 (https://www.ibm.com/products/spss-statistics) was used to calculate basic statistics such as species richness, relative abundance (*F*) and frequency of occurrence (*C*). A linear regression was used to study the influence of air temperature and humidity on hoverfly activity. We used correspondence analysis to reveal a more general picture of the relationships between ground cover flowering plant species and hoverfly species. Correspondence analysis thus allowed to look for putative generalist feeders (i.e. no association between a certain hoverfly and plant species) or putative more specialist feeders (i.e., strong association between a certain hoverfly and plant species).

3 | RESULTS

3.1 | Hoverfly diversity, abundance and activity

Fifteen hoverfly species were recorded and collected from ground cover vegetation flowers in the study area, eight of which were recorded for the first time in Cameroon (Table 1). Five species of five genera belonged to the subfamily Syrphinae: *Allograpta nasuta* (Macquart, 1842), *Paragus borbonicus* Macquart, 1842, *Asarkina* sp., *Ischiodon aegyptius* (Wiedemann, 1830) and *Toxomerus floralis* (Fabricius, 1798). Ten species of four genera belonged to the subfamily Eristalinae: *Eristalinus* (four species), *Phytomia* (three species), *Mesembrius* (two species) and *Syritta flaviventris* Macquart, 1842.

Table 2 shows the relative abundance *F* of the 15 hoverfly species recorded. Eristalinae accounted for 74% of the observations, Syrphinae for 26%. *Mesembrius caffer* (Loew, 1858) was the most abundant species and accounted for 26.68% of the observations, followed by *Eristalinus tabanoides* (Jaennicke, 1867) ($F = 15.71\%$), *Eristalinus* aff. *arvorum* ($F = 14.96\%$), *P. borbonicus* ($F = 13.46\%$), *T. floralis* ($F = 11.22\%$) and *Eristalinus megacephalus* (Rossi, 1794) ($F = 9.23\%$). All other hoverfly species had low relative abundancies ($F < 5\%$).

Table 3 gives the frequency of occurrence *C* of the hoverfly species recorded. Following Bigot and Bodot (1973) hoverfly species were classified into four groups: (1) constant species: *M. caffer*, *E. tabanoides*, *E.* aff. *arvorum* (Eristalinae) and *P. borbonicus* (Syrphinae), (2) accessory species: *E. megacephalus* (Eristalinae) and *T. floralis* (Syrphinae), (3) accidental species: *Phytomia curta* (Loew, 1858), *S. flaviventris* (Eristalinae) and *I. aegyptius* (Syrphinae) and (4) sporadic species: *Phytomia incisa* (Wiedemann, 1830), *Phytomia pallida* De Meyer, Goergen & Jordaens, 2020, *Eristalinus quinquelineatus* (Fabricius, 1791), *Mesembrius minor* (Bezzi, 1915), *A. nasuta* and *Asarkina* sp.

Figure 3 shows the influence of temperature and humidity on hoverfly activity. Hoverflies were observed throughout the day, yet, foraging activity was high in the morning (low air temperature and high humidity), decreased at midday (high air temperature and low humidity) and increased again in the evening (low air temperatures and high humidity). A linear regression between the daily variation of hoverfly visits as a function of mean relative humidity resulted in a positive linear slope ($y = 0.0358x + 25.388$; $R^2 = 0.93$; $p < .05$), while the regression between the daily variation of hoverfly visits on daily fluctuation of mean temperature showed a significant negative linear slope ($y = -0.0358x + 25.388$; $R^2 = 0.75$; $p < .05$) (Figure 4).

3.2 | Hoverfly–plant relationships

At the study site, hoverflies were observed feeding on twenty different plant species (Table 4). We recorded hoverfly species on three plant species for two families (Malvaceae and Verbenaceae), on two plant species in each of the families Asteraceae, Nyctaginaceae and Poaceae, and on a single species for the remaining eight plant families (Commelinaceae, Cyperaceae, Euphorbiaceae, Plantaginaceae, Portulacaceae, Rubiaceae, Solanaceae and Zygophillaceae). Of these plant species, 13 species (65%) were visited for pollen, while seven species (35%) were visited for nectar (Table 4). Among the 20 plant species that were visited by hoverflies, only *Nichandra physalodes* had a floral diameter >1 cm; the 19 others had a floral diameter <1 cm. Of the 20 plant species that were visited by hoverflies, 30% had yellow flowers, 20% white, 20% purple, 15% blue, 10% brown and 5% green (Figure 5).

The correspondence analysis (Figure 6) shows that plant species, flower colour and hoverfly species are much dispersed and

TABLE 1 Hoverfly species recorded at the study site of Meskine (Maroua, Cameroon)

Subfamily	Genus	Species	Authors	Status
Syrphinae	*Allograpta*	*Allograpta nasuta* (Aln)	(Macquart, 1842)	Known from Cameroon[a]
	Paragus	*Paragus borbonicus* (Pab)	Macquart, 1842	Known from Cameroon[a]
	Asarkina	*Asarkina* sp. (Ass)		New to Cameroon
	Ischiodon	*Ischiodon aegyptius* (Isa)	(Wiedemann, 1830)	Known from Cameroon[a]
	Toxomerus	*Toxomerus floralis* (Tof)	(Fabricius, 1798)	Known from Cameroon[b]
Eristalinae	*Eristalinus*	*Eristalinus megacephalus* (Erm)	(Rossi, 1794)	New to Cameroon
		Eristalinus tabanoides (Ert)	(Jaennicke, 1867)	New to Cameroon
		Eristalinus aff. *arvorum* (Erar)	(Fabricius, 1787)	New to Cameroon
		Eristalinus quinquelineatus (Erq)	(Fabricius, 1781)	Known from Cameroon[a]
	Phytomia	*Phytomia curta* (Phc)	(Loew, 1858)	New to Cameroon
		Phytomia pallida (Php)	De Meyer, Goergen & Jordaens, 2020	New to Cameroon
		Phytomia incisa (Phi)	(Wiedemann, 1830)	New to Cameroon
	Mesembrius	*Mesembrius caffer* (Mec)	(Loew, 1858)	New to Cameroon
		Mesembrius minor (Mem)	(Bezzi, 1915)	Known from Cameroon[a]
	Syritta	*Syritta flaviventris* (Syf)	Macquart, 1842	Known from Cameroon[c]

Note: Abbreviations to denote the hoverfly species in Figure 6 are given in parenthesis.

[a]Ssymank (2012).

[b]Jordaens et al. (2015).

[c]Lyneborg and Barkemeyer (2005).

TABLE 2 Relative abundance of hoverfly species recorded

		Number of floral visits					
Subfamily	**Taxon**	**2017**	**%**	**2018**	**%**	**Total**	**%**
Eristalinae	*Mesembrius caffer*	29	23.77	78	27.96	107	26.68
	Eristalinus tabanoides	21	17.21	42	15.05	63	15.71
	Eristalinus aff. *arvorum*	24	19.67	36	12.90	60	14.96
	Eristalinus megacephalus	13	10.65	24	8.60	37	9.23
	Phytomia curta	2	1.64	17	6.09	19	4.74
	Syritta flaviventris	-	-	6	2.15	6	1.50
	Phytomia incisa	-	-	2	0.72	2	0.50
	Phytomia pallida	-	-	1	0.36	1	0.25
	Eristalinus quinquelineatus	1	0.83	-	-	1	0.25
	Mesembrius minor	-	-	1	0.36	1	0.25
Total Eristalinae		**90**	**73.77**	**207**	**74.19**	**297**	**74.07**
Syrphinae	*Paragus borbonicus*	11	9.01	43	15.41	54	13.46
	Toxomerus floralis	17	13.94	28	10.04	45	11.22
	Allograpta nasuta	2	1.64	-	-	2	0.50
	Ischiodon aegyptius	2	1.64	-	-	2	0.50
	Asarkina sp.	-	-	1	0.36	1	0.25
Total Syrphinae		**32**	**26.23**	**72**	**25.81**	104	**25.93**
TOTAL		**122**	**100**	**279**	**100**	**401**	**100**

Note: Bold numbers correspond to the values per subfamily.

that certain hoverfly species are strongly associated with certain plant species while others seem to be more generalist feeders. For instance, *S. flaviventris* is associated with plant species with purple flowers, while *I. aegyptius* and *A. nasuta* are associated to plant species with brown flowers. The remainder of the hoverfly species are associated to one or more plant species with white, yellow or blue

TABLE 3 Frequency of occurrence *C* for each of the hoverfly species recorded

Taxon	Number of samples (P_i)	C (%)	Category of hoverflies
Mesembrius caffer	26	86.7	Constant species ($C \geq 50\%$)
Eristalinus tabanoides	22	73.3	
Eristalinus aff. *arvorum*	18	60	
Paragus borbonicus	17	56.7	
Toxomerus floralis	14	46.7	Accessory species ($25\% \leq C \leq 49\%$)
Eristalinus megacephalus	12	40	
Phytomia curta	6	20	Accidental species ($10\% \leq C \leq 24\%$)
Syritta flaviventris	4	13.3	
Ischiodon aegyptius	3	10	
Allograpta nasuta	2	6.7	Sporadic species ($C < 10\%$)
Phytomia incisa	1	3.3	
Phytomia pallida	1	3.3	
Eristalinus quinquelineatus	1	3.3	
Mesembrius minor	1	3.3	
Asarkina sp.	1	3.3	

Note: $C = [(P_i/P) \times 100]$ = Frequency of occurrence P_i = Number of samples containing a given hoverfly species; $P = 30$ = Total number of samples.
The categories are based on Bigot and Bodot (1973).

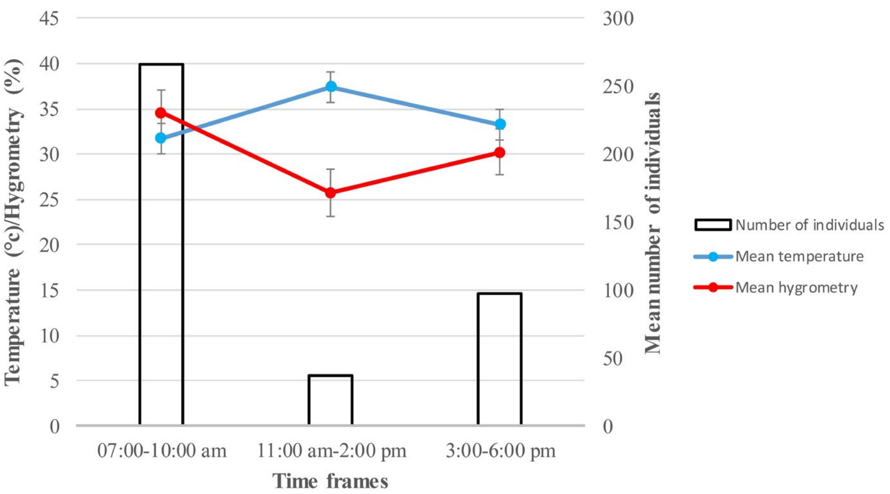

FIGURE 3 Daily variation of hoverfly activity on ground cover vegetation flowers as function of time interval, variation of ambient temperature and humidity in 2018

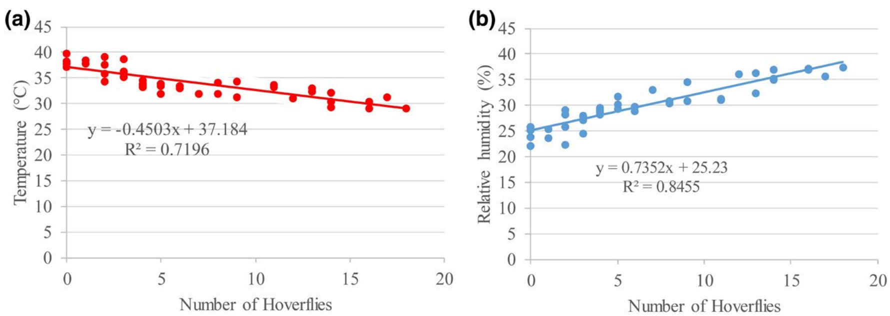

FIGURE 4 Linear regression between temperature (a) and relative humidity (b) as a function of daily variation of Hoverflies

flowers. Within genera, hoverfly species were sometimes associated with flowers of a different colour. For instance, both *P. incisa* and *P. pallida* seem associated to plant species with yellow flowers while *P. curta* seems associated to plant species with blue flowers.

4 | DISCUSSION

Despite the growing appreciation of hoverflies as pollinators, there is a lack of community-wide studies of flower visitation, especially

TABLE 4 List of flowering plant species in the market-gardening area in Meskine from which hoverflies were collected with indication whether pollen or nectar was collected

Family	Grass cover vegetation	Floral product harvested
Malvaceae	*Sida cordifolia* L. (Sic)	Pollen
	Sida acuta Burm. f. (Sia)	Pollen
	Corchorus olitorius L. (Coo)	Pollen
Verbenaceae	*Stachytarpheta angustifolia* (Miller) Vahl (Sta)	Nectar
	Stachytarpheta indica (L.) Vahl (Sti)	Nectar
	Lippia rugosa A. Chev. (Lir)	Nectar
Nyctaginaceae	*Boerhavia diffusa* L. (Bod)	Nectar
	Boerhavia erecta L. (Boe)	Nectar
Poaceae	*Eragrostis aspera* (Jacq.) Nees (Era)	Pollen
	Brachiaria lata C.E. Hubb. (Brl)	Pollen
Asteraceae	*Ageratum conyzoïdes* L. (Agc)	Pollen
	Aspilia kotschyi (Sch. Bip. ex Hochst.) Oliv. (Ask)	Pollen
Commelinaceae	*Commelina bengalensis* L. (Cob)	Pollen
Cyperaceae	*Cyperus rotundus* L. (Cyr)	Pollen
Euphorbiaceae	*Euphorbia hirta* L. (Euh)	Pollen
Plantaginaceae	*Scoparia dulcis* L. (Scd)	Nectar
Portulacaceae	*Portulaca oleacea* L. (Poo)	Pollen
Rubiaceae	*Oldenlandia corymbosa* L. (Olc)	Nectar
Solanaceae	*Nicandra physalodes* (L.) Gaertn. (Nip)	Pollen
Zygophillaceae	*Tribulus terrestris* L. (Trt)	Pollen

Note: Abbreviations to denote the plant species in Figure 6 are given in parenthesis.

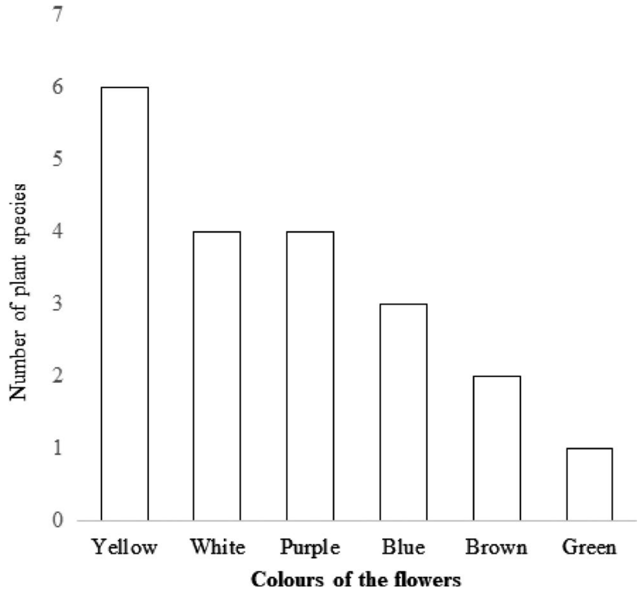

FIGURE 5 Distribution of plant species as a function of flower colours

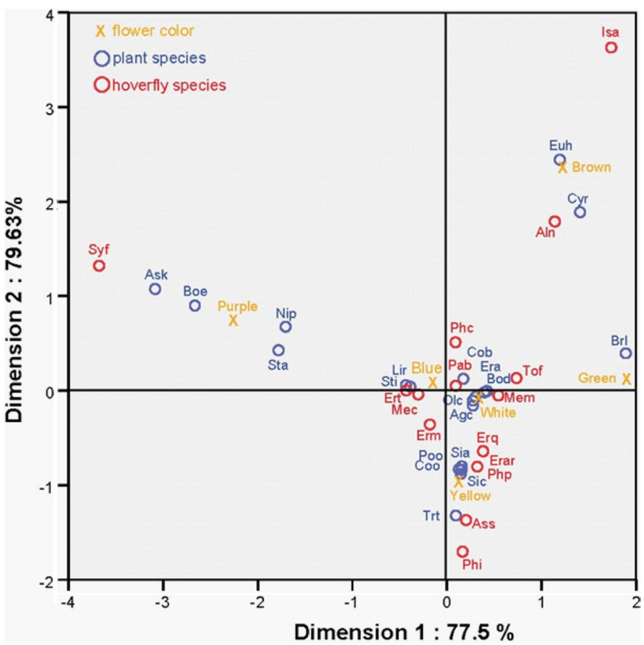

FIGURE 6 Correspondence analysis showing hoverfly species (red circles), plant species (blue circles) and plant flower colour (orange crosses) with respect to their first two principal axis of inertia. Abbreviations for the hoverfly species are given in Table 1 and those for the plant species in Table 4

in the Afrotropics (Klecka et al., 2018). Indeed, the role of Syrphidae in pollination of wildflowers and agricultural crops in sub-Saharan Africa remains largely unexplored. Yet, flower flies are a species-rich family of insects that are among the most important flower pollinators worldwide (Morales & Köhler, 2008). For instance, *Eristalinus arvorum* (Fabricius, 1787) was mentioned as one of the main pollinators of mango tree *Mangifera indica* L. (Anacardiaceae) in India (Reddy et al., 2010).

Hoverflies are usually thought to be rather opportunistic flower visitors, but recently, Klecka et al. (2018) have shown that flower visitation in hoverflies was affected by phylogenetic relatedness, body size and several plant traits assuming complex plant–pollinator interactions. Understanding the role of hoverflies in plant–pollinator networks not only requires a thorough understanding of their complex relationships with flowering plants but also of their taxonomy, diversity and abundancy and our study is the first to attempt to describe these latter aspects for the hoverfly community in an agricultural landscape in the vicinity of Maroua (Cameroon). We have recorded 15 hoverfly species visiting flower of 20 plant species. The relative abundance of hoverfly species was highly variable with four hoverfly species accounting for 70% of the number of flower visits.

In particular, the relative abundance decreased drastically as the ambient temperature increased in the midday. This suggested that high temperatures are not favourable to the foraging activity of flower flies. This result could be explained by the depletion of floral resources and/or adverse abiotic factors during hoverfly floral activity. According to Polatto et al. (2014), the adverse abiotic factors such as ambient temperature and relative humidity are responsible for the depletion of floral resources which influence negatively the floral activity of foragers.

It appeared that plant species with small diameter of flowers attract more hoverflies than others. This may hint at a selective pattern to the foraging behaviour of hoverflies. Indeed, the short mouthparts of flower fly species make them generalist browsers (Speight, 2011) thus predispose these insect species to visit predominantly plant species with small and easily accessible flowers. Hoverflies feed on both pollen and nectar. Pollen provides proteins to females that contribute to oocyte maturation while nectar provides the necessary carbohydrates (e.g., Speight, 2011). Hoverflies exploited their food resources from several plant species simultaneously suggesting that these insects are for the most part polylectic (see also Branquart & Hemptinne, 2000; Sinzinkayo et al., 2017). Moreover, our study confirms that yellow and white flowers with shallow corolla are the most visited by hoverflies. Yet, we have not quantified the relative abundance of flower colour and thus the higher abundance of hoverflies on white and yellow flowers may reflect a relative high abundance of plant species with white or yellow flowers and may not reflect a preference of hoverflies for white and yellow flowers. Nevertheless, other studies suggested that hoverflies have a preference for white and yellow flowers (Haslett, 1989; Sutherland et al., 1999).

Finally, our study shows that, as from most countries of the Afrotropical Region, our knowledge on hoverfly diversity is far from complete. For example, Ssymank (2012) reported 96 hoverfly species for Cameroon but the present work already adds eight new species (Table 1) even though the sampling was done in a highly disturbed area. Considering also *T. floralis* reported from Cameroon by Jordaens et al. (2015), this raises the current number of hoverfly species recorded in Cameroon to 105.

5 | CONCLUSION

This study shows that ground cover vegetation in the agricultural area of Meskine-Maroua (Cameroon) attracts a number of hoverfly species which may pollinate adjacent fruits and vegetables. Ground cover vegetation might provide pollinators with nectar and pollen during off-season cultivation. The management of wild flowering plant species and ground cover vegetation should therefore take into account possible effects on the abundance and diversity of hoverflies. For instance, it would be interesting to investigate if increased complexity or diversity of ground cover vegetation positively affects hoverfly abundancy and diversity. If this holds, then the preservation of a rich community of non-honeybee pollinator species may positively affect the pollination of cultivated fruits and vegetables. Evidently, many more floristic and ecological factors need to be taken into account to fully disentangle the plant-pollinator interactions in this area [see Klecka et al. (2018)].

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CONFLICT OF INTEREST

The authors declare not to have any conflict of interest.

AUTHOR CONTRIBUTIONS

MAE designed the study, collected part of the data, analysed the data and wrote the manuscript. BBW collected most of the data. KJ contributed to the identification of the hoverflies and the writing of the manuscript.

DATA AVAILABILITY STATEMENT

All data are available upon request to the corresponding author.

ORCID

Michelson Azo'o Ela https://orcid.org/0000-0002-5012-2423
Kurt Jordaens https://orcid.org/0000-0003-4321-5944

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