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Diversity of populations of predators and parasitoids of insect pests of millet (*Pennisetum glaucum*) in far north region of Cameroon

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Abstract

To develop a biological control method of fight, an inventory of predators and parasitoids of insect pests of millet was conducted in one agro-ecological zones in far North region of Cameroon (Sudanian, Sahelian and Sudano-Sahelian). The predateurs and parasitoids was trap using a sweep net was performed every two weeks on a site (Maroua). This study, which focused on diversity of populations of predators and parasitoids of insect pests of millet production, was conducted in the Far North of Cameroon in the Meskine agroecosystem. The aim was to determine the biological diversity of predators and parasitoids of insect pests of millet in this area. A system consisting of two plots containing two varieties of millet (CHACKTI and SL28) was adopted. One plot contained the CHACKTI variety and the second plot consisted of the SL28 variety with an area of 16 m in length and 10 m in width for each plot. Insects were captured using sweep nets in each elementary plot on the phenological stages of millet, from the 15th day after sowing until harvest. This insect collection method consisted of mowing the insects along the elementary plots, i.e. 50 mowings per elementary plot. These collections of predators and parasitoids of insect pests on the two millet varieties tested allowed us to observe the dynamics of predators and parasitoids of insect pests at the different phenological stages of millet, and to gain insight into their abundance. The results obtained on biological diversity showed that the predator *Araneus sp*. visited the CHACKTI and SL28 varieties. Regarding dynamics of predators and parasitoids of insect pests, a variation in the number was observed depending on the different phenological stages of millet. These results allow us to confirm that several predators and parasitoids of insect pests inhabit the Meskine agroecosystem; they are dynamic and cause considerable damage to millet production. The results of this study indicate a potential biological control against insect pests of millet using predators and parasitoids. This potential should be developed to manage the yield losses caused by insect pests of millet.

Keywords: *Pennisetum glaucum*; Predators; Parasitoids; Insect pests; Agroecosystem; Meskine; Maroua

1. Introduction

This work aims to improve millet production through proper management of predators and parasitoids of millet insect pests in the Far North region of Cameroon. The topic is all the more important because the Far North of Cameroon is a prime production area for millet production. It is one of the pillars for economic recovery and food self-sufficiency in order to firmly emerge from underdevelopment and embark on the path of emerging countries. Plant production sectors have significant production potential, limited however by geographical, technical, and phytosanitary constraints (FAO, 2018).

Nowadays, millet has many dietary and socioeconomic importance; despite these multiple importances, its production remains low, hampered by insect pests. The inventory of predators and parasitoids of millet insect pests is marked by

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several recent developments that reflect the challenges and opportunities facing millet producers globally and nationally.

Here are some highlights: Climate change and pest spread: Studies show that climate change can alter the habitats and life cycles of insect pests. As a result, species traditionally found in other regions are beginning to emerge in new millet-growing areas.

This underscores the need for frequent and regular inventories to monitor the emergence of new pests. Crop resilience: In the face of rising pests, significant research is focusing on the development of millet varieties. These efforts are part of a breeding and biotechnology approach aimed at strengthening the natural resistance of plants to pests. Integrated pest management (IPM): Increasingly, agronomists and researchers are developing integrated pest management as a response strategy.

This includes the use of biological (natural predators), cultural (crop rotation), and chemical (insecticides to minimize the impact of targeted pests) methods to minimize the impact while preserving the environment. Technology and monitoring: Remote sensing and technologies, including artificial intelligence, are increasingly used to monitor pest populations and assess damage in the field.

These tools enable rapid and more efficient inventories. Collaborative research initiatives: International initiatives bring together researchers and agronomists who share data on insect pests. This insect data helps produce more comprehensive information and develop regionalized solutions adapted to local specificities.

Awareness and training programs are being implemented in several millet-producing countries to help identify pests and adopt effective control practices. This education is essential for strengthening the resilience of local communities.

The current situation regarding inventories of millet insect pests is dynamic and requires continuous development and attention to adapt and effectively respond to emerging challenges. The integration of scientific research, modern technology, and community engagement will be crucial to protect this essential crop.

The importance of millet as a food crop and source of income for millions of people, particularly in tropical and subtropical regions, is undeniable. However, millet cultivation faces increasing challenges due to the presence of various insect pests, which threaten the productivity and sustainability of agricultural systems. In this context, the central problem of this study can be formulated as follows: How can we establish an effective and dynamic inventory of millet insect pests in order to better understand their diversity, their impact on yields, and management methods adapted to environmental and agronomic developments? Given their more generalist nature, insect predators have a much greater taxonomic variety than parasitoids (Holling, 2016).

Arthropods, however, include the most interesting predatory entomophages, including polyphagous insect species (Sunderland et al., 1983). Predators act in a simple and direct way: the prey is captured and generally eliminated without delay (Jackson, 2016). A predator may eliminate several prey during its lifetime, its voracity being a useful index of its repression potential (Holling, 2016).

Arthropods, however, include the most interesting predatory entomophages, including polyphagous insect species (Sunderland et al., 1983). Predators act in a simple and direct way: the prey is captured and generally eliminated without delay (Jackson, 2016). A predator can eliminate several prey during its lifetime, its voracity being a useful index of its repression potential (Holling, 2016).

Furthermore, predation requires less specialization than parasitism, which results in a lower specificity than in the case of parasitoids (Holling, 2016). A polyphagous predator uses several prey species and the importance of each varies according to its relative availability (Jackson, 2016). However, no generalist predator is universal, with all showing clear preferences or aptitudes for certain types, sizes, or sets of ecologically similar prey (Hanski et al., 2017).

Furthermore, the prey used by a predator may vary with its age or size, with younger individuals having to settle for smaller, more easily captured prey. The majority of predators actively pursue their prey and capture it by running (Coccinellidae, predators of various Hemiptera) or by pouncing (non-specialized predatory spiders) (Holling, 2015).

A parasitoid can be defined as: “an organism that develops on or in another organism, its host, derives its subsistence from it, and kills it as a direct or indirect result of its development” (Boivin, 2018). According to this definition, parasitoids can be insects, nematodes, fungi, bacteria, protists, and viruses (Eggleton et al., 2016).

However, the majority of known parasitoids are insects (Boivin, 2016). The 87,000 recorded species of parasitoid insects are divided into six orders: Hymenoptera (67,000), Diptera (15,600), Coleoptera (4,000), Neuroptera (50), Lepidoptera (10), and Trichoptera (1) (Boivin, 2016, 2018).

The two main orders in which parasitoids used in biological control are Hymenoptera and Diptera (Byers, et al., 2015). The Hymenoptera families most commonly used in biological control are Braconidae, Ichneumonidae, Eulophidae, Pteromalidae, Encyrtidae and Aphelinidae. Diptera, on the other hand, are mainly represented by the Tachinidae family (van Driesche et al., 2016).

2. Materials and methods

2.1. Presentation of the area

The trial was conducted in a plot located in Meskine, Maroua 1st Arrondissement, Diamaré Department, Far North Region of Cameroon. This region is located between the 10th and 13th degrees of North latitude, and between the 13th and 15th degrees of East longitude (Bouba et al., 2017; INSC, 2019); it covers an area of approximately 34,262 km^2, or more than 7% of the national territory, and stretches for nearly 325 km from the Sudanian zone to the shore of Lake Chad (INSC, 2019). It is part of the Sudano-Sahelian agro-ecological zone (INSC, 2010).

2.2. Plant Material

The plant material consisted of millet seeds of the CHACKTI and SL28 varieties. All of these varieties come from CIMMYT (International Maize and Wheat Improvement Center) and were obtained from IRAD in Maroua.

2.3. Insect Collection Equipment

The sweep net is the insect collection equipment, with the following characteristics: The sweep net is a net used to collect insects that live on plants (Goldstyn, 2003). There are different types of nets, generally for aerial capture, ground capture, and mowing, but all consist of three parts: a circle (or hoop), a bag (or sac), and a handle (Buffington et al., 2008).

These three parts can be adapted to specific types of hunting, for example, in water or in the air. The net used in this study is characterized by the length of its bag, which measures approximately twice the diameter of the circle (Callahan et al., 2016). The diameter of the circle was 40 cm, the bag was approximately 80 cm, and the handle was long (over 1 m) (O'leske et al., 2007). The bag's fabric, with its relatively fine mesh, offers little air resistance. The net was used for mowing by rapid lateral back-and-forth movements.

2.4. Experimental Design

The design consists of two plots. In these plots, there is one plot of the CHACKTI variety and the second plot of the SL28 variety, each with an area of 16m in length and 10m in width, resulting in a spacing of 75 cm between rows and 50 cm between pockets (75cm x 50cm).

2.5. Method for determining the biodiversity of predateurs and parasitoids of insect pests of irrigated millet in the Meskine Agroecosystem

In each elementary plot, regardless of the treatment applied to the elementary plot, insects will be captured using a "Sweep Net" net.

In the elementary plot, 25 double mowings (50 mowings) are applied to the insect pests according to the phenological stages of the millet. Mowing is carried out early in the morning to better capture the insects that use the millet plants as their refuges or biotopes.

After mowing, the bag is closed so that the captured insects cannot escape. Then, the bag is removed from the sweep net circle and labeled and tied to prevent insects from escaping. The same process is repeated until the entire experimental plot is covered. Insects were also captured by hand and preserved in bottles containing 70% ethanol, with the exception of Lepidoptera, which were preserved in foil bags according to the recommendations of Barror and White (1991).

The insect identification keys of Heinrich (1993), Hill (1983), Heinrich and Barrion (2004), and the family recognition key of Delvare and Aberlenc (1989) were used to identify the various species collected.

2.6. Method for determining the dynamics of predateurs and parasitoids of insect pests of irrigated millet in the Meskine agroecosystem

The dynamics predateurs and parasitoids of insect pests of millet were determined by counting insect pests after collection and identification on the plots according to the different phenological stages, while taking into account the varieties used (CHACKTI and SL28). Then, the totals of predateurs and parasitoids of insect pest, variety, and millet phenological stage allowed us to plot histograms by species to see the dynamics of each species.

Regarding the Order Lepidoptera, larvae, pupae, and adults will be counted as representing the species population on each variety. This allowed us to classify the different specimens collected into the different orders, families, genera, and species, and then determine the number of each of these specimens in relation to the plant's phenological stages.

2.7. Insect collection

Period Sampling was carried out at seedling, tillering, heading, and seed maturation.

2.8. Data Analysis

The data collected during the study were manually analyzed. After processing, they were entered into EXCEL 2016 software and analyzed using the same software.

3. Results and discussions

3.1. Inventory of biological diversity and classification of millet of predateurs and parasitoids of insects in the irrigated agroecosystem of Meskine

The table 1 presents the species collected in the irrigated area of Meskine in 2025. The collected species were divided into Class, Orders, Families, Genus/species, and their status according to Heinrich et al. (2004).

Table 1 Status and classification of species collected on millet in the irrigated agroecosystem of Meskine

Class	Orders	Family	Genus/species	Status according to Heinrich and *al.*, (2004)
Insecta	Odonata	Lestidae	*Lestes* sp.	Predator
		Libellulidae	*Palpopeura* sp.	Predator
	Hymenoptera	Braconidae	*Bracon* sp.	Parasitoïd
		Platygastridae	*Platygaster*	Parasitoïd
Spider	Arachnides	Araneidae	*Araneus* sp.	Predator

This table shows that 2 arthropod species divided into two classes (the class Insecta and the class Arachnids) have been inventoried. Among the 2 arthropod species, 4 species belong to the class Insecta divided into 2 orders and 4 families, and 1 species belongs to the class Arachnids divided into the order Araneae and the family Araneidae.

Within the insect class, of the 5 insect species inventoried, 3 have predators status, 2 have parasitoids status. One arachnid species, *Araneus* sp., has predator status for insect pests.

3.2. Inventory of insect pests according to millet phenological stages

The inventory of insects and spiders captured in the Meskine ecosystem in 2025 in the Far North region of Cameroon shows that these arthropods and spiders vary in number and species according to the millet phenological stages.

3.2.1. Seedling stage

The table 2 presents the numbers of predateurs of insect pest collected at the tillering stage in the Meskine ecosystem in 2025.

Table 2 The numbers of predateurs of insect pest inventoried at the seedling stage in the Meskine agroecosystem

Order	**Families**	**Genus/Species**	**Number of species collected on each variety of millet**	
			CHACKTI	**SL 28**
Odonata	Lestidae	Lestes sp.	1	1
	Libellulidae	Palpopeura sp.	4	2
Total 1	2	2	5	3

This table shows that predateurs of insect pest of millet at the seedling stage are 1 order, 2 families, and 2 predateurs of insect pest species. The most represented family is the Odonata family, with 2 species: *Lestes sp*. and *Palpopeura sp*.

At the seedling stage, the most abundant species is *Palpopeura* sp., which belongs to the Odonata order, which is predateur.

3.2.2. Tillering stage

The table 3 presents the numbers of predateurs and parasitoids of insect pest collected at the tillering stage in the Meskine ecosystem in 2025.

Table 3 Predateurs and parasitoids of insect pest collected at the tillering stage in the Meskine ecosystem

Orders	**Families**	**Genus/ Species**	**Number of species collected on each variety of millet**	
			CHACKTI	SL 28
Odonata	Lestidae	*Lestes* sp.	1	1
	Libelludae	*Palpopleura* sp.	4	2
Hymenoptera	Braconidae	*Bracon* sp.	5	1
Araneae	Araneidae	*Araneus* sp.	1	0
Total 3	4	5	10	4

The table 3 shows that predateurs and parasitoids of insect pest captured on millet at the tillering stage are divided into 3 orders, 4 families, and 5 species.

The most represented orders, with 2 species, are the order of Odonata (*Lestes sp*. and *Palpopleura sp*.). The orders Hymenoptera and Araneae are each represented by one species.

Among these predateurs and parasitoids of insect pest, the species *Palpopleura* sp. is the most represented, with an average of 0.76 on the CHACKTI variety and 0.86 on the SL28 variety of millet. An observation based on the analysis of the averages of species per variety suggests that the CHACKTI variety have more predateurs and parasitoids of insects pests.

3.2.3. Heading stage

The table 4 presents the predateurs and parasitoids of insect pest inventoried at the heading stage in the Meskine ecosystem in 2025.

Table 4 Predateurs and parasitoids of insect pest inventoried at the heading stage in the Meskine ecosystem

Orders	Families	Genus/Species	Number of species collected on each variety of millet	
			CHACKTI	SL28
Odonata	Lestidae	*Lestes* sp.	19	34
Hymenoptera	Platygastridae	*Platygaster sp*	6	3
Araneae	Araneidae	*Araneus* sp.	15	8
Total 3	3	3	40	45

The table 4 shows us that the predateurs and parasitoids of insect pest captured on millet at the heading stage belong to 03 orders, 3 families and 3 species. Each orders of Odonata, Coleoptera, Hymenoptera and Araneae are represented with 1 specie. We note the appearance of the species *Platygaster* sp in the order of Hymenoptera, the order of Hymenoptera which did not appear at the seedling and tillering stage appear with the species *Platygater* sp (Hymenoptera).

This work is similar to that of (Sadou and al., 2013) which showed that the most recurrent predateurs and parasitoids of insect pest at the heading stage in millet. This shows that predateurs and parasitoids of insect pest have a broad cultural spectrum.

3.3. Maturation stage

The table 5 presents the predateurs and parasitoids of insect pest inventoried at the maturation stage in the Meskine ecosystem in 2025.

Table 5 Predateurs and parasitoids of insect pest inventoried at the maturation stage in the Meskine ecosystem in 2025

Orders	Families	Genus/ Species	Number of species collected on each variety of millet	
			CHACKTI	SL28
Odonata	Lestidae	*Lestes* sp.	5	3
Hymenoptera	Braconidae	*Bracon* sp.	3	6
Araneae	Araneidae	*Araneus* sp.	4	7
Total	3	3	12	16

The predateurs and parasitoids of insect pest of millet collected at the mature stage belong to 3 Orders (Odonata, Hymenoptera and Araneae).

3.4. Predator and parasitoids of insects pests diversity according to millet phenological stages

Table 6 Predators and parasitoids inventoried according to millet phenological stages in the Meskine ecosystem in 2025

Orders	Families	Genus and species	Seedling	Talling	Haeding	Maturation
Arachnida	Araneidae	*Araneus* sp.	00	11	21	11
Odonata	Lestidae	*Lestes* sp.	01	03	22	8
	Libellulidae	*Palpopeura* sp.	08	00	00	10
Hymenoptera	Braconidae	*Bracon* sp.	00	02	00	9
Total 3	04	04	9	15	43	38

This inventory revealed that 4 predatory species, comprised of two classes spread across 3 orders and 4 families, were collected from irrigated millet in the Meskine agroecosystem.

This demonstrates that millet cultivation is a favorable environment for the development of these natural enemies. The collected predators and parasitoids are found in various orders and numerous families of arthropods (insects and spiders).

The collected predators are divided into shock predators that attack abundant prey populations (Odonata) and clean-up predators that can effectively search for their prey and thrive even at the expense of small populations (Coccinellidae).

The majority of predators actively pursue their prey and capture it, either by running (Coccinellidae) or by leaping (spiders). Spiders are polyphagous predators that attack a wide range of prey.

They capture insects by lying in wait or running, or by building webs that vary depending on the species.

According to CTA (1995), predatory insects (*Araneus sp*., *Tetragnatha sp*., and *Pardosa injucunda)* have an entomophagous effect that helps regulate pest insect populations. The high prevalence of predators during the earing and maturation periods is explained by the fact that pest insects are also present in abundance during this period. These insects are prey for spiders. Adult dragonflies (*Lestes sp*. and *Palpopleura sp*.) are excellent fliers that capture their prey in flight and help regulate pest insect populations.

Predators regulate the populations of other species by intensifying their predatory activities. They therefore present themselves as potential biological control agents. During the millet crop cycle, a growing number of predators are observed.

The most abundant species is *Lestes sp*., an Odonata, both entomophagous and phytophagous, appearing at heading with abundant proliferation at maturity. *Araneus* sp is abundant at tillering and remains present throughout the plant's cycle, while *Mentis religiosa* disappears at maturity.

4. Conclusion

The study, which focused on the inventory of predateurs and parastoids insect pests of millet in the irrigated agroecosystem of Meskine in the Far North region.

This inventory allowed us to identify several insect species in the orders Odonata, Hymenoptera, and also the order Araneae, associated with these ecosystems.

Four predateurs and parastoids insect pests species belonging to four families and distributed across four orders were collected from the irrigated millet of Meskine. The number of predateurs and parastoids insect pests captured was significantly higher at the seedling stage compared to the other tillering and heading stages.

Among the species of predateurs and parastoids insect pests collected on millet, the *Araneus sp* species from the Araneidae family is the most abundant.

The least represented orders are the Odonata order with two species: *Lestes* sp. and *Palpopleura* sp., the Hymenoptera order with two species: *Bracon* sp. and *Platygaster* sp..

The predators collected were much more numerous at the maturity stage. However, it should be noted that spiders are the most important predators, therefore natural enemies that help control other insect pests. Among the natural enemies captured, predatory species (Araneidae: *Araneus* sp.), *Lestes* sp. and *Palpopleura* sp. (Odonata: Lestidae) are present at all phenological stages.

The presence of these predators and parasitoids are great importance and helps a lot in the natural regulation of insect pest and disease (vector) populations. It is therefore important to have a good understanding of the dynamics and biodiversity of millet insect pests in order to better combat pests and preserve useful ones.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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