A preliminary study of biodiversity and bio-ecology of Brachyceran flies (Insecta: Diptera) in oases of Ghardaïa (Sahara, Algeria)

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ABSTRACT
In the region of Ghardaïa (32°21’ to 32°36’N.; 3°29’ to 4°17’ E.), belonging to the Saharan bioclimatic region and characterized by a dry climate, we studied the faunal composition of Diptera Brachycera between August and October 2011. We undertook a comparative biodiversity study in three oases located along the Oued M’Zab. Altogether, 48 species from 20 families of Diptera Brachycera were found. The family Muscidae is represented by eight species, followed by Calliphoridae (eight species) and Dolichopodidae (five species). The highest species richness was found in the oasis of Tadjnint (38 species), followed by Zelfana (24 species) and Ghardaïa (12 species). The highest relative abundance was from Ghardaïa (90.4 %, family Muscidae) and from Zelfana (69.3 %, family Dolichopodidae) and as such both these families have a particular importance in this study. The environment of the oasis of Ghardaïa is disturbed by the surrounding human dwellings. This may explain low species richness and eudominance of synanthropic species Musca domestica. On the other hand, the environment of the Zelfana oasis is still very little disturbed. The traditional oasis (old system of date palms) of Tadjnint hosts economically important harmful Diptera species such as Bactrocera oleae (Tephritidae) and Stomoxys calcitrans (Muscidae).

KEYWORDS: Diptera, biodiversity, economic importance, oasis ecosystem, M’Zab Valley, Sahara, Algeria

INTRODUCTION

Throughout the world, much work has been done on taxonomy and the biology of different families of Diptera. In the desert and arid environments and the Palearctic, it is worth mentioning the studies of Leclercq [31] in Morocco and Leclercq [32] in Saudi Arabia and Oman on the family Tabanidae. El-Hawagyry [18] and El-Hawagyry and Evenhuis [19] studied Bombyliidae in Egypt, which belongs to the great Afro–Asiatic desert belt. In the arid and semi-arid regions of Algeria the work of Becker [4] on Diptera in general is noteworthy., Raffone [35] reported on Empididae, Hybotidae and Microphoridae, Munari [34] on Tethinidae, Arigue et al. [1] on the distribution of aquatic Diptera in Biskra (35°05’ to 35°35’N; 5°30’ to 6°17’E), Hafiane et al. [24] studied Diptera of Oued El Abiod (34°43’N; 5°22’E), Kourim et al. [28] worked on diversity of insects and partially also on the Diptera in the vicinity of Tamanrasset (22°47’N.; 5°31’E.), Baba Aissa et al. [2] on Tephritidae of Ghardaïa (32°21’ to 32°36’ N; 3°29’ to 4°17’E), Chouihet and Doumandji-Mitiche [12] on the
entomofauna of M'Zab Valley and that of Deghiche-Diab et al. [14] on the entomofauna of the Ziban oases. These papers give much data on Diptera Brachycera particularly in the M'Zab.

The present paper attempts to add additional data on this taxonomic group in the region of Ghardaïa. It deals with the diversity of Brachycera and aspects of their bio-ecology under extreme conditions of desert climate.

**MATERIAL AND METHODS**

**Study area:**

Oued M’Zab in the region of Ghardaïa (Fig. 1) is located in the mid-northern part of the Sahara in Algeria, in the Hamada plateau (32°21’ to 32°36’ N; 3°29’ to 4°17’ E). The average altitude is 500 m and the average annual temperature is 22.2 °C. The annual rainfall: 153.9 mm. The study area is located in the Saharan bioclimatic zone with temperate winters. The dominant plant culture in the oases is date palm (*Phoenix dactylifera* L. 1753). It protects the underlying fruit crops such as orange: (*Citrus sinensis* (L.) Osbeck 1765), olive (*Olea europaea* L. 1753) and vegetables such as several Cucurbitaceae.

![Geographical location of the study area (Oued M’Zab) with sampling sites (black triangles)](image)

**Methodologies adopted in the field and in the laboratory:**

This study was carried out in three oases located along the Oued M’Zab including traditional, suburban and modern. The sampling of Diptera was performed by means of lemon-yellow colored water pan traps (35 cm diameter and 12 cm deep). Each trap was filled with water into 3/4 height, and a drop of detergent was added. Altogether 18 dishes were installed in the three studied oases, located at random on distances of nearly 5 meters. The dishes were put on the ground between 10th and 20th of each month, from August until October 2011, and emptied after 24 hours. Specimens were then collected and placed in small plastic bottles with 70˚ alcohol.
provided with locality data, before being transported to the laboratory of Zoologie agricole et forestière – El Harrach for closer examination, preparation and identification.

All specimens were mounted dry using a method described by Barták [3]. According to this method, flies are placed into the following three successive solutions: I – formalin (40% water solution of formaldehyde) + 96% ethyl alcohol (1:1 to 1:3); II – 96% ethyl alcohol + ethyl acetate (1:1); and III – pure ethyl acetate. In each of these three solutions, flies should stay at least 12 hours. From practical reasons, 24 hours may be better but flies are not damaged if they remain several days in any of these three solutions. Flies are transferred from the solution III onto a piece of cardboard using soft tweezers, and the wings and legs, if necessary, are stretched and dried for approximately 30 minutes, the flies are mounted on cards. Material obtained (620 specimens) was identified to family level and separated into morpho-species.

**Results:**

A total of 620 individuals of Diptera belonging to 48 species distributed between 20 families of Brachyceran flies were trapped by means of yellow dishes in three locations along the Oued M’Zab during the period from mid-summer to October 2011 (Tab. 1).

**Table 1:** Total richness and relative abundance of Diptera families in the oases of Ghardaïa in 2011

<table>
<thead>
<tr>
<th>Oasises</th>
<th>Ghardata</th>
<th>Tadjmnt</th>
<th>Zelfana</th>
<th>Région de Ghardaïa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family</td>
<td>Ni S A.R.%</td>
<td>ni S A.R.%</td>
<td>ni S A.R.%</td>
<td>Ni S A.R.%</td>
</tr>
<tr>
<td>Dolichopodidae</td>
<td>8 3 3.67</td>
<td>104 4</td>
<td>39.25 5</td>
<td>69.34 207 5 33.39</td>
</tr>
<tr>
<td>Hybotidae</td>
<td>0 0 0.00</td>
<td>6 4</td>
<td>2.26 0 0</td>
<td>0.00 6 4 0.97</td>
</tr>
<tr>
<td>Empididae</td>
<td>0 0 0.00</td>
<td>2 1</td>
<td>0.75 2 1</td>
<td>1.46 4 1 0.65</td>
</tr>
<tr>
<td>Phoridae</td>
<td>0 0 0.00</td>
<td>2 2</td>
<td>0.75 0 0</td>
<td>0.00 2 2 0.32</td>
</tr>
<tr>
<td>Syrphidae</td>
<td>0 0 0.00</td>
<td>2 2</td>
<td>0.75 3 1</td>
<td>1.29 5 3 0.81</td>
</tr>
<tr>
<td>Tephritidae</td>
<td>0 0 0.00</td>
<td>3 2</td>
<td>1.13 1 1</td>
<td>0.73 4 3 0.65</td>
</tr>
<tr>
<td>Sepsidae</td>
<td>0 0 0.00</td>
<td>10 2</td>
<td>3.77 1 1</td>
<td>0.73 11 2 1.77</td>
</tr>
<tr>
<td>Sphaeroceridae</td>
<td>0 0 0.00</td>
<td>6 1</td>
<td>2.26 2 1</td>
<td>1.46 8 1 1.29</td>
</tr>
<tr>
<td>Chryomyiidae</td>
<td>0 0 0.00</td>
<td>13 1</td>
<td>4.91 3 1</td>
<td>2.19 16 1 2.58</td>
</tr>
<tr>
<td>Opomyzidae</td>
<td>1 1 0.46</td>
<td>10 2</td>
<td>3.77 7 2</td>
<td>5.11 18 2 2.90</td>
</tr>
<tr>
<td>Agromyzyidae</td>
<td>0 0 0.00</td>
<td>0 0</td>
<td>0.00 1 1</td>
<td>0.73 1 1 0.16</td>
</tr>
<tr>
<td>Drosophilidae</td>
<td>1 1 0.46</td>
<td>0 0</td>
<td>0.00 0 0</td>
<td>0.00 1 1 0.16</td>
</tr>
<tr>
<td>Ephrydidae</td>
<td>0 0 0.00</td>
<td>7 2</td>
<td>2.64 0 0</td>
<td>0.00 7 2 1.13</td>
</tr>
<tr>
<td>Chloropoda</td>
<td>0 0 0.00</td>
<td>0 0</td>
<td>0.00 1 1</td>
<td>0.73 1 1 0.16</td>
</tr>
<tr>
<td>Muscidae</td>
<td>197 3 90.37</td>
<td>85 8</td>
<td>32.08 18 6</td>
<td>13.14 300 8 48.39</td>
</tr>
<tr>
<td>Ulidiidae</td>
<td>0 0 0.00</td>
<td>0 0</td>
<td>0.00 1 1</td>
<td>0.73 1 1 0.16</td>
</tr>
<tr>
<td>Caliphoridae</td>
<td>10 3 4.59</td>
<td>8 3</td>
<td>3.02 2 2</td>
<td>1.46 20 6 3.23</td>
</tr>
<tr>
<td>Rhiniophoridae</td>
<td>0 0 0.00</td>
<td>3 1</td>
<td>1.13 0 0</td>
<td>0.00 3 1 0.48</td>
</tr>
<tr>
<td>Tachinidae</td>
<td>0 0 0.00</td>
<td>1 1</td>
<td>0.38 0 0</td>
<td>0.00 1 1 0.16</td>
</tr>
<tr>
<td>Sarcophagidae</td>
<td>1 1 0.46</td>
<td>3 2</td>
<td>1.13 0 0</td>
<td>0.00 4 2 0.65</td>
</tr>
<tr>
<td>Total</td>
<td>218 12 100</td>
<td>265 38</td>
<td>100 137 24</td>
<td>100 620 48 100</td>
</tr>
</tbody>
</table>

Two families were dominant: Muscidae (48.4 %) with 8 species and Dolichopodidae (33.4 %) with 5 species. All other families were much less represented (Fig. 2).

![Fig. 2:Relative abundances (RA %) of Diptera families in the region of Ghardaïa](image-url)
In the oasis of Ghardaïa, a total of 218 individuals from Brachycera, distributed among 12 species and 6 families, were captured (Fig. 3).

![Fig. 3: Relative abundances (RA %) of Diptera in the oasis of Ghardaïa. Superdominance of the family Muscidae is apparent (90.4 %).](image)

In the oasis of Tadjnint, pan traps captured 265 individuals distributed among 24 species and 16 families. The family of Dolichopodidae (39.3 %) and this of Muscidae (32.1 %) were ranked first among the captured individuals. The other families were poorly represented (Fig. 4).

![Fig. 4: Relatives Abundances (RA %) of Brachycera families in the oasis of Tadjnint.](image)

In the palm groves of Zelfana, a total of 137 individuals from Brachycera, distributed among 26 species and 13 families, were trapped. Within these catches, the Dolichopodidae dominated (69.3 %) followed by Muscidae (13.1 %) (Fig. 5).

![Fig. 5](image)
Relative abundances (RA %) of Diptera families in the oasis of Zelfana

It should be noted that some families present in an oasis are not represented in another oasis. This is the case of Drosophilidae. Indeed, *Drosophila melanogaster* was captured only in the oasis of Ghardaïa. However, five families were found only in the oasis of Tadjnint. These were Hybotidae, Phoridae, Ephyridae, Rhinophoridae and Tachinidae. In addition, three other families were noticed only in the palm groves of Zelfana: Agromyzidae, Chloropidae and Ulidiidae.

The Syrphidae caught by the yellow traps in Ghardaïa were *Eristalis tenax* and *Episyrphus balteatus*. The housefly, *Musca domestica* (Musciidae) was captured in very large numbers in Ghardaïa (194 ind.). This species was less numerous in Tadjnint (7 ind.) and still less in Zelfana (2 ind.). Five species of Dolichopodidae were trapped in the oasis of Zelfana, while in Ghardaïa, 3 species of this same family were collected.

The small diversity of dipteran families together with superdominance of *Musca domestica* indicate that the oasis ecosystem in Ghardaïa is more disturbed than the other two.

The families present in oases may be distinguished according to their economic or environmental importance into six categories: those of crop pests such as *Bactrocera oleae* (Tephritidae) and *Phytomyza* sp. (Agromyzidae), predators such as Dolichopodidae and Syrphidae, pollinators (Syrphidae), recyclers of organic matter (Calliphoridae, Sarcophagidae, Sphaeroceridae), parasitoids (Tachinidae), and vectors of disease such as *Musca domestica* (Musciidae).

**Discussion:**

Diptera species are extremely economically important. Some of them damage agricultural crops e.g. Leaf-miner flies (Agromyzidae), fruit flies (Tephritidae) [41,6]. This is confirmed by Merz et al. [33] who report the importance of Tephritidae species in the Mediterranean region. Indeed, fruit flies are exclusively phytophagous and endophytic in the larval state [7,36]. In addition, some species of Diptera are saprophagous or even mycophagous [37]. Scavengers provide nutrients for plants, space for all organisms, and support for healthy ecosystems and clean environments [41]. The role of flies in decomposition is physical rather than chemical [38]. This last author mentions that about a half of all Diptera families have larvae that feed on decaying organic matter. Skevington [40] listed 24 families of flies which contain at least one parasitoid species including Sarcophagidae.

It is worth recalling that Ghardaïa region is known by its arid ecosystem. Specifically, the richness of animals depends upon the climatic constraints of the environment and upon the resources that the natural environment can offer to animal populations [29]. For example, Kourim et al. [28] were able to sample only nine species belonging to five families of Brachycera using the sweep net and Barber pots in the oases of Tamanrasset during the summers of 2008 and 2009 and the winters of 2009 and 2010. Even Guerzou et al. [23] captured only 12 individuals of Brachycera during five months of sampling in Barber pots in the steppe and semi-arid region of Djelfa.

We found altogether 20 families of Diptera Brachycera in our study. In Oued El Haïf near Biskra, Argue et al. [1] reported 13 families of Diptera of which six belong to the Brachycera. These were Tabanidae, Dolichopodidae, Athericidae, Ephyridae, Anthomyiidae and Rhagionidae.

The species richness increases in the presence of large water bodies. This is the case of the Lake of Reghaïa (36°44’ N; 03°21’ E). Indeed, Lounaci et al. [32] captured by the same type of trap as used in this study 22,406 individuals distributed among 88 species including 59 species belonging to 23 families of Brachycera out of a total of 34. Similarly, Berrouane et al. [5] near the same lake caught between July and September 2009

**Fig. 5:** Relative abundances (RA %) of Diptera families in the oasis of Zelfana.
altogether 1,630 individuals of Diptera belonging to 31 species and 16 families including 10 families of Brachycera. More specifically, from the surrounding area of Lake Reghaïa, Lounaci et al. [32] captured 59 species of Brachycera, 40 in the marshes, 25 in the maquis and 13 near the lake margin. Chouihet and Doumandji-Mitchie [12] found a similarity between Al Atteuf and Beni Izguen in terms of invertebrate species, in contrast to Dayah. The last authors emphasized spatial variation; indeed, the oasis which is located at the midpoint of the Oued M’Zab presents a significant diversity in Diptera compared to those located in upstream and downstream because its habitat diversity. In addition, it is worth mentioning that the oasis of Ghardaïa is located upstream of the Oued M’Zab comparing to the altitude of the other oases. It was generally dry during sampling periods. In Tadjninte located halfway, there is a sewage waste water treatment plant. Zelfana palm plantations are located downstream of Oued M’Zab where a rise of the water level was observed in October.

The family Muscidae was eudominant in our studies (48.4 %) with eight collected species. Lounaci et al. [32] captured four species of this family in the Lake of Reghaïa. Some species of this family are considered as nuisance in the adult stage to man, wildlife and livestock around the world by annoying attention such as Musca spp., Stomoxys spp., etc. [26,21]. Others are vectors of microorganisms such as viruses, bacteria, protozoa and helminthes [11,40,42,27]. De Carvalho et al. [33] indicated that the housefly, Musca domestica is associated as an ambient of humans. This cosmopolitan fly is considered as a potential agent of disease transmission to humans and domestic animals [21,28]. Some other representatives of this family are serious pest of crops (Atherigona spp.).

The family of Dolichopodidae was ranked second with the relative abundance of 33.4 %. Five species were trapped in the oasis of Zelfana, while four in Tadjnint and three in Ghardaïa. According to Arigue et al. [1] the relative abundance of the family Dolichopodidae at the Oued El Hai was 0.05%. Lounaci et al. [33] captured four species of this family with three near the pond of Reghaïa, one in the maquis and none in the marshes. Species of this family are very important in ecosystems. Adults are efficient predators of agricultural pests [10]. They are also significant as indicators of degraded environments [9].

The Calliphoridae (3.2 %) was represented by six species in the region of Ghardaïa. Lounaci et al. [33] captured four species of this family.

The Syrphidae was only poorly represented in Ghardaïa. Kourim et al. [29] captured in the oases of Tamanrasset only two species. Deghiche-Diab et al. 2015 captured four species in the Ziban oases between II and IV 2010. Sphaerophoria scripta, Cheilosia variabilis, Syrphus vitripennis and Melanostoma mellinum.

Generally, flies of this family are useful and beneficial in the environment. They play an important ecological role as natural enemies of a wide variety of organisms [8], especially aphids [15]. Larvae of some species are even phytophagous. Adults are important pollinators.

Sarcophagidae and Tephritidae are less represented in Ghardaïa (0.65 %). Sarcophagidae are represented by two species, Tephritidae by three species.

The families Agromyzidae, Drosophilidae, Chloropidae, Ulidiidae and Tachinidae were more scarce (0.16 %) in Ghardaïa region. These families were each represented by only a single specimen. Lounaci et al. [33] captured Drosophila melanogaster only in marshes of Reghaïa with relative abundance of 0.43% in October 2009.

Tachinidae are parasitoids of various arthropods, mainly insects [42,17,23]. Deghiche-Diab et al. [14] aptured in the Ziban oasis one species of Tachinidae, Peleteria varia.

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