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Evaluation and Characterization of Black Rat (*Rattus Rattus*) Population in the Phoenicultural Environments of Algeria

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ABSTRACT

The counting and characterization of the black rat population in 4 stations (2 palm groves and 2 storage sites) located in the region of Touggourt (southern Algeria) were studied by comprehensive trappings, following the use of BTS traps. These allowed the capture of 492 individuals through a trapping effort of 936 trap nights. The palm groves (n = 301) were more infested than the storage sites (n = 191). So for the densities, the latter are more infested (0.49 and 0.97 ind./m2) than the palm groves (0.04 ind./m2). On the other hand, June (16.3 ± 7.3), July (17 ± 7.0), August (18 ± 7.5) and September (18.5 ± 5.8) were characterized by the highest captures. The sex ratio showed a predominance of males in both palm groves (185♂ / 116♀) and storage sites (115♂ / 76♀). The adults (33.5%) and the sub-adults (28.6%) were the most important in the black rat.

Keywords: *Counting, Rattus Rattus, Age Class, Sex Ratio, Palm Grove, Hangar, Algerian Sahara.*

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1. INTRODUCTION

Rodents have a natural geographical distribution that covers the whole world (Aulagnier and Thevenot, 1986). They can cause extremely important damage, especially in case of outbreaks (Hubert, 1984). Some species, such as the black rat *R. rattus* (Linnaeus, 1758), can cause considerable losses on different crops (Giban and Haltebourg, 1965). Recently introduced in Saharan regions where it has taken refuge in the palm groves, this latter species attacks spars (inflorescences) and dates in the open fields and even in the storage sites in the southeastern Algeria (Alia et *al*., 2015). It is an anthropophilic species, with a dark color, adapted to humid environments, unlike Saharan species which are rather pale colored, like gerbils (Kowalski et Rzibek Kowalska., 1991).

Generally, several studies have been carried out on rodent's counting in the world (Corominas, 2004; Harris, 2009) and in Algeria (Bebba and Baziz, 2009; Hadjoudj et *al*., 2011; Souttou et *al*., 2012; Adamou-Djerbaoui et *al*., 2015). But few studies have been done on the bio-ecology of *R. rattus*, particularly in Tunisia (Ben Falah, 2012), France (Cheylan and Granjon, 1985) and New Zealand (Innes, 1977). In addition, this species remains unknown in the Saharan zones, although it is widely responded, and very frequently abundant in the palm groves (Mlik et *al*., 2017). It is in this context that the present study aimed to characterize black rat populations in two types of environments that are ecologically different (2 palm groves and 2 storage sites) in the Saharan regions of Algeria, in order to qualify its adaptive behavior to these recently colonized regions. This was amended by the biometric properties and distribution in these environments with extremely hard living conditions?

2. MATERIEL AND METHODS

Study area

The present study was conducted in the region of Touggourt (33° 02' to 33° 12' N; 5 ° 59 'to 6 ° 14' E) which is located in the southeastern part of Algeria on an altitude of 75 m. It is bordered to the north by the palm groves, to the south and east by the Great Eastern Erg and to the west by the sand dunes. In order to compare black rat damage, four stations were chosen. There were two palm groves and two hangars.

Station 1 (Hangar1):

It is a storage site (33 ° 3'10.01 "N; 6 ° 1'17.60" E) for dates with a surface of 100 m², placed next to (South) a palm grove of 3.5 ha. It consists of 350 date palms of different cultivars (Deglet Nour, Degla Beida and Ghars) as well as 192 plants of

various fruit species (pear, bitter orange, pomegranate, apricot and almond). The stored dates are deposited directly in clusters on a plastic film covering the ground.

Station 2 (Hangar2):

It is a storage place (33 ° 3'7.48 "N; 6 ° 1'15.83" E) for dates, which covers an area of 200 m^2, placed in the western periphery of a palm grove of 2 ha. The latter includes 200 date palms of different cultivars (Deglet Nour, Degla Beida and Ghars) in addition to 75 fruit trees of various species (pomegranate, apricot and plum). The dates are stored in the same way as the first hangar.

Station 3 (Palm grove1):

It is presented by a palm grove (33°11' 38.37" N; 6°4' 14.82" E) of 1,5ha, located in the northern part of the city of Touggourt. This one includes 150 feet of date palm trees of different cultivars (Deglet Nour, Degla Beida and Ghars) as well as 150 fruit trees (pomegranate, olive and fig trees). It presents a northeast exposure and characterized by a drip type irrigation. No chemical treatment is applied against rodents. This station is delimited by a windbreak of dry palms.

Station 4 (Palm grove2):

It's a palm grove (33°11'40.31"N; 6°4'14.62"E) of 1,5 ha. It counts about 150 date palms of different cultivars and more than 50 trees of various fruit species (pear, pomegranate, apricot and almond). The station is delimited by a windbreak of dry palms, having a northwest exposure. The irrigation is ensured by submersion in drain well organized and maintained. It should be mentioned that only chemical treatment was applied against rodents in 2016.

Sampling method

For the trapping of rats, BTS (Besonçon Technology System) traps were used. They were gridded meshes of 26 cm × 12 cm × 14 cm, which were triggered by a hook when the animal touches the bait hooked in the trap (Hadjoudj et *al.*, 2011). These are very lightweight devices, easy to store and transport. They allow the capture of live individuals which allows a very good exploitation of the captured animal. Several baits were used including toast, dates and cheese.

Rodents capture and identification

The capture of black rats was carried out monthly, with one exit per month, from September 2016 until September 2017. The traps were dropped randomly and they were checked early in the morning. These latter were left on the ground for a minimum of three consecutive nights. Each specimen of captured *R. rattus* were preserved in a numbered jar containing alcohol until manipulation in the laboratory.

Once in the laboratory, each captured individual was examined. Then, they were identified based on several criteria, especially morphological (coat coloration, palmar and plantar soles...) and craniometric (upper and lower molars ...) criteria. The age and the confirmation of species were done through the examination of the form and the wear of the molar rows of each individual (Barreau et *al*., 1991).

Exploitation of results

Different ecological indices were used, namely abundance, which is an important parameter for the description of a population (Ramade, 2003). It was calculated according to the number of rats (AR %) and the trapping effort (IA %). The relative abundance of rats was calculated with following formula:

$$AR\ (\%) = \frac{Ni \times 100}{N.N.P.}$$

Which Ni is the number of individuals caught in each month and N.N.P is the number of trap nights = number of nights' x number of traps. The relative abundance of the trapping effort (IA %) was calculated by the following formula:

$$IA\ (\%) = \frac{Ni}{N.N.P.} \times 100$$

The constancy (FO) is a ratio expressed as a percentage of the number of records (Pi) containing the species (i) present to the total number of records (P) (Mulleur 1985, Faurie et *al*., 1984). It was calculated (Dajoz, 1971) by the following formula:

$$FO\ (\%) = \frac{Pi}{P} \times 100$$

Statistical analysis

For the statistical analyses the analysis of variance (ANOVA) in the case of normal data and the Kruskal-Wallis test for the abnormal data were used. For this, Statistica v.10.0 (StatoSoft) software was used.

3. RESULTS

Individuals number of captured *Rattus rattus* depending on study stations

Following to a trapping effort of the order of 936 trap-nights, realized in the region of Touggourt (palm groves and hangars), a total of 492 individuals of black rats were captured. Over the 13 months of study, the captures showed that the palm groves are more infested then the hangars with the black rat. In first position comes the 1st palm grove (164) with a monthly average of 12.6 ± 9.1 (min = 1; max = 25) (Fig. 1). In second position comes the 2nd palm grove (137) with a monthly average equals to 10.5 ± 8.9 (min = 2; max = 24), while in the last position comes the hangar (97) with an average of 7.5 ± 4.2 (min = 2; max = 14). The comparison between the four stations showed the absence of a difference between the monthly captures ($p = 0.488$), whereas the opposite was observed within each station ($p = 0.0001$).

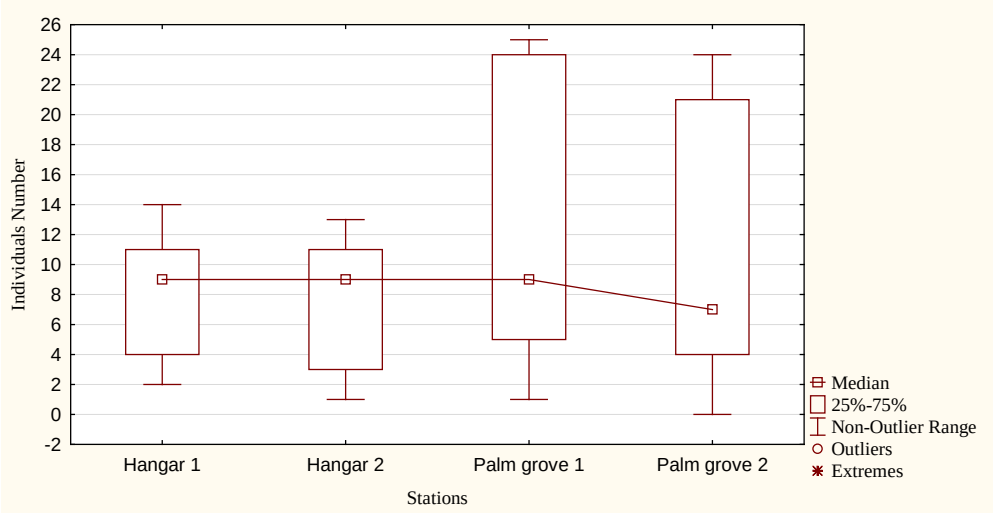

Figure 1. Number of *R. rattus* individuals depending on study stations.

Number of captured *Rattus rattus* individuals depending on months

During the first month of this study, the captures started with 4.5 ± 1.0 individuals (Fig. 2). Just after a fall that was observed until December 2016 (4.5 ± 1.0), there was an increase in the captured individuals number until may (12 ± 3.6) and then a slight decrease that lasted just one month (16.3 ± 7.4), then the capture number increased until September 2017 (18.5 ± 5.8). The comparison of black rat numbers collected during the 13 months of sampling depending on months showed the existence of a highly significant difference ($p = 0.0003$). However, there was a big variability of captures in the months of June (16.3 ± 7.3), July (17 ± 7.0), august (18 ± 7.5) and September (18.5 ± 5.8) (Fig. 2).

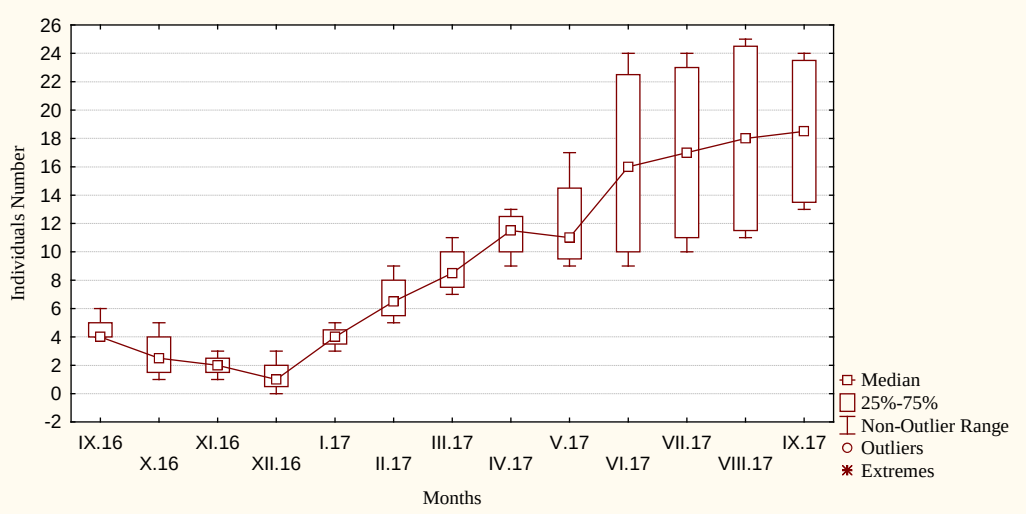

Figure 2. Individuals number of *R. rattus* depending on months.

Relative abundance (AR %), trapping effort (IA %) and monthly density of *R. rattus*

Depending on the sampling effort, the palm groves presented the highest values of the 1st palm grove (17.5%) (Tab. 1), unlike the hangars (10%) which were characterized by the weakest efforts. Thereby, the abundance in individuals followed the same order, the 1st palm grove (33.3%) was characterized by the highest value, while the hangar 2 had the lowest value (19.1%). Unlike the density, the hangars came in first positions with high densities, ranging between 0.49 ind./m² (hangar 2) and 0.97 ind./m² (hangar 1). While the palm groves presented the lowest values (0.04 ind./m²) (Tab. 1).

As for the monthly variations of captures, the month of august posted the highest one in the palm groves ($15.2 \leq AR\ \% \geq 17.5$). It was the opposite in the storage sites where the captures were important during the month of September ($13.8 \leq AR\ \% \geq 14.4$). For the densities, the hangars came in first position by relatively high values recorded during the month of September (0.07 ind./m² in the hangar 2 and 0.14 ind./m² in the hangar 1). While in palm groves, it was the hottest months (June, July, august and September) of the year that offered the max of individuals with a similar density (0.01 ind./m²).

Table 1. Results of monthly sampling of *R. rattus* in the study stations.

	Months	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Total
H1	IA (%)	0.4	**0.2**	**0.2**	0.3	0.4	0.5	1.2	1.3	1.1	1.0	1.1	1.2	**1.5**	**10.4**
	AR (%)	4.1	**2.1**	**2.1**	3.1	4.1	5.2	11.3	12.4	10.3	9.3	10.3	11.3	**14.4**	**19.71**
	D (ind./m²)	0.04	**0.02**	**0.02**	0.03	0.04	0.05	0.11	0.12	0.1	0.09	0.1	0.11	**0.14**	**0.97**
H2	IA (%)	0.4	**0.1**	**0.1**	0.1	0.3	0.7	1.0	1.2	1.0	1.2	1.3	1.3	**1.4**	**10.0**
	AR (%)	4.3	**1.1**	**1.1**	**1.1**	3.2	7.4	9.6	11.7	9.6	11.7	12.8	12.8	**13.8**	**19.10**
	D (ind./m²)	0.02	**0.01**	**0.01**	**0.01**	0.02	0.04	0.05	0.06	0.05	0.06	0.06	0.06	**0.07**	**0.49**
P1	IA (%)	0.6	0.5	0.3	**0.1**	0.5	1.0	0.9	1.4	1.8	2.6	2.6	**2.7**	2.6	**17.5**
	AR (%)	3.7	3.0	1.8	**0.6**	3.0	5.5	4.9	7.9	10.4	14.6	14.6	**15.2**	14.6	**33.33**
	D (ind./m²)	0.002	0.001	0.001	**0.000**	0.001	0.002	0.002	0.003	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.04**
P2	IA (%)	0.4	0.3	0.2	**0.0**	0.4	0.6	0.7	1.0	1.3	2.2	2.4	**2.6**	2.5	**14.6**
	AR (%)	2.9	2.2	1.5	**0.0**	2.9	4.4	5.1	6.6	8.8	15.3	16.1	**17.5**	16.8	**27.84**
	D (ind./m²)	0.001	0.001	0.001	**0.000**	0.001	0.002	0.002	0.002	0.003	**0.01**	**0.01**	**0.01**	**0.01**	**0.04**

H1: Hangar1; H2: Hangar2; P1: Palm grove1; P2: Palm grove2; IA: Sampling effort; AR: Relative abundance; D: Density.

Frequency of occurrence (FO %)

Overall, the occurrence index applied to the captures of *R. rattus*, showed that, it's an omnipresent species (FO = 100%) in both storage sites and in palm grove 1. While in the palm grove 2 (FO = 92.3%), this species was considered as a constant pest (Fig. 3).

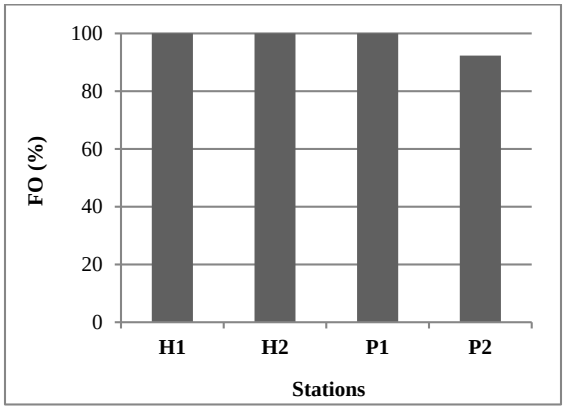

Figure 3. Frequency of occurrence (FO %) of *R. rattus* in the study stations.

Sex-ratio of *Rattus rattus*

Depending on sex, there was a predominance of males (n=300) compared to females (n=192) at all the stations, with an important variability for the captures (Fig. 4). They were high in the 1st palm grove, with values ranging between 1 and 16 for males (7.9 ± 5.5) and between 1 and 10 for females (4.8 ± 3.6), followed by the 2nd palm grove with 6.4 ± 5 for males (min = 2; max = 14) and 4.2 ± 4 for females (min = 1; max = 11). Otherwise, the comparison between the four stations showed the absence of difference between the captures of males (p = 0.4019) and females (p = 0.6488).

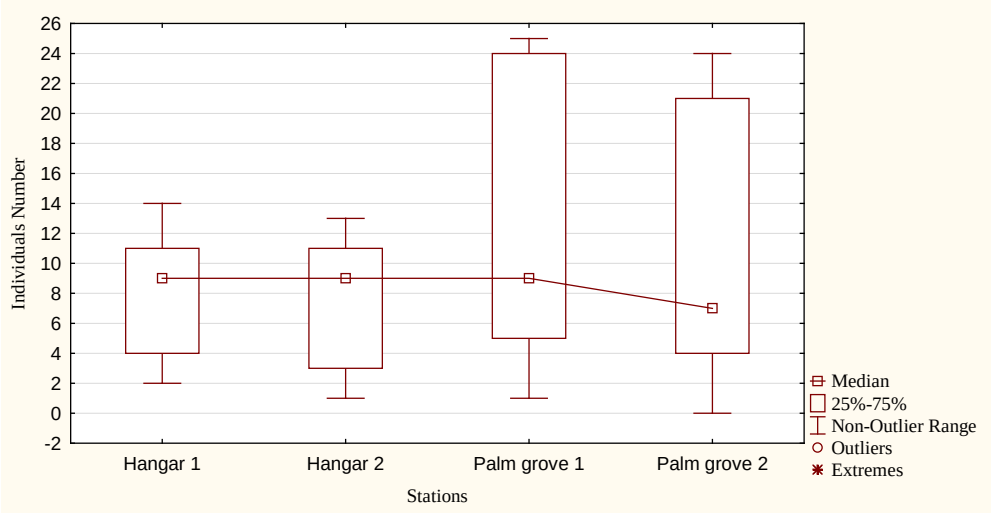

Figure 4. Sex-ratio of individuals of *R. rattus* depending on stations.

Depending on months, the captured number of black rats during the 13 months of sampling showed the existing of a very highly significant difference in males (p = 0.00001) and females (p = 0.00003).

During the month of September 2016, the trapping was a bit weak for both males (3.3 ± 1 individuals/month) and females (1.3 ± 1 individuals/month) (Fig. 5). Thereafter, a decrease was noted until December 2016 (♂ = 1 ± 0.8; ♀ = 0.3 ± 0.5). Just after, an increase in captures was observed until august for males (11.3 ± 3.8) and September for females (8.3 ± 2.8). Otherwise, the captures of the last four months have experienced a great variability, especially in June and July for males and in August and September for females (Fig. 5).

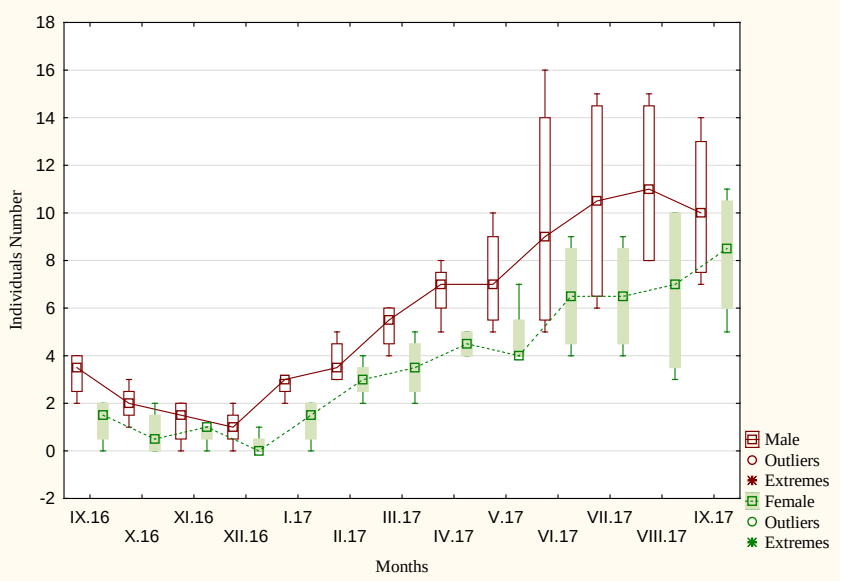

Figure 5. Sex-ratio of individuals of *R. rattus* depending on months.

Age variation of *R. rattus*

Overall, the class of adults came in first position, containing about one-third of the sampled black rat population (33.5%) (Fig. 6). This last class was followed closely by sub-adults (28.6%). On the other hand, the least inventoried were juveniles (15.4%).

Depending on stations, the categories of adult and sub-adult were the most caught in the four stations, especially in palm grove 1 (56 adults and 49 sub-adults) and palm grove 2 (43 adults and 35 sub-adults) (Fig. 6).

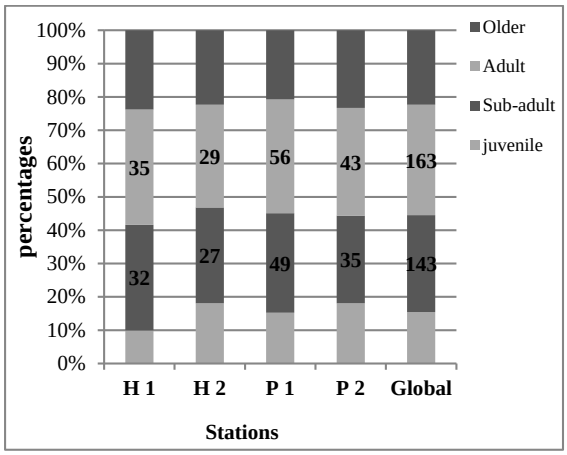

Figure 6. Age variation of *Rattus rattus* captured in the study stations.

Effect of climatic factors on captures of black rats

Trapping of *R. rattus* during a period of 13 months (September 2016 to September 2017) allowed to note that the individuals number increase according to the temperature in the field (r = 0.77235, p = 0.0019726) and stock sites (r = 0.55428, p = 0.049332) (Tab. 2). On the other hand, for the humidity, there was a negative correlation with the captures at the level of the palm groves (r = -0.72806) than in the storage sheds (r = -0.58548). For the wind, it had a positive influence on the rats living in the sheds (r = 0.55755). It should be mentioned that there was a positive correlation between the captures of palm groves and stock sites (r = 0.85872, p = 0.00017073), thus forming the same class (Fig. 7). While the precipitation had no influence on the rats.

Table 2. Correlation matrix applied for the effect of climatic factors on the captures of black rats.

r\p	T m (°C)	HR (%)	FX (m/s)	RR (mm)	NI Han	NI Palm
T m (°C)		**0,00016293**	0,72449	0,63559	**0,049332**	**0,0019726**
HR (%)	-0,85998		0,14364	0,70902	**0,03553**	**0,0047776**
FX (m/s)	0,10839	-0,42889		0,37149	**0,047732**	0,29215
RR (mm)	-0,14537	0,11471	0,27045		0,34023	0,77635
NI Han	**0,55428**	**-0,58548**	**0,55755**	0,28786		**0,00017073**
NI Palm	**0,77235**	**-0,72806**	0,31646	-0,08745	**0,85872**	

T m: Average Temperature; **HR:** Relative Humidity; **FX:** Wind; **RR:** Precipitation; **NI Han:** Individuals number in the hangars; **NI Palm:** Individuals number in the palm groves.

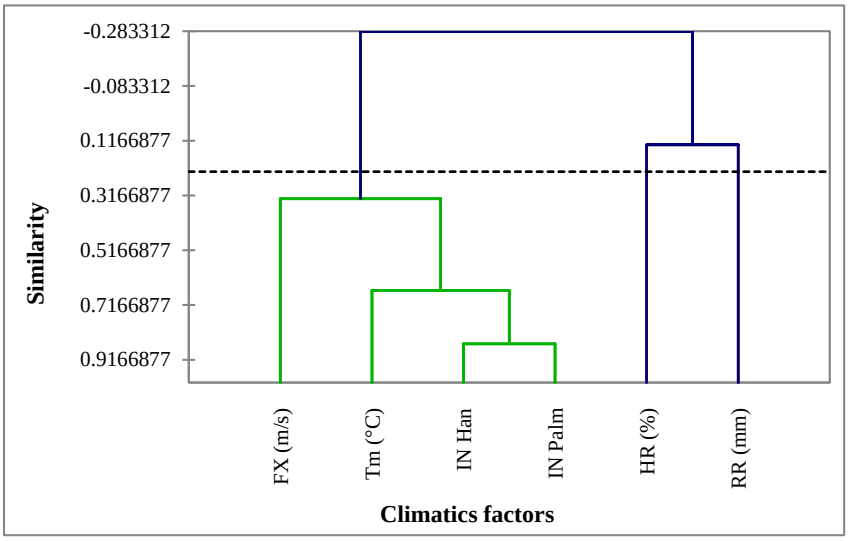

Figure 7. Effect of climatic factors on the captures of black rats.

4. DISCUSSION

Individuals number of captured *Rattus rattus* depending on study stations

Over the 13 months of study, 492 individuals of black rat were captured (IA = 936 trap nights) in the region of Touggourt, with differences between stations (p = 0.0001). Indeed, most individuals were captured in the palm groves (n = 301), which were more infested than hangars (n = 191). These results confirmed those noted by different authors in the palm groves (100%) of Touggourt (Mlik et *al*., 2017) and in a forest environment (90%) in Annaba (Madoui et *al*., 2014). This same remark was reported around the world, particularly in the Mandoto region in Madagascar (Rahelinirina and Duplantier, 1997), and in Oklahoma in the USA (GIRARD et *al*., 1990). On the other hand, in the highlands (Tiaret), Adamou-Djerbaoui et *al.* (2015) reported that this same species (*R. rattus*) occupy the second position (21,9%) after the Shaw's Merione (25.7%). Following a study on the relative biomass of rodents found in the regurgitas of the barn owl *Tyto alba,* in the same study area, Hadjoudj et *al*. (2015) reported that *R. rattus* ranked first (14.1%).

Number of captured *Rattus rattus* individuals depending on months

Depending on month, the captures showed very large differences (p = 0.0003). The coldest months of the year were characterized by low captures. Unlike the hottest months, where the max of trapped individuals presented a great variability, especially in June (16.3 ± 7.3), July (17 ± 7.0), August (18 ± 7.5) and September (18.5 ± 5.8).

It should be noted that the captures were relatively high in the palm groves in August, against September in sheds. These results could be explained by the fact that the month of August coincides with the period of maturity of dates, which justifies the strong captures of rats which are attracted by the fruit. While in September, it is the period of harvest and storage of dates in the hangars.

These results were similar to those reported by Rahelinirina and Duplantier (1997) who observed a marked seasonality of rodent's abundance in the crops with a maximum during the hottest months (July-August) of the year. This is also what Salvioni (1989) noted at Alaotra Lake, which reported high captures during the months of July and August. In Nigeria, Ivoke (2009) recorded a spike for captures made during the warm period of the year (July and August).

Relative abundance (AR %), trapping effort (IA %) and monthly density of *R. rattus*

Depending on the trapping effort that varies between 10 - 17.5%, the palm groves had the highest values, while the

hangars were characterized by the weakest efforts. In an agricultural area located in the region of Souf (Algerian Sahara), Alia et *al*. (2015) indicated abundances ranging between 5 and 17.6%. In Morocco, Echchakery et *al*. (2017) found that black rats have the majority (40.61%) of the captured rodents. On the other hand, in a study carried out in the palm groves of the same study area, Hadjoudj et *al*. (2015) reported that the black rat occupies the second place (23%) after *Gerbillus nanus* (32.3%). While in a forest environment in Hawaii, the black rat had a very high average of abundance (25.5 ind./trap night) (Shiels et *al*., 2017).

For the abundances, the values were strongly influenced by the trapping effort. In fact, the 1st palm grove (33.3%) was characterized by the highest captures, unlike hangar 2 which was characterized by the lowest value (19.1%). Moreover, the opposite was observed in terms of density, it was the hangars that were denser (0.49 and 0.97 ind./m^2), while the palm groves (0.04 ind./m^2) were the least dense in black rats. It should be noted that these results were very high compared to those noted by different authors around the world (Innes, 1977; Clark, 1980; Miller and Miller, 1995; Harper, 2006; Harper and Rutherford, 2016). Indeed, in a forest environment in New Zealand, Innes (1977) reported a density of 0.00028 rat/m^2. While Harper and Rutherford (2016) mentioned values ranging from 0.0028 to 0.0036 rat/m^2.

Frequency of occurrence (FO %)

Based on the occurrence index values, *R. rattus* was either an omnipresent species (FO = 100%) in both storage locations and in palm grove 1, or constant (FO = 92.3%) in palm grove 2. These results confirmed those noted by Hadjoudj et *al*. (2011) who classified black rats as omnipresent species in palm groves in the same study area. Ditto for Hadjoudj et *al*. (2015) reported values of FO% varying between 88.5% and 100% in the same region. This same remark is already reported in several regions, notably by Rahelinirina and Duplantier (1997) in Madagascar (FO> 98%), and by Stokes et *al*. (2009) in southeastern Australia (FO = 86%). By contrast, Sarker et *al*. (2013) mentioned that it is an accidental species in rice cultivation in Bangladesh.

Sex-ratio of *Rattus rattus* depending on study stations

Depending on sex, the males (n = 300) were trapped more compared to the females (n = 192) at all the stations. The palm grove 1 had the highest captures, for both males (7.9 ± 5.5) and females (4.8 ± 3.6). Followed by the palm grove 2, where the males (6,4 ± 5) were always captured more compared to the females (4.2 ± 4). These results were similar to those of Bebba and Baziz (2009) in the same study area, where they found that the males were the most numerous. Dako et *al*. (2002) in the southern Benin noted a high number of males captured compared to females in the black rat. It was also the same for Clout (1980), which recorded a high number of males (58.8%) compared to females (41.2%) in New Zealand. Thus, in the southeastern Australia, Stokes et *al*. (2009) found a predominance of males (72%). On the other hand, in the island of Congreso, VENTURA and LOPEZ-FUSTER (2000) found that there was no significant difference between the two sexes in the black rat. While Ben Faleh et *al*. (2012) in Tunisia and Echchakery et *al*. (2017) in Morocco mentioned the importance of females.

Sex-ratio of *Rattus rattus* depending on months

For the captures depending on months, black rat numbers differed in males (p = 0.00001) and females (p = 0.00003). In September 2016, trapping was a bit low for both males (3.3 ± 1 individuals / month) and females (1.3 ± 1 individuals / month). Subsequently, a decrease was noted until December 2016 (♂ = 1 ± 0.8, ♀ = 0.3 ± 0.5). Just after, an increase in captures was observed until August 2017 for males (11.3 ± 3.8) and September for females (8.3 ± 2.8). These results were different with those recorded by different authors. Stokes et *al*. (2009), reported the importance of males in October and November. On the other hand, Innes (1977) announced the importance of females in July (n = 38).

Age variation of *R. rattus*

The study of age structures showed that the adults (33.5%) and sub-adults (28.6%) were the most important in black rats. It was the most captured at the four stations, especially in the palm grove 1 (56 adults and 49 sub-adults) and the palm grove 2 (43 adults and 35 sub-adults). These last categories constituted the most active age classes. This implied that these categories that are susceptible to cause damage. In addition, Rahelinirina and Duplantier (1997) reported that the adults represent between 50% and 70% of the black rat population sampled in the Mandoto region (Madagascar). Similarly, for Ventura and Lopez-Fuster (2000), which inventoried 42 individuals of black rat, of which 22 individuals belong to the adult class (52.4%). Also, on Pearl Island (New Zealand), Harper (2006) found that the adults (64%) were more surveyed than the other age classes. Stokes et *al*. (2009) found a marked capture of adults than the other classes during the four seasons. By contrast, Tobin et *al*. (1994) found that the sub-adults accounted for 31% of the capture.

Effect of climatic factors on captures of black rats

The climatic factors were essential factors to explain certain results and behaviors of animals. Indeed, the temperature was considered to be the most important limiting factor (Ramade, 2003). According to Faurie et *al*. (2002), the small rodents, at the approach of the bad season, build themselves a nest of leaves and mosses in the trees or sometimes, in old granaries to avoid the torrential rains. As for the precipitation was concerned, it should be remembered that the black rat is an anthropophilic species, so that water expenditure can be easily composed thanks to human practices, especially the irrigation in palm groves.

5. CONCLUSION

The study of the population of *Rattus rattus* recorded in four study stations in the Algerian Sahara, showed that it was an omnipresent species in storage sites, while it was omnipresent to constant in palm groves. These latter were less infested than storage sites which were characterized by high densities. The black rat concentrated during the maturity of dates in palm groves (August) and just after the harvest, it moved towards stocks (September), according to the food resource. The males were more represented than females, with a predominance of the adult age class.

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