Effects of rodent on cultivated barley fields in Southern-Eastern Tunisia

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ABSTRACT

Rodents, particularly those belonging to the Muridae family, can cause serious damage to cereal crops, but little is known about the most sensitive vegetative stage and the amount of losses. In this study, we assess the question of whether rodents (Rodentia: Muridae) caused specific damage to barley cultivated in southern-eastern Tunisia. Based on trapping protocol, we first found that the most common crop pest was Meriones libycus with a relative abundance of 46.34%. The second most common was Psammomys obesus with relative abundance of 17.07%. The genus Gerbillus, in particular G. henleyi, G. nanus, G. pyramidum and G. tarabuli, constituted between 2.43 and 12.19% of the relative abundance. Furthermore, replicated control throughout different vegetative stages showed that all these rodents damage barley crop as soon as seeds appeared and continued until maturity. Losses have been estimated to represent between 6.30 and 14.19% of the potential yield in the maturation stage and in the pre-harvesting stage, respectively. The obtained results will help in the reduction of losses and the development of an effective management of rodent problems in Tunisia.

Key words: Muridae, pests, damage, barley crop, southern-eastern Tunisia.

INTRODUCTION

Rodents are a widespread group of mammals occurring in most terrestrial ecosystems. They are also viewed as major ecosystem components (Shepherd and Ditgen, 2012), and have therefore value as indicators of ecosystem structures, function and changes (Avenant, 2005; Avenant and Cavallini, 2007). Despite their diversity, a tiny minority of species that live in close association with humans are viewed as having negative impact through transmitting disease, contaminating, damaging field crops and consuming stored food (Makundi et al., 1999; Cuong et al., 2002; Manyingerew et al., 2006; Brown et al., 2007; Borowski, 2007; Meerburg and Kijlstra, 2008). Several researchers (Linkie et al., 2007; Meerburg and Kijlstra, 2008; Singleton et al., 2010), considered some rodents as becoming a serious pest issue in some places of the world, leading to significant economic loss. It has been reported that worldwide, Rodentia annually damage up to 25% of food products, 40% of rice and other cereals stocks and 12% of cotton plots (Teka et al., 2002). In France, for example, Le Louran and Quéré (2003) reported that in the cereal fields, the percentage of stems consumed by the terrestrial vole Arvicola terrestris (Linné, 1761) was about 40 to 60% during years of pullulations.

In North Africa, the damage caused by Meriones shawii is considerable especially on wheat and barley (Arroub, 2000; Adamou Djerbaoui et al., 2010). In Algeria, this species can cause losses that reach 7 quintals per hectare (Madagh, 1997). In Tunisia, too little scientific effort has been made to obtain information on the biology, ecology, and behavior of rodent species, and to assess their impacts on crops. In this regard, Singleton (1997) and Meerburg et al. (2004) reported that better knowledge may lead to the development of an effective management of rodent problems through the following four main elements: prevention, monitoring, implementation of a combination of control methods and community involvement in management.

In Tunisia, the cereal crops stand out for its importance...
in diet, as well as its contribution to the national economy. This sector is concerned about 50% of the total number of agricultural operations estimated at 250 thousand and a contribution of 17% to the total of agricultural production (Chebil et al., 2013). However, these crops are faced with difficulties and challenges such as insects, food security and the durability of surfaces cultivated, limited irrigation water resources and an arid climate characterized by frequent drought particularly. To these constraints are added the rodents that have been mentioned as the most important pest mammals in the world. For cereal crops, damage mainly entails all vegetative stages from booting growth until harvest (Sarwar, 2015). Besides, it has been reported that Rodents are the most diverse extant mammal group, with 27 described species in Tunisia (Bernard, 1970; Gharaibeh, 1997). However, there are considerable gaps in knowledge about the most important Rodents’ pest in fields with cereal crops in southern Tunisia, with the exception of the study by Bernard (1977). Also, there is a dearth knowledge about rodents’ biology, behavior and ecology, and assessment of their impacts on crops. Indeed, referring to Singleton (1997) and Meerburg et al. (2004), we believe that raising awareness may go a long way to managing rodent problems. This study was designed to quantify the extent of rodent damage in barley field (*Hordium vulgare*), which is the most cultivated species in the South Eastern Tunisia. In particular, we aimed to (1) identify which rodent species are causing most of the damage, (2) determine the effects of stem cutting on yield and (3) investigate the relationship between rodent damage intensity and barley yield loss for different growth stages. This relationship will be useful for the development of management methods. Also, it will pave way for farmers to minimize losses and to obtain a better yield.

**MATERIALS AND METHODS**

**Study area**

This study was undertaken in an area situated in South East Tunisia. In particular, this area is shared by provinces: the province of Medenine at Latitude 33°21′17″ N, Longitude 10°30′19″ E and elevation above sea level 90 m, and the province of Gabes at Latitude 33°52′53″ N, Longitude 10°05′53″ E and elevation above sea level 9 m (Figure 1). This area is subject to contrasted influences of the Sahara in the West and the Gulf of Gabes in the North East. The average temperature is between 10 and 12°C in winter, 18 and 20°C in spring, 28 and 32°C in summer, and 20 and 22°C in autumn. The annual rainfall is about 200 mm received over approximately 30 days (Ben Fraij, 2016).

**Collection damage data**

This study was carried out between January and May, 2017 in 12 sampling barley fields having areas that vary between 760, 5 and 6760 m². In each sampling site, barley field studies were undertaken during the following vegetative stages: Tillering (T), Booting (B), Maturation (M) and Pre-harvesting (P). During each visit, several parameters were measured (The GPS coordinate, the area, the distance from urban area, the distance from road, the...
total number of stem "NB stem", the number of active burrows at tabias "NB bur/T" and the number of active burrows throughout the field "NB bur/T"). We also counted the cut stem number "NB cut stem" and the stem number per m² "NB stem/m²" using an iron quadrat of 1 m × 1 m. This quadrat is launched randomly in the field, then for reasons of homogenization and representativity, five replications were placed as follows: Three are on the edges of the field and two are inside the field. Thereafter, the damage to the culture was computed in the form of the following ratio:

\[
\text{crop loss (\%)} = \frac{\text{Number of stems cut}}{\text{Total number of stems}} \times 100
\]

**Pattern of rodent’s abundance in barley fields**

Since not any sign of occurrence of rodents during the two first vegetative stages was observed (tillering and booting), two sampling sessions were undertaken during the maturation and pre-harvesting stages. Rodent abundance is based on direct trapping, the presence of active burrows and footprints. For trapping, we used 20 snap traps in each of the 12 sampling barley fields mentioned. To avoid any risk of disturbance such as the mortality of rodent due to over-capture, traps were placed only for two consecutive days (one night) in the burrow entrances showing signs of activity. Traps baited with biscuit dough were spaced 1–3 m apart on each site. The trapping effort reflects the number of rodent individuals caught per 100 trap nights (Avenant and Cavallini, 2007). According to these researchers, a night-trap involves the setting up of a trap for 24 h. According to Hamdine (2000), the abundance index "trapping success" is defined by the following equation:

\[
\text{IA} = \frac{\text{Ni}}{(\text{NNP})} \times 100
\]

Where
Ni: the number of individuals captured for the different species
NNP: the number of night-traps = number of nights × number of traps

After their capture, rodent specimens are transported to the Laboratory for measurement and identification based on a morphometrics gerbils keys (Gharaibeh, 1997), a mammal guide (Aulagnier et al., 2008), and a microscopic observation of the bristle (Incorvaia, 2004)

**Statistical analyses**

One way analysis of variance using the XLSTAT version 9 software and then a Tukey’s Honestly Significant Difference (HSD) test were performed to identify which vegetative stage was more sensitive to rodent damage. Also, correlation analyzes were performed using the Pearson rank correlation procedure in SAS (SAS Institute, 1996) to assess the relationship between the percentage of loss and the different variables taken into consideration during the replicated field controls namely the distance from urban area and distance from road, number of total stem, number of cut stem, stem number/m², loss percentage %, number of active burrows at tabias and the number of active burrows throughout the field.

**RESULTS**

**Rodent trapping in barley fields**

The effort of 240 nights, allowed the capture of 41 individuals which corresponds to a trapping success rate of 17.08%. In total, six rodent species (Meriones libycus, Psammomys obesus, Gerbillus henleyi, Gerbillus nanus, Gerbillus pyramidum and Gerbillus tarabuli) were trapped during the replicated visits. Results showed that the M. libycus was the most dominant species trapped with a relative abundance of 46.34%, followed by P. obesus (17.07%), G. henleyi and G. nanus (12.19%), G. pyramidum (9.75%) and G. tarabuli (2.43%) (Figure 2).

Based on highest density, the M. libycus could be considered as the main responsible rodent pest for the losses recorded in the barley fields. Stem cuts were observed at the vicinity of the burrow of the captured rodent, between 0.5 and 1 cm above the ground from the formation of seeds containing a soft and milky pulp. It was also observed that tillers around rodent galleries were the most threatened by the damage.

**Rodent impact assessment on barley**

The damage caused by rodents on barley fields varied from one vegetative stage to another. Absolutely, the tillering and booting developing stage were marked by the absence of losses. While, during maturation and pre harvesting stages, the number of stem cut increased significantly. The maturation stage was characterized by the presence of watery ripe grain. The quantity of stems cut was about 6.30% (0.013 quintal/ha). As regard the pre harvesting stage, it was distinguished by the presence of hard grain and 14.19% (0.031 quintal/ha) of stems were cut. The cuts of stems carried out during the period of the appearance of the grains gave very different results. Based on comparison of the pre-harvesting stage with other stages, the intensity of the damage inflicted was significant (F=4.55; P=0.007) and the intensity of the damage increased with the maturation of the grain (Table 1). The frequency of occurrence of stem density varied from
Academia Journal of Agricultural Research; Ettiss et al. 275

Figure 2: Comparison of densities of different rodent species recorded in two growth stages of crop (maturation and pre-harvesting) in barley fields.

Table 1: A comparison of damage in barley fields by rodent at various growth stages of crop.

| Stage             | Percent cut stems of Barley | Value   | Standard Error | t   | $P>|t|$ | Lower bound (95%) | Upper bound (95%) |
|-------------------|----------------------------|---------|----------------|-----|--------|------------------|------------------|
| Tillering         | 0                          | 0.000   | 0.155          | 0.000 | 1.000  | -0.311           | 0.311            |
| Booting           | 0                          | 0.000   | 0.000          | -   | -      | -                | -                |
| Maturation        | 6.30                       | 0.251   | 0.155          | 1.624 | 0.112  | -0.061           | 0.562            |
| Pre-harvesting    | 14.19                      | 0.577   | 0.155          | 3.735 | **0.001** | 0.266           | 0.889            |

18.6 to 43.22/ m² for all the sampled fields. In general, it was observed that there is no relationship between the stem density per unit area and the damage degree.

Furthermore, the positive linear relationship between the percentage of loss and the number of active burrows in Tabias ($r=0.58$, $P=0.04$) suggest that the impact caused by rodents is more important around the edges. On the other hand, it is important to note that the damage were observed since the formation of fruit and evolved when the seeds began to ripen and the fields began to dry.

Several factors can influence rodent occurrence in barley fields including anthropogenic factors, such as distance from the urban area ($r=0.66$, $P=0.017$) and distance from the road ($r=0.68$, $P=0.013$). Pearson rank correlations showed that when the distance from the urban area and the distance from the road are important, the number of active burrows at the tabia increases (Table 2).

**DISCUSSION**

The present study showed that rodent caused substantial damage to cereal crop barley in southern Tunisia. The damage is probably caused by the following six rodent species, such as one *Meriones (M. libycus)*, one *Psammomys (P. obesus)* and four *Gerbillus (G. henleyi, G. nanus, G. pyramidum and G. tarabuli)*, that were recorded in barley grass fields. The species that seems a priori the most destructive was *M. libycus* because it is the most abundant at the two stages of cultivation (Maturation and pre-harvesting). Ouzouit and Messaoud (2000), Madagh (1997), Adamou-Djerbaoui et al. (2010, 2011 and 2013) and Bernard (1977) suggested comparable damage caused by *Meriones shawi* in Morocco, Algeria and Tunisia respectively. The findings of the present study are contrary to those found for wheat grass fields in the southwest of Pakpattan and south of Sahiwal District in which the culture damage was ascribed to the lesser bandicoot rat *Bandicota bengalensis* and to Nile grass rat *Arvicanthis niloticus* (Sarwar, 2015; Deskoy, 2015). Interestingly, the present study found that damage began with the formation of seeds and increase with the maturity stage of the barley crop. This finding supports that of Singh and Saxena (1989) who observed more damage at the maturation...
stages. Yet, Hasanuzzaman et al. (2009) pointed out more activity of rat at the grain filling stage when compared with that at the grain maturation stage. Sarwar (2015) also showed that damage occurs throughout the wheat growth period. As reported by Tristani and Murakami (1998), there is increasing evidence that damage is highly variable, and that rodents cause more damage during some stages of growth of crop than during other stages. On the other hand, previous study explained high loss at maturation stage by the fact that seeds have high energy value (Prakash, 1978, 1993; Barnett, 1988; Xiao et al., 2006; Wang and Chen, 2012) and flavor. According to Leirs (1992), Makundi et al. (2009) and Massawe et al. (2011), the major loss during the barley maturation phase can be explained by the fact that this phase coincides with the dry season which is characterized by reduction of other feeding sources for rodent. Although, the current study showed a small damage not exceeding 0.031 quintal/ha, on the contrary, Ouzaouit and Messaoud (2000) and Madagh (1997) considered that damage can reach 4 to 7 quintals of cereal harvests.

The factors found to affect rodent occurrence and therefore crop loss were distances from road and distance from urban area. The results suggest that both variables are positively correlated to the number of active burrows at tabias. One explanation is that rodent become more abundant when going away from urban area and roads. This finding is supported by the evidence that urbanization and roads reduce the quality and quantity of habitat by changing levels of available resources, and therefore affect the dynamics of populations and their densities (Bolger et al., 1997; Forman and Alexander, 1998; Germaine and Wakeling, 2001; Merenlender et al., 2009).

As regard stem density, it seems not to influence the degree of degradation observed in the fields which can be explained by the fact that our fields are characterized by a low frequency and insignificant variability of the density of the stems. Contrary findings have been shown by Poché et al. (1982) who confirms that, in the wheat fields, the damage percent increased with increasing stem density per unit area. They explained that better coverage, guaranteed better protection from predators and home ranges with optimal feeding and coverage. The increasing of the stem density can also reduce feeding time, which reduces energy costs. In addition, higher stem density may mean greater carrying capacity, larger populations, population compression and intolerance, and thus a smaller home range. Similar results have been reported by Sarwar (2015), who confirms that rat predations on the wheat seeds might have great impact on the wheat stem density. Absolutely, when there was sufficient cover in the wheat fields, the rodents especially the bandicoot rat, the gerbil and the mouse began to colonize it.

In general, this study showed that rodent damage in barley fields appeared during seed formation. Among the identified rodents, M. libycus was the most important pest

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