UNGULATE GRAZING IMPACT ON THE LOCAL DISTRIBUTION OF THE RARE SPECIES *RHOPALOMYIA TANACETICOLA* KARSH (DIPTERA: CECIDOMYIIDAE), IN SOUTH SINAI ECOSYSTEM

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INTRODUCTION

Plants provide both the food and the shelter where herbivorous interaction takes place. The modular growth of plants produces different patterns of structural development and a varied size hierarchy (Zamora and Gomez, 1993). The resulting architecture of the plant is a major determinant of the diversity of herbivores, animals that show an impressive array of differences with regard to taxonomic identity, size, and life history strategies (Huntly, 1991). In spite of this ecological complexity, the trophic level of herbivores has long been considered as a "black-box" where competition is the prevalent interspecific interactions and where results of paired competitive interactions might be symmetrical, or nearly so (Abrams, 1987; Shorthouse *et al.* 2005). Many studies indicate that the asymmetrically competitive interactions are more common among herbivores than the symmetrically competitive interactions (Lawton and Hassell, 1981; Stamp, 1984; Karban, 1986). The interspecific relationships between two herbivorous species may range from mutually competitive to mutually beneficial, including amensalism and commensalisms, where only one species is affected (Strauss, 1991a). An asymmetrical result may be the consequence of an indirect interaction of any species (competitor, predator, mutualist) upon a pair of symmetrical competitors (Strauss, 1991b), or can simply result from the interaction between two unequal competitors (Lomnicki, 1988). There are many factors causing inequalities between consumers, belonging to the same trophic level, although the body size is probably the most common (Ebenman and Persson, 1988; Wheeler and Ordung, 2006). When competitors differ in size, an interference mechanism of competition can easily be developed (Polis, 1988). In the case of herbivores, an interference interaction can potentially appear when large herbivores browse on plant tissues where tiny herbivores live.

In the Sinai ecosystem the cecidomyiid midge *Rhopalomyia tanaceticola* Karsh, Cecidomyiidae: Diptera) is a gall forming insect on the *Tanacetum sinaicum* Del. Ex DC. (Compositae), where it develops into adult. The plant, as an edible food, is subjected to an intensive grazing by ungulates. The current study concerned with the impact of grazing by ungulate of the plant on the reproductive success of the insect and hence its local distribution in the study area in addition to some other factors which may affect its distribution.

MATERIAL AND METHODS

Study area

The current study was conducted during March in 3 successive years (2003-2005) in the high mountainous area of St. Katherine South Sinai. The study area is characterized by its dry weather with little rains in winter, which reflected as a unique flora and fauna. The flora of St. Katherine includes some plants with a high economic importance *e.g. Asclepias sinaica, Achillea fragrantissima, Artemisia herba alba, Mentha microphylla, Origanum syriacum, Stachys aegyptiaca,* and *Teucrium polium.*

The study was carried out along an altitudinal gradient ranging from 1620 m.a.s.l. (where the St. Katherine town is located) up to 2440 m.a.s.l. (near to the top of the highest mountain in the area (Gebel Katherine, 2642 m.a.s.l.). The chosen study sites were, wadi El-Arbaein, El Ferra, Farsh Elias and top of Gebel Katherine

Study plant

The plant under study (*Tanacetum sinaicum* Del. Ex DC.) is a shrubby fragrant plant with solitary discoid yellow heads and pinnatifid wooly leaves. Branches are few, stiff, naked in the upper part and terminated by the solitary small heads. It is grown on mountains and on mountain slopes (Tackholm, 1974 and Boulos, 1995).

Study insect

The study insect (*Rhopalomyia tanaceticola* Karsh, Cecidomyiidae: Diptera) is a small delicate yellowish brown midge. It is distributed in Europe and Africa; in Egypt it is rare and found in South Sinai, forming galls on *Tanacetum sinaicum.* The male and female are similar except in body size; the male length is 2.3 mm long, while the female is 2.9 mm long; wing length is 2-2.5 mm. In Egypt only one genus represented by one species is recorded, *R. tanaceticola* (Abdel Rahman,Y.A. 2001)

Grazing and gall distribution

As the plant is one of the most important and preferred plants for grazing ungulates, two different groups of plants were tested: the first one in opened area, where the plants were available to the grazing ungulates. The second group of plants was fenced against the grazing ungulates. Each fenced area measured 10 X 10 meters. The plant size, number of branches and number of galls were measured in each plant within the two groups.

The immature stages of the insect was collected from the field and reared in the laboratory until the adults emerge then, they was identified by experts.

Plant morphology and gall distribution

The size of each plant within the sample was measured (width, length, and height) using a tape meter. The number of branches per plant was also counted, in addition to the number of galls in different parts of the plant.

Age of the plant and number of galls

The sampled plants within the study area were classified into two groups according to their conditions; young plants: which are newly vegetative plant with "newly grown branches" and old plant "last year plant". The number of galls in each plant was counted.

Altitudinal gradient and insect distribution

The mean number of galls per plant was used as an index of insect abundance. Sampling was done at different altitudinal gradient starting from the wadi bed at the town 1620 m.a.s.l. up to 2440 m.a.s.l.

Data analysis

The collected data were analyzed using SPSS computer package.

RESULTS AND DISCUSSION

The ungulates grazing of the *Tanacetum* plant tissues has a clear negative impact on the reproductive success of the gall making midge *Rhopalomyia tanaceticola* Karsh (represented by the number of galls survived). Fig (1) shows that there was a highly significant difference in number of galls between the fenced plants (un-grazed) and non-fenced plants (subjected to grazing) ($\chi^2 = 76$, d.f. =1, $P < 0.0001$).

The plant size also plays a role in the distribution of the galls on the plant. It was clear that the number of galls per plant increases with the increased plant size. Fig (2) illustrates that there was a positive correlation between the plant size and the number of galls per plant in the study area ($r = 0.325$, $P < 0.01$). Moreover, the number of branches inside the plant has a positive effect on the number of galls formed on the plant. There was a positive correlation, in the number of galls, between the number of branched per plant and number of galls per plant in the study area ($r = 0.587$, $P < 0.001$) Fig (3).

On the *Tanacetum* plants, the gall maker midge *Rhopalomyia tanaceticola* forms its galls on plant tissues of both leaves and stems. Meanwhile, the gall maker prefers the tissues of the leaves more than the tissues of the stems (Fig.4). There was a significant difference, in the mean number of galls per plant, between the stems and leaves ($F_{1,19} = 5.478$, $P < 0.03$).

The age of the plant may affect the number of galls formed per plant. It was clear that the insect prefers the branches of the old plants (last year plant) more than the branches of new plants (this year plants) to form galls (Fig.5). There was a significant difference between the two groups of the plant in mean number of galls formed/group ($F_{1,94} = 4.06$, $P = 0.03$).

The altitudinal gradient shows a noticeable effect on the number of galls per plant as it increased gradually with the increased elevation, the higher the elevation the higher the number of galls per plant (Fig.6). There was a high positive correlation between the altitude and the number of galls per plant in the study area ($r = 0.95$, $P < 0.0001$).

Although both the goats and the gall makers are herbivores of *Tanacetum* plants, their relationship is not a typically competitive interaction indirectly mediated by the host plant (Strauss 1991a). On the contrary, the resulting interaction is direct, the goat acting as a true predator of the midge, although this ungulate cannot apparently distinguish the galls from the vegetative tissues. The goat may take the advantage of this incidental insect ingestion, obtaining a reward of nitrogen and oligoelements currently scarce in the vegetative tissues. The key factor governing the interphyletic interaction between the goat and the gall maker is the size difference between the two herbivores (Zamora and Gomez, 1993). Consequently the asymmetrical relationship between the species is a hierarchy, in which the bigger one regulates the smaller one, but the reverse does not occur. Similar case have been reported between frugivore vertebrate and invertebrate seed organisms feeding on the same fruit species (Herrera, 1989), and can be extended to any herbivorous relationship where the species are of markedly different sizes, especially when the small herbivore is sessile and lives on plants intensely foraged by the bigger one. This idea is similar to the hypothesis of Janzen, (1984) concerning the incidental seed dispersion of small plants and grasses by big herbivores, but with the important difference that, in the above case, the indirect interaction does not benefit the gall maker, but instead is true predation. In the current study the edible plant, *Tanacetum sinaicum* is subjected to an intensive grazing by ungulates which consume most of the newly vegetative parts of the plant. This in turn makes the ungulates a regulating factor for the distribution of the gall maker.

A question of great interest in herbivory is how plant traits affect attack by phytophagous insects (Prado and Vieira, 1999). The plant stress hypothesis stated that stressed, slow- growing plants or plant modules are more prone to herbivore attack because they are more nutritive and less protective by defensive chemicals (White, 1984). Alternatively, the plant vigor hypothesis (Price, 1991) proposes that more vigorous, fast- growing plants or plant modules will be preferred by many kinds of herbivores that depend on high meristematic activity, modules of large size, or some chemicals of nutritional property associated with vigor. The current study supports the plant vigor hypothesis as the gall maker prefers the large plants more than the small ones which is clear from the positive correlation between the plant size and the number of galls per plant. Moreover, the number of branches on the plant, as index of the plant size, may also support the same hypothesis, through the positive correlation with the number of galls per plant. In addition, the gall maker prefers the more rewarding parts of the plant to make the gall. Leaves, as the factory of food through the process of photosynthesis make them a preferred part for the gall maker to form galls.

When the gall maker and predator are similar in size, a predator-evasion strategy may consist of modifying the gall characteristics in order to reduce the chance of larval predation. This situation occurs when, for example the predator is an insect parasitoid (Criag *et al.*, 1988) or even when the gall maker interacts with herbivores of similar size (Basset, 1991). However, when the gall maker indirectly browsed by a bigger vertebrate herbivore, an evasion strategy might consist of ovipositing preferentially in the lesser foraged plant parts; avoiding the more foraged ones (Faeth, 1988). In the St. Katherine area, where the study was conducted, the ungulates prefer the fresh newly vegetative parts of the plant, so the gall maker avoid these parts as it prefers the old plants to make the gall, and in turn avoid the risk of predation.

Fig (1): Gall distribution on the Tanacetum plants in the fenced and non fenced sites(X2=76.0, d.f. =1, P<0.0001)

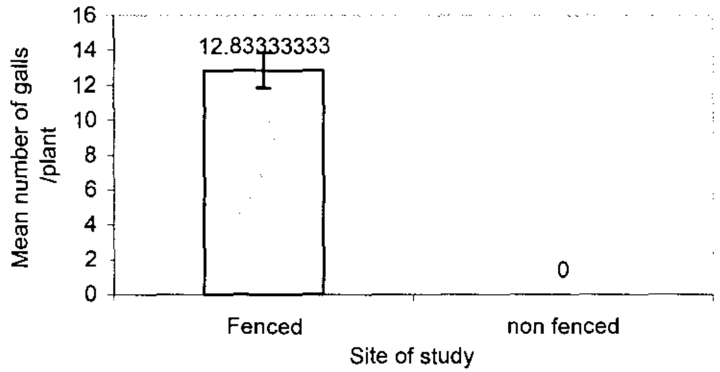


Fig (2): The relationship between the plant size and number of galls on the plant in the study area(r=0.325, P <0.01))

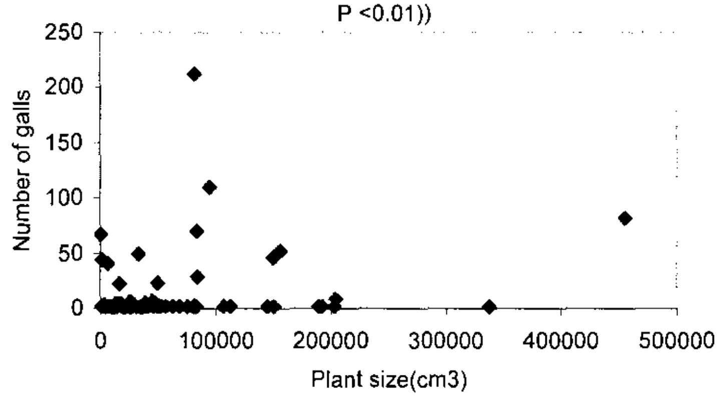


Fig (3): The relationship between the number of branches of the plant and the number of galls on the plant (r =0.587, P <0.01)

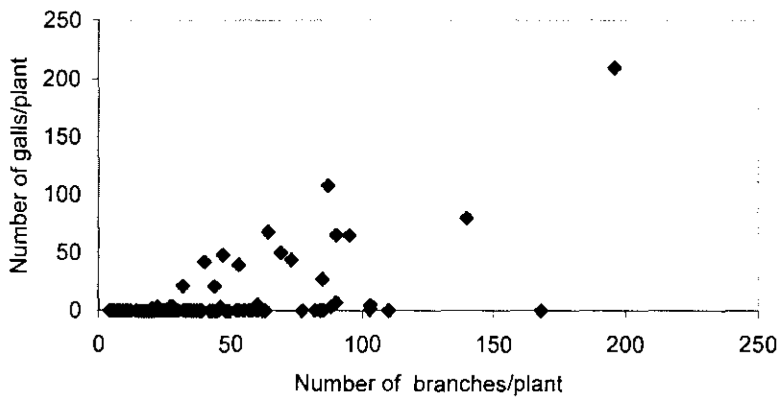


Fig (4): Galls distribution on the Tanacetum at the study area (F1,19 = 5.478, P <0.03)

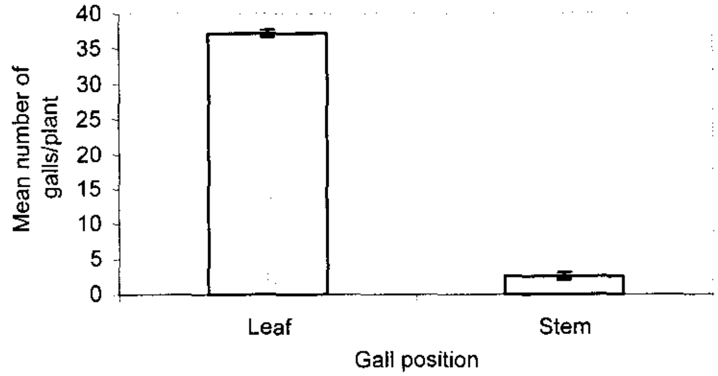


Fig (5): The distribution of galls on the different age groups of the plant (F1,94=4.06, P=0.03)

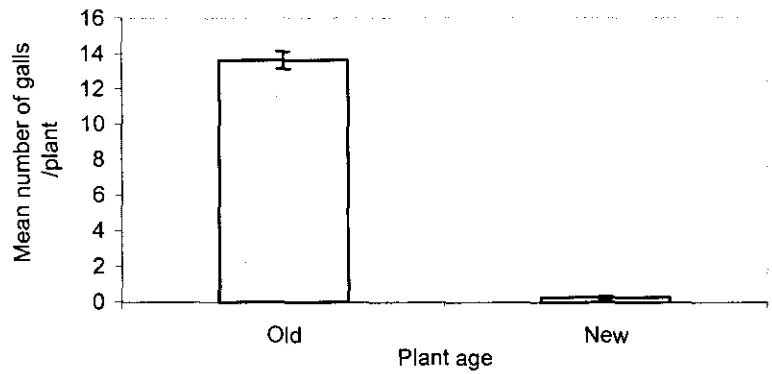
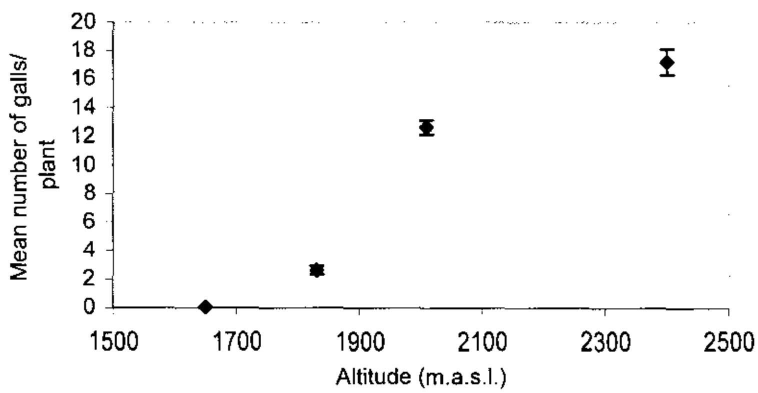


Fig.(6): The relationship between the altitudinal gradient and the number of galls per plant in the study area (r= 0.95, P <0.001)



The positive correlation between the number of galls per plant and the altitude may indicate that the high the altitude the less chance for the ungulates (especially the domestic ungulates) to reach, so the plant size will be bigger and the plants are older and hence a good opportunity for the gall maker to exist without risk of predation.

In conclusion, the grazing ungulates in the area of St. Katherine are considered as a limiting factor of the local distribution of the rare species, gall maker midge *Rhopalomyia tanaceticola*. As the midge has an important biological control agent in different parts of the world, the study recommends to increase the areas of protection (in the form of fenced areas) in the St. Katherine ecosystem to preserve and protect the midge or declare a controlled grazing program in these areas to decrease the risk of predation of this important insect.

SUMMARY

The current study was conducted in the arid ecosystem of St. Katherine, South Sinai, Egypt, in March, 2003 - 2005. It is concerned with the impact of the gazing ungulates on the local distribution of the rare gall maker midge *Rhopalomyia tanaceticola* Karsh (Cecidomyiidae: Diptera) on *Tanacetum sinaicum* Del. Ex DC. (Compositae). The impact of the plant morphology and some environmental factors were also investigated. The study revealed that the ungulates grazing have a clear negative impact on the distribution of the midge. The galls were common on the fenced plants, but no galls were found on the plants subjected to the ungulate grazing. The plant morphology (plant size and number of branches) has a positive effect on the distribution of the insect. The insect makes the galls on stems and leaves, but it prefers leaves more than stems. Also, the midge prefers the old plants more than the new vegetative ones. The altitudinal gradient has a positive effect on the midge as the number of galls per plant increases by the increased altitude.

Key words: Grazing – ungulates –galls - *Rhopalomyia tanaceticola* Karsh- Cecidomyiidae - *Tanacetum sinaicum* Del. Ex DC

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