

BIASED SEX RATIOS IN SPANISH POPULATIONS OF *PISTACIA LENTISCUS* (ANACARDIACEAE): THE POSSIBLE ROLE OF HERBIVORY

by

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Resumen

HJÄLTÉN, J., M. ÅSTRÖM, E. ÅBERG & K. DANELL (1993). Proporciones desequilibradas de sexos en poblaciones españolas de *Pistacia lentiscus* (Anacardiaceae): El posible papel de la herbivoría. *Anales Jard. Bot. Madrid* 51(1): 49-53 (en inglés).

Se determinaron las proporciones de plantas masculinas y femeninas en dos poblaciones de lentisco (*Pistacia lentiscus*), así como el grado de herbivoría por insectos en cada uno de los sexos. Se encontraron porcentajes de 60-70% de pies femeninos en las poblaciones estudiadas. Sin embargo, no se encontraron diferencias en el daño causado por insectos a las hojas de pies masculinos y femeninos, respectivamente. Tampoco se detectaron diferencias en la cantidad de nitrógeno foliar, la cual es un factor importante que determina la calidad de las hojas como alimento. Nuestros resultados sugieren que la herbivoría por insectos no es responsable de las proporciones desequilibradas de sexos encontradas en las poblaciones estudiadas de lentisco.

Palabras clave: *Pistacia lentiscus*, proporciones de sexos, herbivoría por insectos, concentración de nitrógeno.

Abstract

HJÄLTÉN, J., M. ÅSTRÖM, E. ÅBERG & K. DANELL (1993). Biased sex ratios in Spanish populations of *Pistacia lentiscus* (Anacardiaceae): The possible role of herbivory. *Anales Jard. Bot. Madrid* 51(1): 49-53.

Sex ratios in two populations of the Mastic tree (*Pistacia lentiscus*) were determined and the degree of insect herbivory on leaves was estimated for each sex. The populations were female biased, consisting of 60% to 70% females. However, no differences in the degree of insect damage on leaves was found between male and female trees. Similarly, no sex-related differences in leaf nitrogen content, which is known to be an important determinant of food quality, were found. Our findings suggest that insect herbivores are not responsible for the female biased sex ratios in mastic tree populations.

Key words: *Pistacia lentiscus*, sex ratios, insect herbivory, nitrogen concentration.

INTRODUCTION

Male and female individuals of dioecious plant species differ in many respects, including floral number, flower size and nectar content (LLOYD & WEBB, 1977), leaf size (CONN, 1981) and tissue chemistry (STANFIELD, 1937, 1944; THIEME, 1965; PRICE & *al.*, 1989; DANELL & *al.*, 1991; HJÄLTÉN, 1992).

In some cases sex-related differences can be detected by herbivores, as reflected in their preference for one of the sexes. For

example, voles feeding on willows were found to prefer male plants over females (DANELL & *al.*, 1985, 1991; ELMQVIST & *al.*, 1988), and hares preferred the males of a number of *Salicaceae* species (HJÄLTÉN, 1992). Theoretically, sex-differentiated utilization of dioecious plants by herbivores could influence the sex ratios in plant populations. ELMQVIST & *al.* (1988) suggested that the observed tendency for sex ratios in willow populations to become increasingly more female biased towards the northern part of Scandinavia was the combined result

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of differential feeding by voles on the two sexes and the northward increase in herbivore pressure.

However, sex ratio variation in dioecious plants could also be a result of spatial segregation of sexes along environmental gradients (see BIERZYCHUDEK & ECKHART, 1988 for review), and differences in reproductive cost between sexes (ELMQVIST & GARDFJELL, 1988; ELMQVIST & *al.*, 1991) could be one explanation for such a segregation.

Differences in palatability between sexes are not confined to the *Salicaceae* family; insect herbivores are also able to detect these differences in other plant families. For instance, ÅGREN (1987) reported that levels of feeding associated leaf damage were higher on males than on females in the herb *Rubus chamaemorus* L. (*Rosaceae*), and ELMQVIST & GARDFJELL (1988) found a similar pattern in *Silene dioica* L. (*Caryophyllaceae*). Furthermore, results from other biomes suggest that this phenomenon is not restricted to the boreal zone (ALLIENDE, 1989; BOECKLEN & *al.*, 1990). In both the above studies higher numbers of insect herbivores were found on male willows and KRISCHIK & DENNO (1990) reported similar results for the shrub *Baccharis halimifolia*.

The Mastic tree, *Pistacia lentiscus* L. (*Anacardiaceae*), is a dioecious evergreen shrub widely distributed in the Mediterranean area (POLUNIN & SMYTHIES, 1973) which is fed upon by many species of herbivores (DAVATCHI, 1958). For information on the species' natural history see JORDANO (1988, 1989) and references therein.

The aim of this study was to determine whether biased sex ratios occur in natural populations of *Pistacia lentiscus* and to determine whether sex-related differences in palatability exist. The following questions were addressed: 1) Do male and female individuals of *Pistacia lentiscus* occur in equal numbers? 2) Does the degree of insect herbivory differ between sexes? 3) Does the concentration of nitrogen (a rough measure of food quality, e.g. MCNEIL & SOUTHWOOD, 1978) differ between the sexes?

METHODS

Sex ratio

At two localities in Southern Spain (Huelva and Jaén provinces) we collected information on the sex ratios of *Pistacia lentiscus*. The two localities were El Rocío 60 km SW of Seville (36°8' N; 6°28' W) and La Carolina (38°7' N; 3°38' W) 20 km NW of Linares. We visited the sites on 11 and 17 April 1989, respectively, when plants were flowering and therefore easy to sex. At each site we walked along line transects and counted the number of male and female plant genets (total no. 206 and 95 at El Rocío and La Carolina, respectively) within an area of approximately 5 ha. *Pistacia* drops the inflorescences shortly after flowering and we therefore had to scan the ground below the bushes for flowers in order to sex some of the genets. However, we were not able to accurately sex all genets encountered and we estimate the number of unsexed genets as less than 5% of the total number of genets.

Degree of herbivory

At one of the above sites (El Rocío) we investigated the degree of leaf herbivory by haphazardly selecting 1 to 2 m high shrubs of *Pistacia*. The shrubs were growing beneath 10 to 15 m high trees of *Pinus pinea* L., and we selected shrubs growing on microsites where the crown coverage of *Pinus* was approximately 75%. Dominant plants in the shrub layer were *Cistus* spp. and *Halimium halimifolium* L. together with *Pistacia*. The proportion of the total leaf area removed by insect herbivores was determined (four feeding intensity classes were used 0, 1-10, 11-50 and more than 50% of the leaf area removed) for 20 haphazardly selected leaves (1 year old) from the upper part of the crown (i.e. the whole compound leaf) on each of 30 male and 30 female shrubs.

Nitrogen concentration in leaves

At the El Rocío site every fourth leaf examined on 15 male and 15 female plants was

saved for future chemical analysis, unless it had been damaged by herbivores. In such cases we selected a new, intact leaf. The five leaves from each shrub were dried at room temperature, milled to pass through a 1.0 mm screen and analysed to determine their nitrogen concentration on a CHN elemental analyser (Perkin-Elmer 2400).

RESULTS

At both localities we found statistically sig-

nificant female-biased sex ratios (Table 1), with 60-70% of each population consisting of females. The highest proportion of females were found in the El Rocío population. The mean degree of damage per shrub and the incidence of leaf herbivory, which was consistently low, did not differ significantly between males and females (Wilcoxon rank sum test, $P > 0.05$) (Table 2.). Similarly, nitrogen concentration did not differ between the sexes ($P > 0.05$) (Table 3).

TABLE 1

SEX RATIOS OF *PISTACIA LENTISCUS* AT THE TWO SPANISH LOCALITIES. THE 95% CONFIDENCE LIMITS WERE CALCULATED USING A BINOMIAL DISTRIBUTION TABLE (***, $P < 0.001$; **, $P < 0.01$)

Localities	No. of males	No. of females	Sex ratio % males	95% C.L.	Chi-square	P
El Rocío	63	143	30.6	24.3-37.4	30.3	***
La Carolina . . .	34	61	35.8	24.9-43.8	7.1	**

TABLE 2

LEAF HERBIVORY ON *PISTACIA LENTISCUS* AT THE EL ROCÍO SITE. MEAN AND STANDARD DEVIATION GIVEN FOR $N = 30$. DIFFERENCES IN MEAN LEVELS OF HERBIVORY (four feeding intensity classes were used 0, 1-10, 11-50, and more than 50% of leaf area removed) BETWEEN THE SEXES WAS ANALYSED USING A WILCOXON RANK-SUM TEST

Sex of plant	Degree of leaf herbivory (mean damage class)	P
Male	0.75 ± 0.28	$Z = 0.097$
Female	0.73 ± 0.22	
		0.923

TABLE 3

LEAF NITROGEN CONCENTRATION OF MALE AND FEMALE PLANTS OF *PISTACIA LENTISCUS* AT THE EL ROCÍO SITE. MEAN AND STANDARD DEVIATION GIVEN FOR 15 PLANTS OF EACH SEX. DIFFERENCES IN NITROGEN CONCENTRATION BETWEEN THE SEXES WERE ANALYSED USING AN INDEPENDENT SAMPLE T-TEST

Sex of plants	Concentration of nitrogen (percent of dry mass)	P
Male	1.23 ± 0.18	$t = 0.159$
Female	1.24 ± 0.24	
		> 0.875

DISCUSSION

LLOYD (1973) pointed out that female-biased sex ratios are rare among woody perennials. ELMQVIST & *al.* (1988) noted that there is little reason to believe that the life history traits of willow differ in any important respect from those of other woody plants with equal or male-biased sex ratios. They consequently concluded that the voles' preference for feeding on male plants was the mostly likely cause of the female-biased sex ratios of willows in boreal areas. DANELL & *al.* (1991) confirmed that voles prefer male willow individuals, and HJALTÉN (1992) found that hares do also. These results, together with the fact that willows are generally highly preferred by voles and hares, support the hypothesis proposed by ELMQVIST & *al.* (1988).

Insect herbivores can also detect sex related differences in plant palatability, both in willows (ALLIENDE, 1989; BOECKLEN & *al.*, 1990) and other dioecious plants (ÅGREN, 1987; ELMQVIST & GARDFIJELL, 1988; KRISCHIK & DENNO, 1990). However, there is little evidence suggesting that insect herbivores can change the sex ratio of their host plants. For *Pistacia lentiscus* we found a female-biased sex ratio. However, our results differ from earlier reports of even sex ratios in *Pistacia* populations (JORDANO, 1988; C. Herrera, pers. comm.). The reason for this discrepancy is not clear. One possibility would be that some bias occurs in our data. Such bias could arise in cases where it is impossible to accurately sex all genets and the probability of remaining unsexed is greater for one sex. This could be a problem with *Pistacia*, since males are more difficult to sex than females (P. Jordano, pers. comm.). However, our *Pistacia* individuals were generally quite easy to sex and a very limited number of individuals lacked flowering parts, i.e. the proportion of plants that could not be scored was not big enough to make up for the sex ratio bias. One explanation for differences in sex ratio between our study and that of JORDANO (1988) could be the presence of sex ratio variations along environmental gradients (see BIERZYCHUDEK & ECKHART, 1988 for

further discussion). If some kind of spatial segregation of sexes occurs in *Pistacia* and the habitat used in our study favours females, this could theoretically explain why our sex-ratio results differ from those in earlier studies. However, sex differentiated herbivory in combination with different herbivore pressure in different habitats could possibly also explain sex ratio variations between habitats (DANELL & *al.*, 1991).

We did not find any differences in the level of insect herbivory between sexes. Furthermore, there were no differences in nitrogen concentration between sexes. Differences in nitrogen concentration in other plant species have been reported earlier (ALLIENDE, 1989; BOECKLEN & *al.*, 1990; HJALTÉN, 1992) and could give rise to sex related differences in plant palatability.

The fact that we were unable to detect differences in the degree of insect herbivory between sexes does not necessarily mean that herbivores could not influence sex ratios in *Pistacia*. The level of leaf herbivory was very low in our study, suggesting that we may have focused on the wrong herbivore. During the course of our study we found that the stems of the *Pistacia* shrubs often were scarred by mammalian herbivores. Since rabbits are very abundant in this area they were probably responsible for the scars. Sex-related differences in digestibility and phenolic concentrations, which could effect palatability, have been reported for woody plants (THIEME, 1965; PRICE & *al.*, 1989; BOECKLEN & *al.*, 1990; HJALTÉN, 1992), and it is possible that mammalian herbivores can detect such differences. This could result in one sex being subjected to greater herbivore pressure than the other, and theoretically, higher mortality rates in the sex fed upon most could result in skewed sex ratios.

However, skewed sex ratios on dioecious plants could have other causes as well. Thus, biased sex ratios could also be explained by spatial segregation of the sexes (for review see BIERZYCHUDEK & ECKHART, 1988), which could be due to gender-related differences in mortality between environmental patches, individual sex choice,

maternal adjustment of the progeny sex ratio, active habitat selection, and differences in germination requirements between male and female seeds. Furthermore, there are at least three genetically based hypotheses that could account for female-biased sex ratios in dioecious plants (see ELMQVIST & *al.*, 1988). Further studies are therefore needed to determine whether or not *Pistacia lentiscus* populations generally are female biased and, if so, to explain the predominance of females in the populations.

ACKNOWLEDGEMENTS

The work described here was carried out in connection with a postgraduate course in Spain. We thank C. Herrera and P. Jordano for valuable comments on the manuscript and D. Tilles for correcting the English. This study was financially supported by the Faculty of Forestry at the Swedish University of Agricultural Sciences, The Kempe Foundation and "1959 års fond".

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