

Study of the Diet of *Locusta Migratoria Cinerascens*

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Abstract

This work focuses on the dietary preferences of *Locusta migratoria cinerascens* (Orthoptera: Oedipodinae) in irrigated crops under pivot systems in the Adrar region of the Algerian Sahara. The variations in the dietary preferences of the migratory locust depend on floristic diversity, overall coverage, and environmental conditions. The results showed that individuals of *Locusta migratoria cinerascens* have a food spectrum based primarily on grasses, particularly *Sorghum vulgare*, with an occurrence frequency of 82.75% in males and 84.61% in females, and on *Lolium multiflorum* (with an occurrence frequency of 50% in males and 43.58% in females). In terms of plant species consumed in the field, males accounted for 30% while females consumed 25%.

Keywords: *Locusta migratoria cinerascens*, Adrar, dietary habits, pivot irrigation crops.

INTRODUCTION

Algeria has experienced the appearance of *Locusta migratoria* in three periods: before 1943 (Chopard, 1943); 1946-1956 (collections); and from 1988 to the present (theses and studies). In 1994, the species was found in the irrigated areas of Zaouiet-Kounta (Adrar) by survey teams from INPV (Drias, 1994). The development of land and the expansion of cultivated cereal areas in southern Algeria, particularly through the implementation of pivot irrigation systems, have led to a rapid and concerning increase in *L. migratoria*, as these irrigated areas provide a favorable biotope for its reproduction (Ould-El Hadj, 2000). Following the appearance of the migratory locust in Algeria starting in 1943, and the establishment of irrigated areas in the Sahara regions after 1991, particularly in the Adrar region from 1994, we deemed it useful to conduct a bioecological study (dietary habits) of this species.

MATERIALS AND METHODS

The Adrar province is located in southwestern Algeria in the central Sahara, approximately 1543 km from the capital and at an altitude of 279 m. Its latitude is (27° 49' N- 0° 11' E) (Anonymous, 2004). It covers a total area of 242,139 km², which represents 19.97% of the national territory (Dubost, 2002). The annual relative humidity does not exceed 27.9%. The Adrar region is characterized by a dry period that extends throughout the year. It can also be said that our study area is part of the Saharan bioclimatic zone with a temperate winter.

Our work took place in the Adrar region from September 2007 to April 2008. Our sampling was conducted at two stations that are considered sites of signs for this locust. The Sbahi area is located 30 km north of the city of Adrar in the Tsabit district. Its geographic coordinates are 28°13'N 0°09'W, at an altitude of 230 m. The total area of the station is 300 ha. The Moulay Nadjem station is situated 120 km south of the city of Adrar and at an altitude of 390 m (Khider, 1999). Its geographic coordinates are 27°04'N 0°08'W.

We collected the maximum number of *Locusta migratoria* individuals encountered randomly. These individuals were placed in plastic bags, on which the date, capture location, and station name were noted. They were kept in this manner for 24 hours to empty their digestive tracts. The feces were preserved in paper cones labeled with the date, capture location, and sex of the individual.

The plants collected randomly in the two study stations throughout the plot were placed in paper bags to create a herbarium; the identification was carried out by Mm Ben Houhou.

The plants collected to create the reference epidermotheque will be used to determine, by comparison, the plant species contained in the feces of *Locusta migratoria*.

2.2- Study Technique of the Diet of *Locusta migratoria cinerascens*

The creation of reference epidermal libraries is done using the aerial parts of plants, stems, leaves, and flowers. The epidermises are prepared according to a classical technique (Ould El Hadj, 2004). The epidermises are carefully detached from the underlying tissues using fine tweezers. The obtained epidermises are then immersed in 12% bleach for a few seconds to lighten them and to better visualize the structures of the cell walls. After rinsing in distilled water, they undergo baths for a few seconds in progressively concentrated alcohol (75%, 90%, then 100%). The treated epidermises are preserved between a slide and a coverslip in Faure's liquid. Finally, the preparation is placed on a heating plate to eliminate air bubbles. Under microscopy, the cells of the plant epidermises can be seen.

2.2.3- Analysis of the feces of *Locusta migratoria cinerascens*

The feces analysis techniques are inspired by the method of Launois-Luong (1975), which involves first softening the samples in water for 24 hours, allowing fragments to be released without damaging them. Then, the epidermal fragments are clarified in sodium hypochlorite for a few seconds to a minute, undergoing a discoloration without apparent destruction of the epidermis. The subsequent procedures are identical to those used for all the plant epidermises collected at the two sites.

3- METHODS FOR EXPLOITING THE RESULTS

We refer to total and average richness, relative frequency of plant species in the feces, and statistical methods (Excelle and Statistica software 6.2).



Fig. 1 Location of the study area.

RESULTS

1- The plant species consumed by the migratory locust in Adrar

The results obtained from the reference epidermotheques and the epidermises present in the feces are illustrated in figure 2.

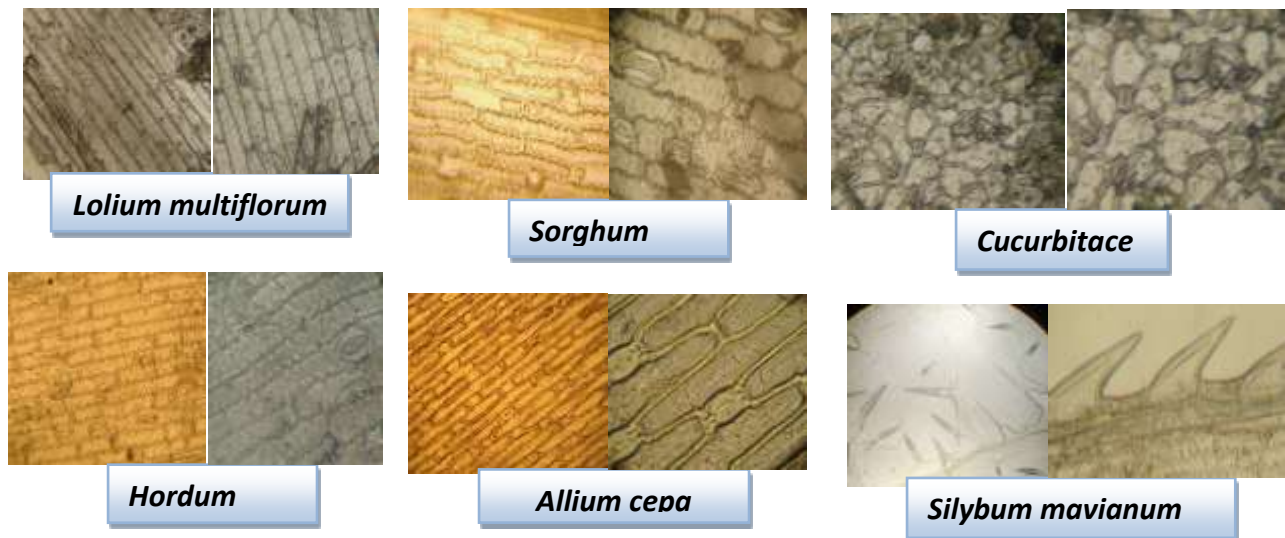


Fig.2 Comparison between the epidermis of the collected plant species and that found in the feces of *Locusta migratoria*.

2.2- Total richness, averages, and frequencies of the plant species identified in the feces of *Locusta migratoria*

2.2.1- Total and average richness

In our work conducted at two different stations in the Adrar region, we analyzed the feces of: 58 males and 39 females for the two stations Sbahi and Moulay Nadjem. The nature and number of plant species consumed per individual, along with the total richness of vegetation per individual, are summarized in Table 1.

Tab.1- Number of plant species consumed by each captured individual

Stations	Sorties	Sexe	N° Ind.	Plant species						n
				<i>S.vul.</i>	<i>L.mul.</i>	<i>H.vul.</i>	<i>S.mav</i>	<i>Cucurb.</i>	<i>A.cepa</i>	
Sbahi	16-09-2007	M	01	++	-	-	+	-	-	2
			02	++	-	-	-	-	-	1
			03	+	-	-	++	-	-	2
			04	+	+	-	-	-	-	2
			05	+	++	-	-	-	-	2
			06	+	+	-	-	-	-	2
			07	+	-	-	-	-	-	1
			08	++	-	-	+	-	-	2
			09	+	-	-	-	-	-	1
			10	++	-	-	-	-	-	1
			11	++	-	-	-	-	-	1
			12	+	+	-	-	-	-	2
			13	+	-	-	-	-	-	1
			14	-	+	-	+	-	-	2
			15	++	-	-	-	-	-	1
			16	++	-	-	-	-	-	1
			17	++	-	-	-	-	-	1
			18	++	-	-	-	+	-	2
			19	-	+	-	-	-	-	1
			20	++	-	-	-	-	-	1
			21	++	-	-	-	-	-	1
			22	-	+	-	-	+	-	2
		F	01	+	-	-	-	-	-	1
			02	+	++	-	-	+	-	3
			03	++	-	-	-	-	-	1
			04	-	+	-	-	-	-	1
			05	++	-	-	-	-	-	1
			06	+	+	-	-	-	-	2

			07	++	-	-	-	-	-	1
			08	+	-	-	-	-	-	1
			09	-	+	-	-	-	-	1
			10	+	+	-	-	-	-	2
			11	+	-	-	-	-	-	1
			12	++	-	-	-	-	-	1
			13	++	+	-	-	-	-	2
			14	++	-	-	-	-	-	1
			15	++	-	-	-	-	-	1
			16	+	+	-	-	-	-	2
			17	+	++	-	-	-	-	2
			18	-	-	-	+	-	-	1
	16-10-2007	M	01	+	-	+	-	-	-	2
			02	+	-	-	-	-	-	1
			03	-	+	+	-	-	-	2
			04	++	-	-	-	-	-	1
		F	01	+	-	+	-	-	-	2
			02	++	-	-	-	-	-	1
			03	+	+	-	-	-	-	2
			01	+	-	-	-	-	-	1
			02	+	++	-	-	-	-	2
			03	-	+	-	-	-	-	1
			04	++	-	-	-	-	-	2
	28-12-2007	M	01	+	-	-	-	-	-	1
			02	+	++	-	-	-	-	2
			03	-	+	-	-	-	-	1
			04	+	-	-	-	-	-	1
			05	+	+	-	-	-	-	2
		F	01	+	-	-	-	-	-	1
			02	++	-	-	-	-	-	1
			03	-	+	-	-	-	-	1
			04	++	-	-	-	-	-	2
			01	+	-	-	-	-	-	1
			02	-	+	-	-	-	-	1
			03	++	-	-	-	-	-	1
			04	+	+	-	+	-	-	3
			05	+	-	-	-	-	-	1
			06	+	+	-	+	-	-	3
			07	++	-	-	-	-	-	1
			08	+	+	-	+	-	-	3
			09	++	-	-	-	-	-	1
			10	+	+	-	+	-	-	3
			11	+	-	-	-	-	-	1
			12	+	+	-	-	-	-	2
		F	01	+	+	-	-	-	-	2
			02	++	-	-	-	-	-	1
			03	+	-	-	-	-	-	1
			04	+	-	-	-	-	-	1
			05	+	-	-	-	-	-	1
			06	+	-	-	+	-	-	2
			07	++	-	-	-	-	-	1
			08	+	-	-	+	-	-	2
			09	+	+	-	-	-	-	2
	28-02-2008	M	01	+	+	-	-	-	-	2
			02	+	++	-	+	-	-	3
			03	+	+	-	+	-	-	3
			04	+	+	-	-	-	-	2
			05	+	+	-	-	-	-	2
			06	+	++	-	+	-	-	3
		F	01	+	+	-	-	-	-	2
			02	-	++	-	+	+	-	3
	02-04-2008	M	01	+	+	-	+	-	-	3
			02	+	+	-	+	-	-	3
			03	-	-	+	-	-	-	1
			04	+	+	+	+	-	-	4
			05	-	+	+	-	-	-	2
			06	-	-	+	-	-	-	1
			07	+	+	-	+	-	-	3

		F	08	+	+	-	+	-	-	3
			09	-	-	+	-	-	+	2
			01	+	+	+	-	-	-	3
			02	+	+	-	-	-	-	2
			03	-	+	+	-	-	-	2

M : male ; F : female ; n : total wealth; ++ : dominant species; + : presence ; - : absence.

S.vul. : *Sorghum vulgar* ; *L.mul.* : *Lolium multiflorum* ; *H.vul.* : *Hordum vulgar* ;

S.mav. : *Silybum mavianum* ; *Curcur.* : *Curcubitacea* indéterminée. ; *Al.cep.* : *Allium cepa*.

The results of total wealth and average wealth of both sexes for each output and for each station are recorded in the following table.

Table 2 - Total wealth and average wealth of plant species found in the feces.

Stations	Outputs	Sex	Total wealth	Average wealth
Sbaihi	16/09/2007	Males	4	1,45±0,50
		Femalles	4	1,38±0,60
	16/10/2007	Males	3	1,5±0,57
		Femalles	3	1,66±0,57
Moulay Nadjem	16/10/2007	Males	2	1,4±0,54
		Femalles	2	1,25±0,5
	28/12/2007	Males	3	1,75±0,96
		Femalles	3	1,44±0,52
	28/02/2008	Males	3	2,5±0,54
		Femalles	4	2,5±0,70
	02/04/2008	Males	5	2,44±1,01
		Femalles	3	2,33±0,57

According to the table above concerning the dietary study of *Locusta migratoria* during the year 2007/2008 in the Adrar region, with four samples taken at the Moulay Nadjem station, it is observed that males consumed the most plant species with a total of 5 plants (Tab. 2). For females, the total richness in consumed plant species is lower (3 plants) during the month of April. At the same station in February, females consumed 4 plant species while males only took 3 plant species. In December, both sexes consumed 3 plants. During the first outing, the feces of both sexes contained only 2 species. At the Sbaihi station, two samples were taken. The first outing shows that the dietary spectrum of males of *Locusta migratoria* consists of four plant species (Tab. 2). The same applies to females. However, for the second outing, three plant species were identified in the feces of both females and males. It can be said that the total richness as well as the specific richness of plant species consumed by females and males have the same values, except at the Moulay Nadjem station where the total and average richness of plant species ingested by males is higher than that of females (Tab. 2).

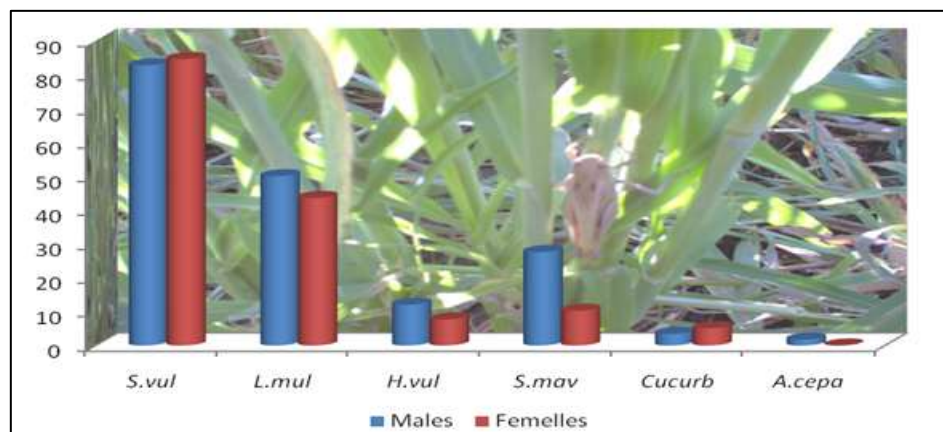


Fig. 3 - Frequencies of plant species identified in the feces of *Locusta migratoria*

2.2- Qualitative study of the dietary habits of *Locusta migratoria* in the two study stations

In our work, the study of dietary habits is primarily based on the qualitative aspect, which involves determining the dietary spectrum. This was carried out on all the feces of the grasshoppers captured in the two stations of the Adrar region.

The two stations, Moulay Nadjem and Sbahi, are agricultural operations characterized by pivot irrigation where sorghum is cultivated, along with vegetable crops, and in the palm groves, there are micro-plots for tomato cultivation. The analysis of the feces is conducted for all individuals captured in these stations.

The presence or absence of plant species in the field and in the feces of both sexes of all individuals of the migratory locust are recorded in Table 3.

Tab. 3- The presence or absence of plant species in the field and in the feces of individuals.

Botanical family	Plant species	Field presence	Presence in the feces	
			males	females
Chenopodiaceae	<i>Chenopodium album</i>	P	a	a
Poaceae	<i>Sorghum vulgar</i>	P	p	p
	<i>Hordum vulgar</i>	P	p	p
	<i>Lolium multiflorum</i>	P	p	p
	<i>Zea mais</i>	P	a	a
	<i>Avena stérilis</i>	P	a	a
	<i>Arundo donax</i>	P	a	a
	<i>Hordeum murinum</i>	P	a	a
	<i>Cynodon dactylon</i>	P	a	a
Liliaceae	<i>Allium cepa</i>	P	p	a
Malvaceae	<i>Lavatera cretica</i>	P	a	a
	<i>Malva rotundifolia</i>	P	a	a
Solanaceae	<i>Lycopersicum esculentum</i>	P	a	a
Composées	<i>Silybum mavianum</i>	P	p	p
Polygonaceae	<i>Polypogon monspeliensis</i>	P	a	a
	<i>Emex spinosa</i>	P	a	a
Asteraceae	<i>Sonchus oleraceus</i>	P	a	a
	<i>Sonchus teneremus</i>	P	a	a
Palmaceae	<i>Phoenix dactylifera</i>	P	a	a
Asclepiadaceae	<i>Calotropis procera</i>	P	a	a
Cucurbitaceae	plante indéterminée	P	p	p

p : the plant presents; a : the absent plant.

From the table above, we can say that the migratory locust consumes much more grasses either by males or by females. Regarding *Silybum mavianum*, it is consumed by both sexes. *Allium cepa* is consumed only by males. Out of 20 plant species present on the field, 6 are consumed by males (30%) and 5 by females (25%).

3- Variation in the number of individuals

3.1- Spatiotemporal variation

According to the histogram in figure 3, which shows the variation in the number of individuals by station and time, we observe that the number of individuals is higher in the Sbahi station (22 for males and 18 for females) than in the Moulay Nadjem station (the maximum number of individuals does not exceed 12 for males and 9 for females). This species was encountered in the Sbahi station only in September and October.

In the Moulay Nadjem station, the population of *Locusta migratoria cinerascens* fluctuates between 5 (second outing) and 12 (third outing) for males and between 2 (fourth outing) and 9 (third outing) for females. *Locusta migratoria* was found in Moulay Nadjem from October to April (Fig. 3).

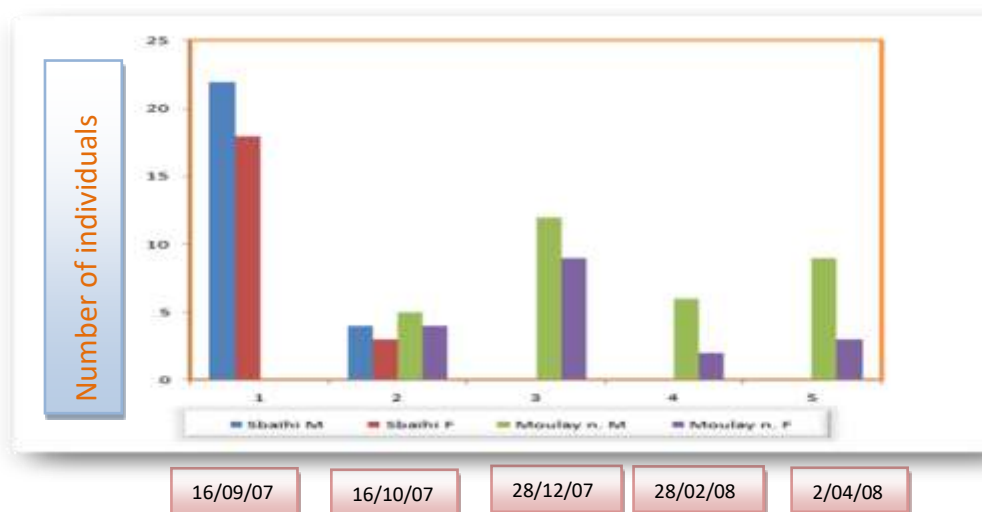


Fig. 4 - Spatio-temporal variation of individuals captured in the two study stations

According to the histogram in figure 4, *Locusta migratoria* was encountered in large numbers at Sbahi but only in September. On the other hand, at Moulay Nadjem, it was found in smaller numbers over a longer period from October to April. This is likely due to the microclimate and vegetation, which differ from one station to another.

Our results show that the sex ratio of *Locusta migratoria cinerascens* populations in the two stations favors males. The number of males at the Moulay Nadjem station (32) is higher than that at the Sbahi station (26). However, in the same station, the number of females (18) is lower than that at the Sbahi station (21).

DISCUSSION

- Qualitative study of the diet of *Locusta migratoria cinerascens* during the year 2007/2008 in the Adrar region

The taxonomy of plants is only involved in defining three main types of diet: graminivorous, non-graminivorous, and mixed. The biochemical composition, spatial distribution, and annual cycle of plants must be considered together to attempt to explain the situations described (Legall, 1989). According to Chapman and Joern (1990), the subspecies *cinerascens*, like other subspecies of *Locusta migratoria*, is graminivorous in the irrigated areas of the Algerian Sahara. The graminivory of *Locusta* is not unique, as many Oedipodinae share this oligophagy. Graminivores are the only example of a close correlation between taxonomy and dietary specialization in acridids. They are the only oligophages that are known with certainty (Legall, 1989).

In both study sites, the plants utilized belong to only 4 different families, including the Poaceae family (*Sorghum vulgar*, *Lolium multiflorum*, and *Hordeum vulgare*), the Polygonaceae family (*Silybum marianum*), the Cucurbitaceae family (wild watermelon), and the Liliaceae family (*Allium cepa*). The phenomenon of preference was described by Launois-Luong (1975) based on field observations and laboratory work. Our results show that the populations of *Locusta migratoria cinerascens* have a trophic preference for grasses, especially the two species *Sorghum vulgar* and *Lolium multiflorum*, given their abundance. Indeed, even Allal Benfekih (2006) reports that sorghum is the most appetizing in the irrigated areas of the Adrar region. Bernays and Chapman (1994) justify this dietary preference by nutritional order but note that other factors may come into play, such as tenderness, water content, and the presence of repulsive molecules.

Rulquin et al. (2001) show that the two plants *Sorghum vulgare* and *Lolium multiflorum* are preferred by *L. m. cinerascens* due to their biochemical composition, which contains a higher lysine content. Allal Benfekih (2006) also notes that the development of *Locusta migratoria cinerascens* populations is satisfactory on sorghum or a mixture of weedy poaceae, especially the mixture consisting of *Bromus madritensis* and *Lolium multiflorum* in irrigated perimeters. Furthermore, Acheuk (2000) showed that the growth of larvae at different stages of *L. m. cinerascens* was faster on *Sorghum vulgare* than on

Pennisetum purpureum. Ohabuiké (1979) also found that the growth of *L. m. migratorioides* on *S. vulgare* is favorable. In general, Bernays and Chapman (1994) confirm that the food intake of a plant species depends on its nutritional value for insect growth.

Variation in the number of individuals

At the Sbahi station, we recorded a maximum number of individuals in September 2007, corresponding to the summer-autumn generation. This number decreases until it disappears in December 2007. These observations occur just after the sorghum harvest. This period coincides with the hatching of the eggs of the second generation, which disperses to a new food source. In contrast, at the southern station (Moulay Nadjem), where populations of *Locusta migratoria cinerascens* remain at considerable density despite sorghum cutting, their presence is justified by their different dietary spectrum compared to the populations at the northern station. Indeed, the influence of climatic factors is very important.

CONCLUSION

Our study was conducted with the aim of providing a general overview of the food spectrum of this oedipodine in two study sites in the Adrar region during the period from September 2007 to April 2008. In Adrar, agricultural exploitations and oasis areas are considered favorable microhabitats for the development and reproduction of this grasshopper.

Our results indicate that the distribution of subspecies populations is linked to two parameters. On one hand, over time, the populations disappeared in the northern station (Sbahi) after October due to the harvest of sorghum, which is the primary food source for this grasshopper. On the other hand, in the southern station (Moulay Nadjem), populations did not disappear because their food spectrum can be diversified. In this case, individuals feed on forage crops and vegetable gardens. Thus, the presence of *Locusta migratoria* populations is longer in the south compared to the north.

Based on latitude, the populations are denser as one moves south, again due to their food spectrum and also climatic factors. Regarding the diet, it is noted that the populations show a preference for sorghum (*Sorghum vulgare*) (the occurrence frequency in feces is 84.61% for females and 82.75% for males), and for weeds like *Lolium multiflorum* (the occurrence frequency is 43.58% for females and 50% for males). This preference varies in proportion between populations in the two study sites and among individuals of the same population.

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