ETHNOBOTANY OF *ANODA CRISTATA* (L.) SCHL. (MALVACEAE) IN CENTRAL MEXICO: USES, MANAGEMENT AND POPULATION DIFFERENTIATION IN THE COMMUNITY OF SANTIAGO MAMALHUAZUCA, OZUMBA, STATE OF MEXICO[1]

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Rendón, Beatriz and Juan Núñez-Farfán *(Departamento de Ecología Evolutiva, Instituto de Ecología, Universidad Nacional Autónoma de México Apartado Postal 70-275, México 04510, D. F., México), and* **Robert Bye** *(Jardín Botánico, Instituto de Biología, Universidad Nacional Autónoma de México. Apartado Postal 70-275, México 04510, D F., México).* ETHNOBOTANY OF *ANODA CRISTATA* (L) SCHL (MALVACEAE) IN CENTRAL MEXICO USES, MANAGEMENT AND POPULATION DIFFERENTIATION IN THE COMMUNITY OF SANTIAGO MAMALHUAZUCA, OZUMBA, STATE OF MEXICO *Economic Botany 55(4) 545–554, 2001* Anoda cristata *is a common weed used for food and medicine in central Mexico where it grows among field crops during the rainy seasons People prefer robust, tender plants from the agricultural fields because these "develop better" Hence, the plants are tolerated within the conventional agricultural activities and benefit indirectly from the improvements in the agrohabitat People do not select individuals with specific morphological characteristics but rather they select for plants at the level of the habitat This step may precede that of direct management of individual plants It is possible that these differences in the level of interaction between humans and plants (i e , within the ruderal and agrestal habitats) may promote morphological and genetic differences over time.*

ETNOBOTÁNICA DE *ANODA CRISTATA* (MALVACEAE) EN MÉXICO USOS, MANEJO Y DIFERENCIACIÓN POBLACIONAL EN LA COMUNIDAD DE SANTIAGO MAMALHUAZUCA, OZUMBA, ESTADO DE MÉXICO Anoda cristata *es una maleza muy común utilizada como medicina y alimento en el centro de México durante la época de lluvias La gente prefiere las plantas robustas y tiernas que crecen en los campos de cultivo porque se "desarrollan mejor" Ahí, las plantas son toleradas dentro de las prácticas agrícolas tradicionales y se benefician indirectamente de las alteraciones que se hacen al agrohabitat La gente no selecciona conscientemente individuos con características morfológicas específicas, sino que seleccionan a las plantas a nivel del hábitat Este paso puede ser previo al manejo indirecto de individuos particulares Es posible que estas diferencias en el nivel de interacción entre los hombres y las plantas (entre el hábitat ruderal y arvense) puede promover diferencias morfológicas y genéticas a través del tiempo*

Key Words: *Anoda cristata*, edible green; Mexico, agricultural activities, morphological differentiation

Anoda cristata (L.) Schlecht. exhibits a wide morphological variation in its growth habit A taxonomic review of Mexican populations of *A cristata* indicate variability in growth form (e.g., decumbent to erect) and leaf form (e.g , ovate, hastate, or lobulate with variable margins) (Fryxell 1988) Also, analysis of development and growth (plant architectures; size, form and pubescence of leaves, total biomass, seed weight) of four accessions from North America with different geographic and climatic conditions demonstrated great variation in this species (Vangessel et al 1998). Based upon herbarium specimens, *A. cristata* is known to grow in different environments in almost all states of Mexico where it ranges in altitude from 0 (Tabasco) to 2650 m (Hidalgo y Estado de México). It is associated with different types of vegetation such as pine-oak forests, tropical (deciduous and subdeciduous) forests and xeric vegetation As a ruderal, it is found mainly along roadsides. Also, it grows as an agrestal with different crops (*Zea mays* L., *Capsicum*

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TABLE 1. COMMON NAMES APPLIED TO *ANODA CRISTATA* IN MÉXICO, BASED ON HERBARIUM SPECIMENS (1), ETHNOBOTANICAL LITERATURE (2) AND THIS STUDY (3).

Common name	Language	State	Reference
Alache		Distrito Federal, State of México, Guerrero, Puebla	1, 2, 3
Alachi	Mixteco	Guerrero, Puebla	1, 2, 3
Altea		Michoacán, Puebla	1, 2
Alushi		Puebla	1, 2
Amapola de campo		Distrito Federal, State of México	1, 2, 3
Amapola o amapolita	Mixteco	Chiapas, Veracruz	1
Amapola o amapolita morada	Mixteco	Chiapas Distrito Federal, State of México, Jalisco, Puebla	1, 2, 3
Bimalva		Michoacán, Puebla	1, 2
Campanita		Veracruz	1
Hierba del ojo		Veracruz	1
Itsukua tsipata	Tarasco	Michoacán	2
Malva		Guerroero, Michoacán, Morelos, Sonora, Jalisco, Aguascalientes	1, 2, 3
Malva chica		Guanajuato	1
Malva de castilla		n r	2
Malvavisco		Michoacán, Puebla	1, 2
Momol	Tzotzil	Chiapas	1
Pie de gallo		Oaxaca	1, 2
Quesitos		Hidalgo, Sonora	1
Rehué	Rarámuri	Chihuahua	1
Tulipancillo		Veracruz	1
Violeta		Distrito Federal, Guerrero, Michoacán, Morelos, Veracruz	1, 2, 3
Violeta de campo		Veracruz	1, 2
Violeta silvestre		Sinaloa	1, 2
Yao nundo		Guerrero	1
Yax noch	Tzotzil	Chiapas	1
Yaxal	Tzeltal	Chiapas	1
Xihuitl	Mexicano	State of Mexico	3
Yiwa taio/yiwa tiio	Mixteco	Guerrero	1, 2

1 Herbario MEXU & IPN, Fryxell, 1988, registro personal
2 Bye 1982, Alcorn 1984, Gómez y Chen de la Cruz 1985, Castro 1988, Casas, Viveros y Caballero 1994, Martinez et al 1995
3 Field interviews with local farmers in State of México, Puebla, Guerrero, Aguascalientes, and Oaxaca

annuum L., *Physalis philadelphica* L., *Medicago sativa* L.) Although *A. cristata* occurs naturally from the United States to Bolivia, Argentina, and Chile (Fryxell 1988; Vangessel and Westra 1997; Vangessel et al. 1998), it is most common in México. Also it is an exotic weed in Australia (Mitchell 1982).

Previous ethnobotanical studies indicate that its most important use is that as food. In this case, young, tender leaves and buds are consumed as *quelites* and can be eaten alone or combined with squash, beans, or corn (Bye 1981, 1982; Casas et al. 1994; Vázquez 1986). Its medicinal use is less important The entire plant, including flowers, is infused with other plants (see below) to produce a tea that is drunk to treat stomach inflammation, fever, cough, and wounds or a hair-rinse to reduce balding (Alcorn 1984; Casas et al. 1994; Castro 1988; Gómez and Chen de la Cruz 1985; Martínez et al. 1995). In addition, the above ground plant is used occasionally as fodder.

Frequent utilization of *A. cristata* by humans is found principally in the central and south regions of Mexico, mainly the states of Michoacán, Guerrero, Oaxaca, Chiapas, San Luis Potosí, Puebla and State of Mexico, but it is also reported in Chihuahua (Bye 1982) Accordingly,

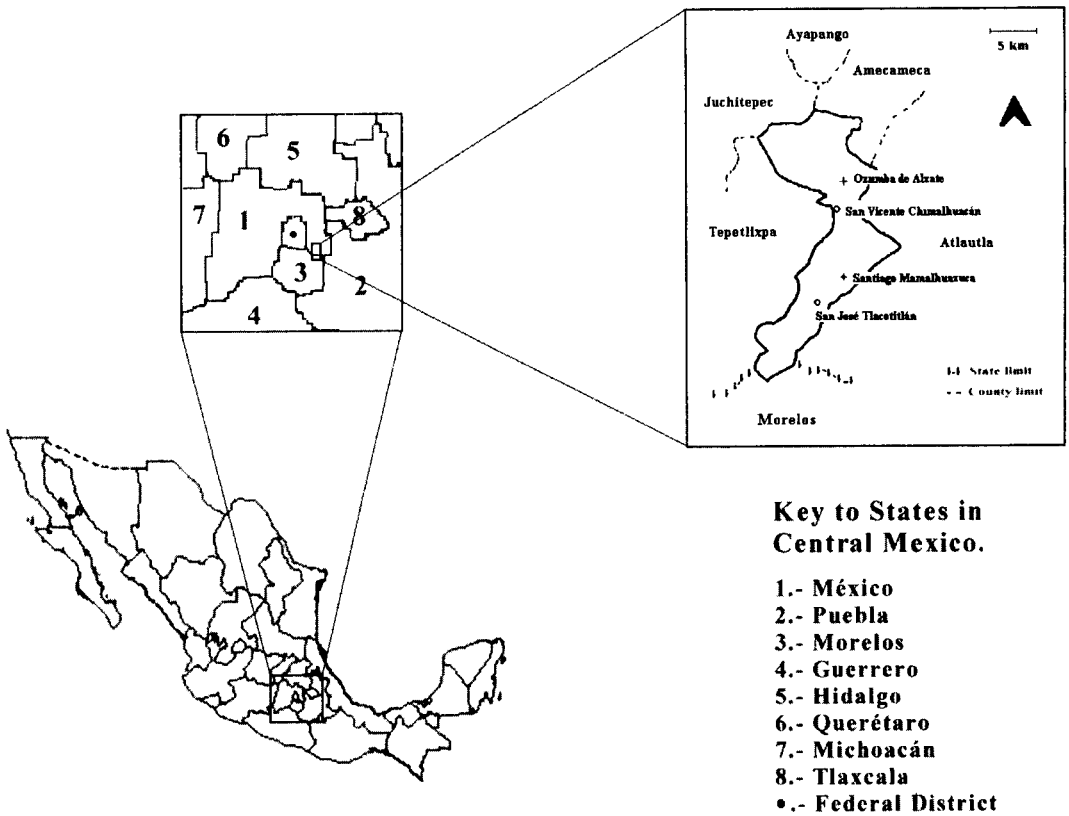

Fig. 1. Geographic location of Santiago Mamalhuazuca, County of Ozumba, State of México

many local names have been applied to this species (Table 1).

The purpose of this paper is (1) to describe the interaction between the inhabitants of the indigenous community of Santiago Mamalhuazuca, State of México, and *A. cristata,* including aspects of its use, harvest and commercialization, and (2) to describe the differences between ruderal and agrestal populations based upon morphological and reproductive characters.

Methods

Study Area

Ozumba is located in the Neotransvolcanic Belt (18° 58′ 00″ N–98° 46′ 30″ W, 2300 m.a.s.l.) between the Popocatépetl Volcano and Chichinautzin Volcano (Gobierno del Estado de México 1988; Martínez 1988) (Fig. 1). In the north and central parts of the county of Ozumba the mean monthly temperature ranges from 12°C to 18°C, while the southern section is warmer with temperature varying from 18°C to 22°C. The mean annual precipitation is 700 mm

The Ozumba County has a population of 18 056 inhabitants (48.5% male, 51.5% female). Most of the people are mestizos. A few older people speak nahuatl or mexicano and, in few cases, teach this language to their relatives. Agriculture is the most important productive sector, which includes almost 30% of the economically active people. Land use also reflects the importance of agriculture in this county Of the county's 4802 ha, 67.23% has been modified by agriculture. The remaining 32.77% are allocated to forests, urban zone and industrial uses or has been eroded.

Ozumba was settled in prehispanic times and, during the 15th and 16th centuries, was an important social, political, and economic center (Vera 1997). In accordance with Spanish policies, soon after of the Spanish Conquest of Mexico during the mid-16th century many isolated settlements were concentrated in a few sites. Among these congregations Santiago Mamalhuazuca and Ozumba were established (Acuña 1985; Jalpa 1997) Later, in the 17th century,

TABLE 2. SOME ENVIRONMENTAL CHARACTERISTICS ASSOCIATED WITH RUDERAL AND AGRESTAL POPULATIONS OF *ANODA CRISTATA* (SOURCE: DIRECT OBSERVATIONS IN SANTIAGO MAMALHUAZUCA).

Environmental character	Ruderal population	Agrestal population
Vegetation	Forest of *Pinus* spp. and *Juniperus* sp.	Cultivated fields of *Zea mays, Phaseolus* spp , *Physalis philadelphica, Lycopersicum esculenta, Opuntia* sp. and different medicinal plants
Benefits from agricultural activities	None, only occasional grazing by cows and donkeys	Indirect benefits of fertilization with chemical or natural products, irrigation, weed removal
Environmental variability (shading, associated species)	Heterogeneous in terms of shade, water supply, high density, high species density, greater interspecific competition	Homogeneous, with full exposure to the sun, reliable water supply, low species richness, reduced interspecific competition

Chalco was formed and has remained to this day as an important town with agricultural production, whereas Santiago Mamalhuazuca was subordinated to Ozumba. The traditional market plays a remarkable role within the region as well as in adjacent areas in the states of Morelos, Puebla, and Federal District.

Santiago Mamalhuazuca is an important agricultural community. Its current population of 1426 inhabitants (7.9% of the total population of Ozumba) is divided between 698 men (48.9%) and 728 women (51.1%) (INEGI 1990). Local products are sold in the Ozumba *tianguis,* which is a periodic market of prehispanic origin and functions on Tuesdays and Fridays (Gobierno del Estado de México 1988; Martínez 1988). Various products are sold in this tianguis as well as exchanged for other items through *trueque,* a traditional barter system Maize, beans, chilies, medicinal plants, and many other products are available, including such quelites as *A. cristata*

FIELD WORK

Specimens in herbaria (MEXU, ENCB, and FCME) were studied in order to obtain information about geographic localities, patterns of morphological variation and ethnobotanical data. A review of ethnobotanical literature provided information on localities, ethnic groups, and characteristics of utilization.

The community of Santiago Mamalhuazuca, county of Ozumba, State of Mexico, was selected based upon the above information as well as field experience of the authors (B.R. and R.B.) along with socioeconomic and historical literature. From a collection of 18 populations of *A. cristata* in different states of Mexico, Santiago Mamalhuazuca is the only one locality where wild and agrestal populations coexist, and people use the plant as food or medicine. Thus, this locality was selected for the present study. Although the plant is used in other localities in Mexico, it has been introduced from other places (B. Rendón pers. obs.)

Based upon extensive field collections and observations, two local populations of *A. cristata* were detected: (1) the ruderal (wild) populations that grow in the Pine forest in the Neotransvolcanic Belt in Central Mexico along paths, or in the vicinity of modified natural vegetation, and (2) the agrestal populations that grow in various agrohabitats, such as orchards, maize, tomato, and medicinal plant fields (Table 2).

Within each habitat, forest or orchard, individual plants were selected randomly to assess morphological differentiation Five measurement on each plant were taken: height (cm), number of branches, cover (area based upon two measurements of diameter) (N = 69–71 individuals from ruderal populations and 104–107 individuals from agrestal populations). Reproductive characters included the number of immature and mature fruits (N = 34 individuals from ruderal populations and 100 individuals from agrestal populations). Variables were scale-transformed prior to statistical analyzed to meet normality and homoscedasticity assumptions of linear models (ANOVA; Sokal and Rohlf 1995). Size variables (height and cover) were log transformed, proportions (no. branches/height and no. mature fruits/no. branches) were arcsine transformed, and counts (no. of immature and mature

fruits) were square root transformed (Sokal and Rohlf 1995). Means and standard errors were obtained for each measured character and one-way ANOVA was applied to all variables only at population level (JMP 3.1 1995).

Structured interviews (Martin 1995) were applied to 31 families of farmers that grow, use, and sell *A. cristata* (26 women and five men) These families are from Santiago Mamalhuazuca and other communities belonging to the county of Ozumba (which represent 0.17% of the total population of this county and 2% of the community of Santiago Mamalhuazuca). Each interview consisted of 24 questions, which included five about each family's socioeconomic condition and the remainder about their knowledge, level of interaction with *A cristata,* agricultural practices applied to this herb, uses of the plant, and level of use (home consumption, local commercialization, etc.). For the sake of brevity only the information regarding the uses, commercialization, and cultural practices is included in the results.

Nutritional value of *A. cristata* growing in orchards and hence used as food, was analyzed using conventional techniques for humidity, crude protein, crude fiber, ash and free nitrogenous compounds Two samples of 500 g each of fresh aerial portion were submitted to Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. Results were compared with taxa of some edible vegetables consumed in the Ozumba region and reported in the literature

RESULTS

USES

Food Use

Anoda cristata is commonly known as *violeta* (93 55% of the interviewees); other names used are *alache* (45.16%), *amapola* (3.22%), and *xihuitl* (3.22%). This species is usually consumed during the rainy season, from August to November. All interviewees reported eating the tender leaves of *A. cristata* alone or mixed with other plants.

The leafy branches are harvested when the rainy season begins by cutting the plants near the base of the stem. Individual young plants with large, tender and glabrous leaves are preferred over mature branching plants Older individuals can be harvested with large leaves, young leaves, buds, flowers and immature fruits. When the plant develops fruits and the leaves change color or develop a coarse texture, it is considered unpalatable by 58.1% of the interviewees.

All the people of Santiago Mamalhuazuca prepare violeta as follows: fresh leaves and buds are separated from the branches, washed with clean water, and placed in a pot with water and *tequesquite blanco* (a natural carbonate) This mixture is boiled and stirred continuously until the leaves soften and the water becomes a slightly slimy. Then, salt is added according to one's preference. When ready, it is mixed and eaten with mushrooms, squash, beans, or meat or consumed separately. It may be spiced with lemon juice and chili pepper.

Nutritional Value

Food analysis (Table 3) of *A. cristata* indicates that it has high protein content that is greater than *cebollinas* (*Allium cepa* L), *espinaca* (*Spinacia oleracea* L.), *lengua de vaca* (*Rumex crispus* L) and *verdolaga* (*Portulaca oleracea* L.), and less than *haba* (*Vicia faba* L), *malva* (*Malva parviflora* L.) and *cenizo* (*Chenopodium berlandieri* Moq.) (Bourges et al. 1996:93–120). Also, it has a high content of polysaccharides, which make this species an important source of energy. Chemical analysis did not include other substances related with slimy characteristics.

Medicinal Use

Less than half of the interviewees (41.9%) use *A. cristata* for medicinal purposes The most frequent medicinal use (53.85%) was as a cough remedy. The flowers of violeta were mixed with *gordolobo* (*Gnaphalium* sp), *bugambilia* (*Bougainvillea* sp), *tejocote* (*Crataegus pubescens* (HBK.) Standl.) and *canela* (*Cinnamomum* sp.) to prepare an infusion sweetened with honey. Fewer people (23.1%) used the plant for kidney problems (based upon the "fresh" nature of the plant) It was also drunk in cases of stomach aches and liver problems associated to hepatitis

Cultural Activities

As a weed, this plant is not promoted intentionally by people in the agrohabitats. The seeds from the dry schizocarps disperse naturally after the rainy season. People do not select or keep the seeds for sowing in the next season. Subsequent plants emerge after the initiation of the

TABLE 3. COMPARATIVE ANALYSIS OF NUTRITIVE COMPOUNDS IN *ANODA CRISTATA* AND OTHER VEGETABLES.

Species	Ash	Crude fiber	Protein	Lipids	Nitrogen free compounds
Violeta (*Anoda cristata*)[1]	2.5	1.1	4.1		8 3
Cebollinas (*Allium cepa*)[2]	1 2	1 0	1.87		1.46
Espinaca (*Spinacia oleracea*)[2]	1.6	0 45	2 12		1.72
Haba (*Vicia faba*)[2]	0.6	2 27	5 87		13 09
Lengua de vaca (*Rumex crispus*)[2]	1.2	0 90	1.90		3 70
Malva (*Malva parviflora*)[2]	2.0	0 88	5.37		3 89
Cenizo (*Chenopodium berlandieri*)[2]	3 7	1 0	4.80		4 0
Verdolaga (*Portulaca oleracea*)[2]	2.4	0 77	2.75		2 38

[1] Analysis carried out by Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias in 1998 Plants were obtained from Santiago Mamalhuazuca, State of México Analysis was based upon two samples (Data represent % of total fresh weight)

[2] Bourges et al (1996)

rainy season. Later, during the weeding practice, people spare plants that are robust and have good leaves. Even though some insect pests cause problems (according to 45.16% of the interviewees), they do not apply any pesticides because insects or fungi do not cause serious damage to the plants.

People identify places where the plants grow better. These sites usually have rich organic, moist soils and are associated with cultivated fields of maize, bean, tomato and medicinal plants or within orchards. In these agrohabitats, violeta plants receive indirectly the benefits of fertilization and irrigation given to the main crop. Plants cut during the weeding resprout easily Thus, one plant may be pruned more than once during the growing season. Less robust plants with smaller leaves are not preferred by the people and are left for cows and other livestock to eat.

COMMERCIALIZATION

The commercialization of violeta occurs during the rainy season. Half of the interviewees (51.6%) sold the plants in the market. The manojos of violeta gathered in the field were sold at the regional market of Ozumba (31.25%), where local people and those from nearby communities purchase their greens. A high proportion of the gathers (68.75%) occasionally go to other markets in neighboring states (Morelos, Federal District, and Puebla) to sell this quelite. There is a great demand for these plants as food and medicine. A manojo (500 to 700 g of fresh weight) of violeta sold for an equivalent of US $0.20 in the Ozumba market. This quelite is less expensive than such leafy vegetables as verdolaga (*Portulacca oleracea*) and *quintonil* (*Amaranthus hybridus* L.) that are normally sold for an equivalent of US $0.50 and US $0.40, respectively per 500 g of fresh weight.

LEVELS OF MANAGEMENT

At least two kinds of plant populations can be distinguished in Santiago Mamalhuazuca (Table 4): 1) ruderal populations which grow along roads in disturbed areas, and 2) agrestal populations found in different agrohabitats (cultivated fields and orchards). As a consequence, differences occur in their life histories, especially the vegetative development, which suggest that these populations may respond differently to selection pressures, both natural and artificial.

In the life history of a ruderal population (Fig. 2), the vegetative phase of violeta is subject to two kinds of pressures: 1) biotic pressures, because some of the individuals growing in ruderal places can be grazed by animals, and 2) abiotic pressures from microenvironmental factors (e.g., light, moisture, soil). These pressures differ in the case of life history of an agrestal population (Fig. 3). First, humans influence both the vegetative and the reproductive plant stages by gathering young stems and, consequently, stimulating new branches and, therefore, more leaves. Second, environmental effects allow the plants to grow in a more predictable microenvironment. The differences between these two habitats in terms of environmental conditions and levels of human interaction can affect vegetative and reproductive characters and, consequently,

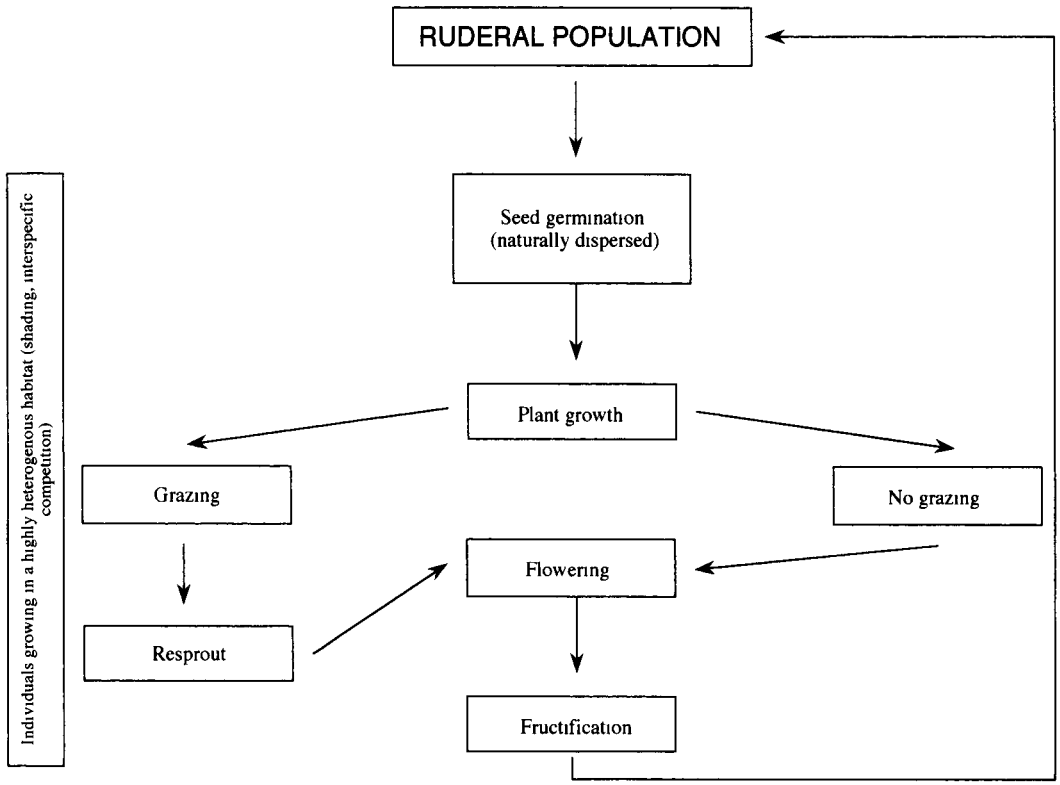

Fig. 2. Proposed ruderal life history of the population growing in Santiago Mamalhuazuca with respect to human activities Ruderal population

promote phenotypic or genetic variation of both populations

A preliminary comparison of individuals growing in their respective habitats is shown in Table 4. Height, plant cover, number of mature fruits and number of branches are significantly higher in the agrestal population than in ruderal population. Nevertheless, branches/height ratio and mature fruits/branches ratio in the two populations were not significantly different.

In general, higher values for these characters in agrestal populations are expected because of more favorable conditions for growth (Table 2). There is less competition with other species, sufficient water supply, fertile soil and adequate light. The lack of differences in architectural proportions suggests that these plant parts grow isometrically.

Discussion

Anoda cristata is an important edible green of indigenous people of Santiago Mamalhuazuca, State of Mexico. It is less important as a medicinal plant. People tolerate violeta in various agrohabitats. These different levels of interaction (agrestal vs. ruderal) with people can promote a differential response within populations due to different selection pressures.

In Santiago Mamalhuazuca, both ruderal and agrestal populations of *A. cristata* exist given the different microenvironmental conditions Two distinct patterns of morphological variation in vegetative and reproductive characters were observed in the two populations and suggest that a morphological differentiation has occurred. This morphological differentiation can have an impact in the evolution of this species under domestication if the preferred characters by people are under genetic control and can be selected.

Based upon the interviews in Santiago Mamalhuazuca the following generalizations can be made about the importance of *A. cristata* in this community: *Anoda cristata* is a complement to the people's diet during the rainy season. Level of management is minimal and consists of conventional agricultural activities that benefit indirectly the plants growing in the agrohabitats Hence in this indigenous community, this spe-

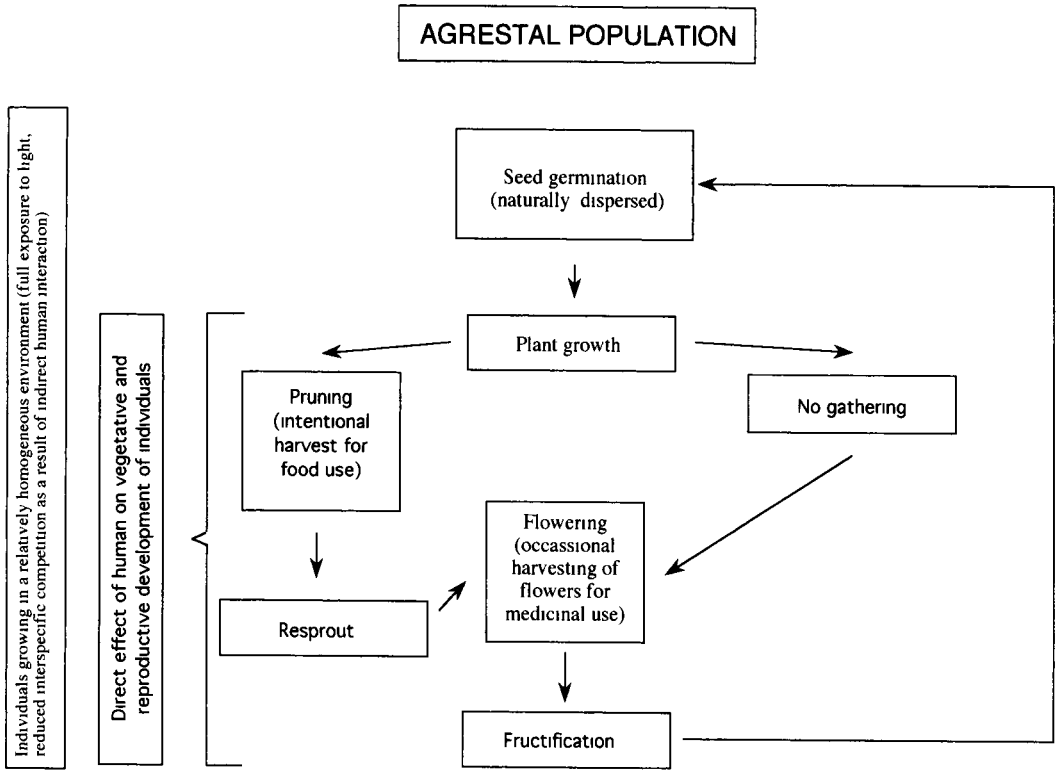

Fig. 3. Proposed agrestal life history of the population growing in Santiago Mamalhuazuca with respect to human activities Agrestal population

cies is tolerated (Bye 1993). People do not select conscientiously for individuals with specific morphological characteristics (e.g., bigger leaves, more glabrous leaves) or through gathering a specific portion of the population and saving the seeds of selected plants with desirable characteristics (as is done in other crops such as maize, bean, squash). Selection occurs at the

TABLE 4. COMPARISON OF MORPHOLOGICAL CHARACTERS BETWEEN *A CRISTATA* PLANTS GROWING IN RUDERAL AND AGRESTAL HABITATS. (ANOVA TEST, $P < 0.001$).

Character	Origin	Sample size (N)	Mean	S E	F	R^2
Height (cm)	Ruderal	71	35 504	2 366	162 69***	0 490
	Agrestal	104	80 851	2.453		
Plant cover (cm^2)	Ruderal	71	799 100	155 400	35 77***	0 168
	Agrestal	107	11751.000	1486 800		
Number of young fruits	Ruderal	34	4 588	1 490	1.67^{ns}	0 012
	Agrestal	100	13 703	4 050		
Number of mature fruits	Ruderal	34	4.880	0 806	11 33***	0.079
	Agrestal	100	22.890	3.100		
Number of branches	Ruderal	69	9 015	1 024	25 19***	0 128
	Agrestal	105	30 571	3 413		
Number of branches/height	Ruderal	71	0 536	0 046	1 04^{ns}	0 006
	Agrestal	104	0 226	0 022		
Number of mature fruits/branches	Ruderal	33	0 746	0 099	0 14^{ns}	0 001
	Agrestal	99	0 780	0 057		

level of the habitat, a step prior to the direct management of individuals (Rindos 1984). It implies that the agrestal condition, that enables the plants to invade agrohabitats, is favored by humans through cultural activities such as weeding, moisture and fertilization Genotypes with the capacity of response in the appropriate direction of the environmental conditions of the agrohabitat will be preserved (i.e , adaptive plasticity). Thus, plasticity in this species has been proposed to evolve prior to the invasion of man-made environments (Rendón and Núñez-Farfán 2001).

People preferred those plants growing in "good" places (agrestal habitats with moisture retention, fertilized soil and less weeds) because plants "developed better." In this case, environmentally induced morphological variation (phenotypic plasticity) is an important component in the domestication process.

These differences in the level of interaction between humans and plants, as well as the artificial environments they create, may promote morphological and genetic divergence over time In Santiago Mamalhuazuca the ruderal and agrestal populations of *A. cristata* differed in four of seven morphological characters It is important to understand the genetic bases of these morphological differences in order to evaluate the role of environment and human selection in process of domestication These aspects will be analyzed in future studies.

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