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ADVANCES ON THE FLORAL MORPHOLOGY OF *CAESALPINIA SPINOSA* (FEUILLÉE EX MOLINA) KUNTZE "TARA", A NATIVE TREE TO PERUVIAN FLORA

AVANCES EN LA MORFOLOGÍA FLORAL DE *CAESALPINIA SPINOSA* (FEUILLÉE EX MOLINA) KUNTZE "TARA", UN ÁRBOL NATIVO DE LA FLORA PERUANA

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ABSTRACT

Descriptive research was conducted on the floral morphology of *Caesalpinia spinosa* (Feuillée ex Molina) Kuntze "tara" (Caesalpinioideae: Fabaceae), a tree native to the Peruvian flora and an important source of tannins. Flowers were found to be 13,3±1,2 mm long and 11,6±2,1 mm wide, yellow colored, and highly zygomorphic. The keel had nectar guides, and the nectar gland was surrounded by the stamens, which formed a tight barrier except for the *fenestrae*. Melittophily was suggested the most probable pollination syndrome, given the morphological characteristics exhibited by the flower.

Keywords: Fabaceae – floral biology – keeled flower – melittophily – Peruvian flora –pollination syndrome.

RESUMEN

Se llevó a cabo una investigación descriptiva de la morfología floral de *Caesalpinia spinosa* (Feuillée ex Molina) Kuntze "tara" (Caesalpinioideae: Fabaceae), un árbol nativo de la flora peruana, e importante fuente de taninos. Las flores son de 13,3±1,2 mm de largo y 11,6±2,1 mm de ancho, de color amarillo, muy cigomorfas. La carina presenta marcas de miel, y el nectario está rodeado por los estambres, que forman una barrera densa, interrumpida por las ventanas. Se propone que la melitofilia es el síndrome de polinización más probable, dadas las características morfológicas exhibidas por la flor.

Palabras clave: Fabaceae – biología floral – flores con quilla – melitofilia – flora peruana – síndrome de polinización.

INTRODUCTION

Studies on floral biology are important as they are a key tool to understand the evolution of plants and their diversification (Barret *et al.* 1996, Barret 1998, Li *et al.* 2004). Their number, however, is very limited, as only some species have been studied regarding this subject (*cf.* Endress 1996, Rodríguez-Riaño *et al.* 1999, Borges *et al.* 2009), especially in the pea family, Fabaceae, which is considered to be the third most diverse family out of the angiosperms, and the second in economic

importance (Rodríguez-Riaño *et al. 1999*) since many important crops belong in it.

Particularly, the genus *Caesalpinia* L. *sensu lato*, which includes about 60 (Bustamante & Bustamante, 2009) to 150 species (Gagnon *et al.* 2013), is an important genus with several plants used either in industry (*v.g.*, *C. echinata* "Brazilwood", *C. spinosa* "tara") due to the production of tannins in their pods (Macbride 1943, *cf.* De la Cruz 2004, Villanueva 2007, Bustamante & Bustamante 2009; Stronati *et al.* 2009), or as ornamental plants (*v.g.*, *C. gilliesii* "bird of paradise", *C. pulcherrima* "flamboyant-de-jardin") (Stronati *et al.* 2009). Nevertheless, as has happened with many other genera within the pea family, the morphology has been poorly studied, as well as many other aspects of their floral biology (Li *et al.* 2004; Borges *et al.* 2009).

The present study aims to firstly understand the floral morphology of one of those species, *C. spinosa* (Feuillée ex Molina) Kuntze, popularly known as "tara", a species native to Peru that has been used to obtain the tannins of its pods (Garro Gálvez *et al.* 1997; Villanueva 2007; Bustamante & Bustamante 2009) and the gum of its seeds (Villanueva 2007; Bustamante & Bustamante 2007). The tannins are known because of their use in the fur and leather industries, and also because of their medicinal properties; the gum is currently used as a stabilizer and emulsifier of both drugs and foods, and even as a fixator of flavors and aromas in sodas (Villanueva 2007; Bustamante & Bustamante 2007). Even so, the treatment of the species as a crop is quite recent, and it is still exploited directly from wild (Calizaya 2009, Ramos 2010). Furthermore, *C. spinosa* is included as a vulnerable species (VU) by Peruvian law (DS N° 043-2006-AG; Reynel *et al.* 2007), for many natural woods made up mainly of this species are being affected by both urban spawn and over exploitation. A better comprehension on the floral characteristics will lead to an appropriate inclusion as a regular crop so that a sustainable treatment can be developed (*cf.* Calizaya 2009).

The goal of this study is to describe and to analyze the floral morphology of *C. spinosa* in order to set the basis of future research on the ecology of its pollination, and innovation on the agronomical treatment of the species, as well as to ensure the creation of suitable strategies for its conservation in wild.

MATERIALS AND METHODS

The study was conducted on the fields of Fundo Canchacalla, an estate located at the District of Ambo, Provice of Ambo, Huánuco Region, Peru between 2200 and 3215 masl. Flowers were collected from the individuals of *C. spinosa* cultivated in the estate. Measurements were made using a digital caliper given the small size of the flowers.

Thirty racemes were collected at random from which flowers totally open were measured. Length and diameter of each flower were recorded. Also, measurements of every single piece of the floral whorls were taken. Univariate analysis was performed in order to obtain average mearsurements (Hammer *et al.* 2001).

Collected material was deposited in the "Augusto Weberbauer" (MOL) Herbarium of the La Molina National Agrarian University, in Lima, Peru. The vouchers are the following:

PERÚ: Huánuco, Ambo. Distrito de Ambo. Arbusto. Flores amarillas, dispuestas en racimos. Nombre vulgar: "tara". Hábitat: Campo de cultivo. Fundo Canchacalla. 2500 m.s.n.m. Domingo, 8 de junio de 2014. *Sánchez-Ocharan 1, con Molinari-Novoa.* (MOL! N° 1229 ×2).

PERÚ: Huánuco, Ambo. Distrito de Ambo. Arbolito espinoso. Con frutos. Este espécimen es fe de la tesis de licenciatura "ESTUDIO DE LA BIOLOGÍA FLORAL Y REPRODUCTIVA EN *Caesalpinia spinosa* (MOLINA) KUNTZE 'TARA'", del B. Sc. Carlos Sánchez. Fundo Canchacalla, Silva Team (-10.128363 m E, -76.176507 m S). 2500 m.s.n.m. Domingo, 8 de junio de 2014. *Molinari-Novoa 84*. (MOL! N° 2012).

RESULTS

The flower of *C. spinosa* is pentamerous, zygomorphic, bisexual and dichlamydeous. Both the calyx and the corolla have free parts. The stamens are arranged in two whorls, although indistinguishable from one another, and there is one single, monocarpic pistil. Flowers are 13,3 ± 1,19 mm long and 11,62 ± 2,07 mm wide. Receptacle is cup-shaped, and the first three whorls (*i.e.*, the calyx, the corolla and the stamens) are inserted on the hypanthium. There is little variation in the length, while it was found that the width shows some variability, which may be related to the moment of blossoming at measuring time.

Perianth
The calyx is made up by five sepals as a general rule, but there may be up to six in some cases. Four of the sepals are pretty homogenous in shape, while one of them – which we named the "dissimilar sepal" – is rather different, as it is larger, concave and laciniate; the concavity is directed adaxially.

The corolla is highly zygomorphic, and petals are very variable in length. The keel has nectar guides, and it is arranged parallel to the symmetry axis of the flower. These features suggest their active participation in the process of attracting visitors and potential pollinators.

Androecium
Stamens are ten, curved, similar in size and free from one another. They all are perpendicular to the symmetry axis, with the arc directed adaxially, very close to each other so that a barrier is formed except for two little splits at both sides of the base of the first stamen known as *fenestrae* (Figure 5), which lead to the nectar gland. The base of the filaments is pubescent, and the anthers show longitudinal dehiscence. As it occurs in all species of pea family, stamens are formed in two whorls that lose differentiation after development, and appear as one unique whorl.

Ginoecium
The pistil is monocarpic, half-inferior, inserted in the receptacle and surrounded by the nectar gland (Figure 3). Style is curved, with a 5,74 ± 0,71 mm long arc, and the ovary is 4,03 ± 0,58 mm long. Up to eight ovules are found per flower, with an average of 6,31 ± 0,73 ovules.

DISCUSSION

Results suggest that the flowers of *C. spinosa* are quite constant in their dimensions, with a similar average size of that in other species of the genus such as *C. nuga* (Aluri 1990). However, the flowers are considerably smaller than those of many other species (Cruden & Hermann-Parker 1979, Lewis & Gibbs 1999, Moré *et al.* 2006, Borges *et al.* 2009). The hypanthium is considered a common feature of some genera whithin the Fabales order (Bello *et al.* 2010).

The color yellow and the presence of nectar guides suggest an adaptation to bee pollination, syndrome known as melittophily, as stated by Endress (1996), Borges *et al.* (2009), and Leite & Machado (2009) who observe also that these features are very attractive to bees; these same characteristics are found in many other species of the genus where melittophily is either suggested or proved to occur (Aluri 1990, Lewis & Gibbs

1999, Li *et al.* 2004, Moré *et al.* 2006, Borges *et al.* 2009, Leite & Machado 2009). The existence of a dissimilar sepal is rare but not unique to *C. spinosa* (*cf.* Li *et al.* 2004).

The way how the stamens are arranged seems very proper of the genus, as many other species have the same tight conformation (Endress 1996, Borges *et al.* 2009, Leite & Machado 2009). Endress (1996) says that this is to prevent the access to the nectar gland except for the splits known as *fenestrae* so that pollen is ensured to be placed on the body of the visitor.

As a final conclusion, melittophily is considered to be the most probable pollination syndrome in *C. spinosa* since all the morphological characteristics of the flower are similar to those found in species where bee pollination has been proved to occur. Moreover, this syndrome itself has been suggested and/or confirmed in several other species within the genus, with very few exceptions, and it seems to be an ancestral feature as stated by Endress (1996).

Table 1. Morphological features of *Caesalpinia spinosa*.

		Mean	Standard deviation	Variation coefficient (%)
Length (in *mm*)		13.30	1.19	8.98
Diameter (in *mm*)		11.62	2.07	17.81
Perianth length (in *mm*)	# sepals	5.04	0.20	3.98
	Dissimilar sepal	8.47	0.63	7.48
	Basal petal 1	6.99	0.91	13.08
	Basal petal 2	7.04	0.89	12.61
	Lateral petal 1	6.62	0.98	14.80
	Lateral petal 2	6.63	0.94	14.20
	Keel	5.20	0.75	14.47
Arc of stamens (in *mm*)	Stamen 1	6.88	0.87	12.71
	Stamen 2	6.97	0.76	10.84
	Stamen 3	7.04	0.81	11.48
	Stamen 4	6.91	0.74	10.73
	Stamen 5	6.74	0.91	13.56
	Stamen 6	6.94	0.79	11.39
	Stamen 7	6.81	1.04	15.26
	Stamen 8	7.03	1.06	15.04
	Stamen 9	6.96	0.93	13.39
	Stamen 10	7.23	1.01	13.99
Pistil length (in *mm*)	Style	5.74	0.71	12.46
	Ovary	4.03	0.58	14.34

Source: Self-made.

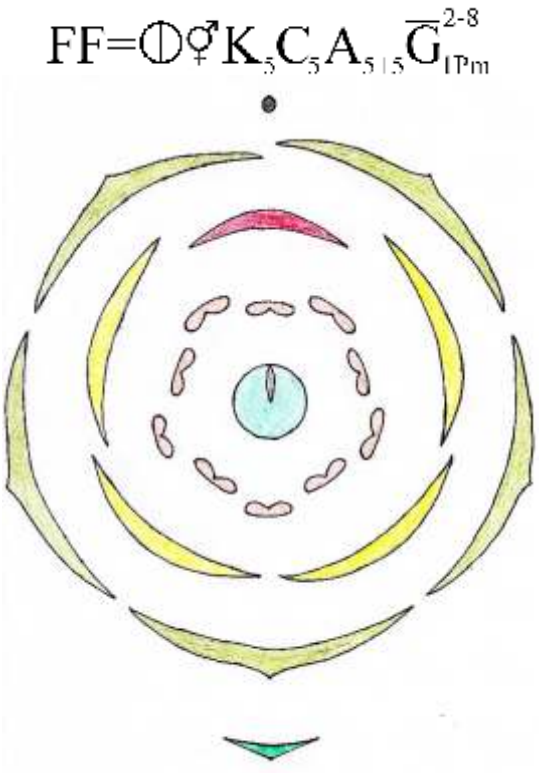

Figure 1. Floral formula and floral diagram specific to *Caesalpinia spinosa*. *Dark green*, bract; *light green*, sepals; *yellow*, lateral (upper) and basal (lower) petals; *red*, keel; *pink*, stamens; *aquamarine*, pistil; *gray*, ovule. Upper sepals, as well as petals, are imbricated. Placentation is marginal. Source: Self-made.

Figure 2. External morphology of the flower *Caesalpinia spinosa*. Lateral view of the flower of *C. spinosa*. Nectar guides are the red lines on the yellow petals. The dehiscence of anthers is longitudinal. Zoom: 25x.

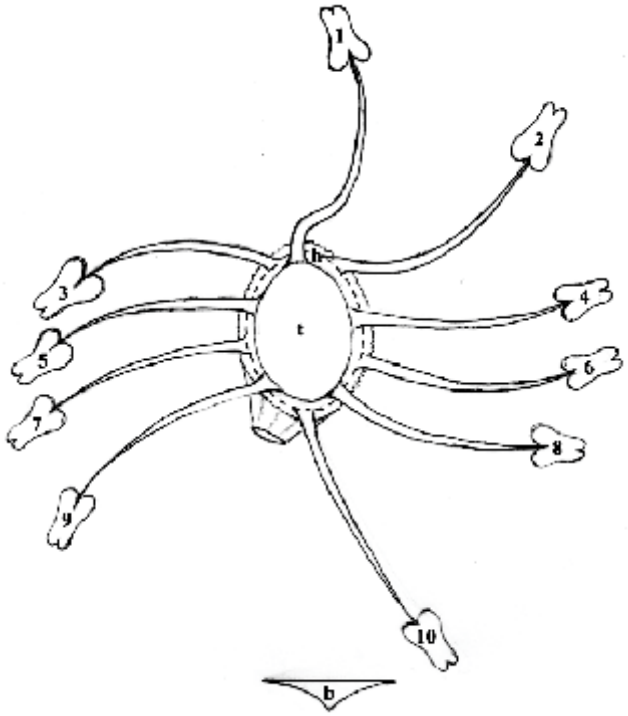

Figure 3. Possible arrangement of stamens of *Caesalpinia spinosa* Source: Self-made. Possible arrangement of stamens in the whorls of the androecium. *Inner whorl*: 1, 4, 5, 8 and 9; *outer whorl*: 2, 3, 6, 7 and 10. The bract (*b*) marks the abaxial region; the receptacle is indicated by *t* and the hypanthium by *h*. Zoom: 25x.Source: Self-made.

Figure 4. Floral structure of *Caesalpinia spinosa*. *Left.* Longitudinal section of the flower, where the receptacle (*t*), the hypanthium (*h*), the sepals (*k*), the petals (*c*) and the stamens (*a*) are shown. Notice the position of the nectar gland (*n*). *Right.* Position of the nectar gland (*n*) at the base of the androecium (*a*). The pistil (*g*) is inserted in the middle of the receptacle. The arrow points to the stigma. Zoom: 25x.

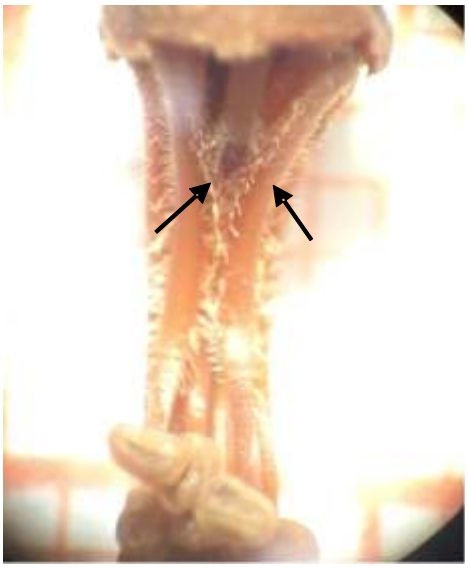

Figure 5. View of the stamens of *Caesalpinia spinosa*. Adaxial (superior) view of the stamens. The arrows point to the *fenestrae*, which are little splits granting access to the nectar gland. Notice the pubescence of filaments. Zoom: 25x. Source: Self-made.

Figure 6. Relative arrangement of the floral pieces of *Caesalpinia spinosa*. Perianth: *d*, dissimilar sepal; *b1* and *b2*, basal petals; *l1* and *l2*, lateral petals; *c*, keel. Androecium: *from 1 to 10*, stamens. Pistil: *o*, ovary; *e*, style.

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