BOTANICAL GARDENS WITH DRINKERS WITH 20% SACAROSE, AS A CONSERVATION STRATEGY OF THE BEARDED HUMMINGBIRD (Oxypogon cyanolaemus), IN COLOMBIA

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SUMMARY

The objective of this research was to describe the interaction between a botanical garden with 20% sucrose drinkers and BEARDED HUMMINGBIRD (Oxypogon cyanolaemus), in a wild environment, in the Sierra Nevada de Santa Marta, Colombia. Once the existence of the interaction was verified, the morphology, taxonomic composition, richness and abundance of the BEARDED HUMMINGBIRD species (Oxypogon cyanolaemus), identified as floral visitors, as well as cephalic and buccal morphometry were characterized. BEARDED HUMMINGBIRD (Oxypogon cyanolaemus), identified, presents as a whole behavioral and morphological characteristic associated with high-efficiency pollinators, with a high visitation rate, rocker activation capacity and maximum body contact of the bird with the anthers and stigma of the flower Additionally, hummingbirds have a very high load of pollen grains of flowers of native species on the body and low investment of time in cleaning your body (grooming). The flowers visited by these birds gave rise to fruits. All of the above allows us to conclude that the conservation status of this critically threatened bird species is favored with botanical gardens with sugary drinking fountains, increasing the pollination rate in its surroundings, generating a type of commensalism.

Keywords. Commensalism, hummingbirds, botanical garden, sugary drinking fountain, pollination, native species.

INTRODUCTION

The BEARDED HUMMINGBIRD (Oxypogon cyanolaemus) is a bird endemic to Colombia, listed as Critically Endangered (CR, 2015) by the IUCN. Before its rediscovery in March 2015, this recently divided species had not been registered since 1946 despite several recent surveys. Excessive burning and grazing have severely degraded their high altitude wasteland habitat, and it follows that the remaining population is very small and decreasing. For these reasons, the species has been classified as Critically Endangered.

This species has been severely damaged by climate change, because it is prematurely attracted by the high temperatures of the Sierra Nevada de Santa Marta, in seasons without flowers, resulting in the death of most specimens (less than 250 mature individuals are calculated) .

In turn, this species of hummingbird is hunted by Arahuac Indians, for santeria rituals "to achieve true love", generating hunting, consumption and illegal trafficking of the species (This species appears in Appendix II of CITES).

This study will prove that the strategic disposition of wild botanical gardens, with drinkers with 20% sugar solution (equivalent to 1,500 flowers), effectively attract and feed this species; strategy to conserve this species whose extinction is imminent.

The moorland of the Sierra Nevada de Santa Marta has suffered a high degree of destruction and degradation through the conversion to cattle pastures and logging for agricultural cultivation (Cortes-Herrera & Villagran 2016). The habitat is severely affected by grazing herds of cattle and pigs belonging to indigenous communities, who repeatedly burn the moorland for grazing (WWF 2013, Rojas and Vásquez 2015). In March 2015, almost all natural vegetation, except pastures, in the locations where the species was observed, had been destroyed by fire; Therefore, food resources are likely to extend over a very wide area of possibly hundreds of hectares (Rojas and Vásquez, 2015). Indigenous communities collect L. occultus for firewood and for use in the construction of houses (Cuatrecasas 2013, in Collar and Salaman 2013; Cortes-Herrera & Villagran 2016), drastically reducing the population of this frailejón, which is classified as Critically Endangered in the Red List of Colombia (García et al. 2005) and that can be a key food source for O. cyanolaemus.

MATERIALS AND METHODS

This study was carried out in the Sierra Nevada de Santa Marta ", located at 2551 m altitude in the city of Santa Marta, at 4º 40' North and 74º 06 'West. The research included the following stages: 1) entomophilia syndrome, 2) taxonomic recognition of the species of Oxypogon cyanolaemus, who visit the flowers, 3) number of the floral visits, 4) Characterization of the inflorescence, the flower and the grain of pollen of S. bogotensis, 5) morphometry of head and pieces Oxypogon cyanolaemus buccal, 6) flower activities, 7) fruit formation and pollen loads and 8) neighborhood effect.

1) This test was performed on seed propagated plants. Before starting the test, it was ensured that the plants were vigorous for seed formation by artificial pollination tests. The first treatment corresponded to plants in the presence of Oxypogon cyanolaemus pollinators and the second to plants in the absence of them, which was guaranteed through the use of net bags. For each treatment three plants were used and in each plant three inflorescences were followed for a total of 820 flowers evaluated in the first treatment and 760 flowers evaluated in the second treatment. The percentage of fruit formation (FF) was estimated by dividing the number of flowers that presented fruit formation (NF) by the number of total flowers (FT). (FF = (NF / FT) * 100). Statistical comparison between treatments was performed using the Mann - Whitney test. Prior to this trial, two trials were carried out in pots and on the ground, and it was observed that only artificially pollinated flowers of the inflorescences covered with net bags, presented fruit formation, which first discarded an autogam and / or apomictive reproductive system and second it was concluded that other small insects that enter the bag such as thrips or cucarrones (coccinalidae) do not act as pollinating agents.

2) Taxonomic recognition of Oxypogon cyanolaemus species: manual captures of Oxypogon cyanolaemus individuals visiting S. bogotensis plants were made during a period of ten days from 8 am to 10 am and for each hour 12 observations were made per plant in five minute lapses. Collected individuals were introduced into vials with 70% ethanol and taken to the laboratory for taxonomic recognition of genera and species based on Carver and Thompson (2003) and Carrejo et al. (2006). Individuals of the species found were dry mounted and deposited in the entomological collection of the Institute of Natural Sciences of the National University of Colombia, Bogotá headquarters (ICN-048905 to ICN-048931).

3) Number of floral visits: pre-sampling was carried out for 10 days to determine and code the behavior of Oxypogon cyanolaemus in the flower and to standardize the protocols. Then 3920 observations were made to assess the presence or absence of floral visitors belonging to Syrphidae through evaluations from 8 am until 10 am and for each hour 12 observations were made. Each observation was made every five minutes. With these data, visit rates by species of Oxypogon cyanolaemus were determined.

4) Characterization of the inflorescence, the flower and the pollen grain of S. bogotensis: from 50 flowers length measurements were taken (from the base of the flower to the point where the corolla forks) and width of the floral opening Subsequently, a description of the inflorescence, the flower and the pollen grain was made. For the description of pollen grains using the ICN methodology, 10 units were evaluated type of grain, polarity, symmetry, type of opening, type of field, type of exina, length of the equatorial axis, length of the polar axis, length of the apocolic side and total exine length.

5) Head and mouth morphometry of Oxypogon cyanolaemus species: taking 14 specimens of Oxypogon cyanolaemus, the width of the cephalic tagma was measured. To measure the proboscis, with the use of a reglilla, the oral appliance was removed with prior clearance in KOH. The morphometric data of the flowers and of Oxypogon cyanolaemus were subsequently discussed with the data taken in the field on the ability to activate the rockers and consumption of nectar by hummingbirds. If the size of the oral appliance is not greater than the depth of the corolla and / or the size of the cephalic tagma smaller than the floral opening, this explains the non-consumption of nectar and the non-activation of the rocker arms, which is one of the aspects which allows us to understand if hummingbirds of the Oxypogon cyanolaemus family act as pollen vectors taking into account that efficient pollinators produce activation of these rockers. This information was statistically analyzed by the t-student test for the species that presented at least four individuals during the sampling time and in general to the family.

6) Activities in the flower: the absolute frequency of each one of the activities of the floral visitor (FC) was estimated as the number of times that each of the behaviors recorded in section three was observed.

7) Formation of fruits and pollen loads: to measure the percentage of fruit formation, the flowers and fruits were formed, formed or in formation, of forty inflorescences corresponding to four plants by means of tweezers, then covered with cloth bags and after One week they retired for exposure to Oxypogon cyanolaemus visits. Observations were made for 8 days from 8 to 10 am and the flowers that were visited were marked with indelible ink, quantified and the inflorescence was covered again with the cloth bag. In total, 58 visits were evaluated. For the recognition and estimation of the effective pollen loads, the protocol of the Palinology Laboratory of the Institute of Natural Sciences (ICN) of Colombia was taken into account. To this end, 55 individuals corresponding to 9 species were collected, each in a 1.5 mm eppendorf with 70% ethanol. After one week the individuals were removed, centrifugation was performed on the eppendorf with alcohol at 4500 rpm for five minutes, then two drops of glycerin were applied to each eppendorf, with subsequent exposure in an oven at 55 ° C. Subsequently, the pollen grains of S. bogotensis and grains of other families were assembled, stained, identified and counted, under an optical microscope, taking into account the previous description of the pollen grain made in stage four. The stomach contents of several visiting sips were used as a witness.

8) Neighborhood effect: to assess the effect of nearby plants in Bloom PF) the days on which data on the rate of floral visits to S. bogotensis were taken, their presence was recorded to determine whether flowering of nearby plants increases the number of visits and visiting species of Oxypogon cyanolaemus to S. Bogotensis To estimate the effect of nearby plants on flowering, the data were used when there was flowering (FA) and when there was no flowering in nearby plants (SA), (PF = FA-SA). To analyze the information, the non-parametric Mann-Whitney test was applied to determine the existence of significant differences between the frequency of floral visits to S. bogotensis in the presence and absence of flowering of nearby plants.

RESULTS

1) The flowers of the inflorescences visited by Birds, corresponding to the treatment in the presence of Birds, had a 13.98% fruit formation, while those in which the access of pollinators was prevented presented floral abortion The difference in fruit formation between these two treatments is significant (Mann-Whitney Test H = 0, $p < 0.05$). The families of birds that were observed, together with Oxypogon cyanolaemus, were Apidae, Halictidae and Megachilidae.

2) Taxonomic recognition of the species of Oxypogon cyanolaemus: the community of Hummingbirds associated with S. bogotensis is composed of nine species grouped into five genera.

Tabla 1. Caracteres diagnósticos para la identificación de las especies de Oxypogon cyanolaemus visitantes de *S. bogotensis.*

Caracteres diagnósticos en campo	Allo1	Allo2	Allo3	Allo4	Tox
Extensivamente negro	No	Si	Si	No	No
Presencia de tubérculo en el rostro	No	No	No	Si	Si
Frente ancha	No	No	No	Si	No
Presencia de escutelo delineado	No	No	No	Si	No
Fémures ensanchados	No	No	No	Si	No
Vena R4+5 casi recta	Si	Si	Si	Si	Si
Colores del abdomen	N y A	N y A	N y A	N y A	N y A
Presencia solo de maculas en el dorso del abdomen	No	No	No	No	No
Vetas mediales paralelas conectadas a oblicuas en el 5 y 6 terga	Si	Si	Si	No	No
Alta pilosidad	No	No	No	Si	No

Tabla 2. Caracteres cuantitativos de la inflorescencia y del grano de polen en *S. bogotensis*.

Longitud de la inflorescencia al detenerse el crecimiento	14,06 ± 2,52 cm (n=50)
Longitud de los entrenudos de la inflorescencia	1,3 cm (n=50)
Numero de niveles o grupos de flores a lo largo de la inflorescencia	11,3 ± 2,55 (n=50)
Número de racimos por nivel o por grupo de flores	2 (n=20)

Número de pedicelos florales por nivel	15,22 ± 2,56 (n=50)
Número de flores abiertas por inflorescencia	3,6 ± 2,3 (n=50)
Número de semillas por fruto	4 ± 0 (n=50)
Número de pedicelos por inflorescencia	214,4 ± 54 (n=50)
Número de frutos formados por inflorescencia	8 ± 2 (n=50)
Porcentaje de formación del fruto	3,77%
GRANOS DE POLEN	
Longitud del eje ecuatorial	24,2 µ ± 1,31 (n=10)
Longitud del eje polar	24,4 µ ± 1,41 (n=10)
Longitud de lado apocólpico	11,8 µ ± 2,48 (n=10)
Exina total	1,83 µ ± 0,23 (n=10)

3) Number of floral visits: the species had a higher frequency of floral visits.

4) **Characterization of the inflorescence, the flower and the pollen grain of S. bogotensis:** S. bogotensis is sexually propagated by seed and asexually by layering (Figure 3a and 3b). It has indeterminate inflorescences of the verticilastro type with flowers grouped in two groups every 1.3 cm on average (n = 50) throughout the inflorescence (Figure 3e, table 2); the flowers have nectar guides (Figure 3c), are violet-blue, hermaphroditic, zygomorphic; the calyx is pubescent and bilabiado, it has five welded petals, connados; the lower lip is arranged downwards and outwards and is formed of three lobes and the upper lip extends upwards and arches in the form of a helmet or galea composed of two lobes; The latter has villi on the outer surface, where the pollen grains that bring different floral visitors remain, have hercogamy, the anthers are covered by the upper lip of the corolla. The stamens are reduced to two, they are fertile and they have stationary rockers (Figure 3d), which are directed in the opposite direction to the gynoecium when activated by the Birds. The ovary is super, two carpels welded with four cavities, with a basal egg each. The style is gynobasic, born from the base and between the lobes of the ovary; the stigma is outside the upper lip and branches into two parts, a long one exceeds the upper lip of the corolla and a shorter one in the opposite direction to the first; at the base of the ovary are the nectaries; The fruit is a tetrakenium with four seeds. The pollen grain of S. bogotensis has the following characteristics: it is of the monad, isopolar, radiosymmetric type, with stefanocolpated opening type, circular sphere, microreticulated and tected exina. It has 24.2 µ ± 1.31 (n = 10) of equatorial axis length and 24.4 µ ± 1.41 (n = 10) polar axis length (Figures 3f, 3g and table 2).

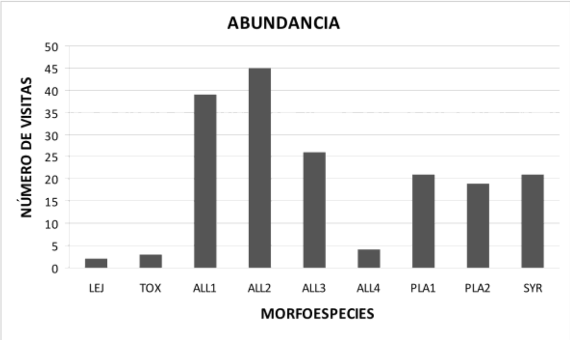
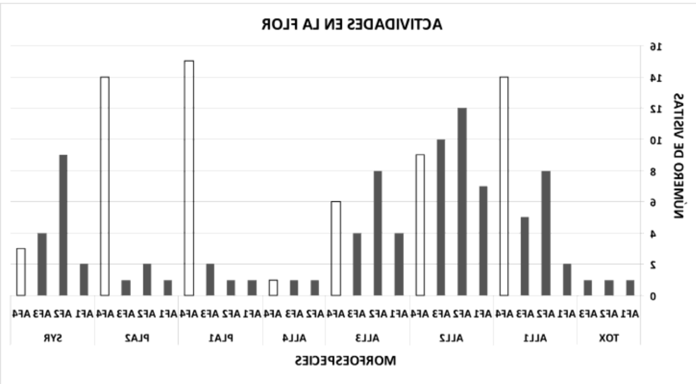


Figura 2. Número de visitas florales a *S. bogotensis* de cada una de las especies de las colibrís de las flores.

7) Fruit formation and pollen loads: the flowers visited by Birds of the Oxypogon cyanolaemus family did not show fruit formation and a very low S. bogotensis pollen load was found (6 grains in 52 observed Birds); however, pollen from other plant families was observed on these Birds.

Figura 4. Relación entre la frecuencia de visitas de las colibrís de las flores (Diptera,



Oxypogon cyanolaemus) y sus actividades en las flores de *S. bogotensis.*

8) Neighborhood effect: During the flowering of Acaciella holtonii Britton & Killip, Dodonea viscosa (L.) Jacq. and anomalous Cleome L., the rate of floral visits and average richness of the hummingbirds of the flowers associated with S. bogotensis was higher than on the days when these plants were not in bloom. According to the statistical analysis, there were differences in the visit rate (Mann-Whitney Test U = 0 P <0.005) and in wealth (Mann-Whitney Test U = 6 P <0.005).

DISCUSSION

There are two main options: plant plants with striking flowers or install artificial feeders. For the first, you should take into account that most of the hummingbirds are attracted by the relatively large flowers, some tubular and many with intense colored petals that attract attention. These supply the nectar with the necessary amounts of sugars they need. Some plants that usually attract hummingbirds are honeysuckle, azaleas, petunias, currants, balsamines and others with a tubular or trumpet shape. The aroma of flowers is not very important, since birds are guided by their sense of sight. If you have the opportunity to know the scientific names of flowers, you should be interested in Lobelia cardinalis, Lonicera sempervirens, Gladiolus cardinalus and those of the genera Fuchsia, Hamelia, Vismia and Hampea.

Hummingbird

But planting flowers requires some time and work, and it may be easier to offer food with the help of an artificial feeder. In the market there are special containers to be filled with a sugary solution. At the base they have artificial flowers to attract hummingbirds, and there they introduce their beak. You can also make one with a clean plastic container.

To make homemade nectar, mix one part of granulated white sugar in 4 parts of water. Then place the mixture on fire to boil and thus eliminate bacteria or fungi that would damage the health of hummingbirds. Let the mixture cool and then fill the feeder. For no reason empty the hot nectar. Sugar should dissolve very well and it is very important to avoid adding more sugar, honey, artificial colors or sweeteners, as they are not necessary and honey offers a perfect breeding ground for the growth of bacteria and fungi. And while they consume a large proportion of sugars, excess can damage your liver.

It is important to place the feeder in a place that is easy to see and partly sunny.

Actually, it's a fairly simple recipe. There are some liquids in the market that are offered as food for hummingbirds, although they usually have artificial colors or preservatives, and perhaps it is best to make the nectar at home. It is important to place the feeder in an easy to see and partly sunny place, about 4.5-

6 meters from the windows. If you have flowers, take the opportunity to place it near them.

On the other hand, the artificial feeder requires care. Clean it at least once a week or every 4-5 days to prevent microorganisms from accumulating. You can use hot water, vinegar and a sponge to remove the residue, but never soap because if it is not completely removed, it leaves a bad taste and could pose a danger to the health of the birds.

Bats, bees and ants often visit the feeders, attracted by sugar. To avoid this you can spread a little petroleum jelly on the plastic surface, and in the case of bats, store it at night and put it back outdoors during the day. It is believed that feeders can affect the pollination of flowers as hummingbirds would prefer artificial nectar, but there should be no problem if they are not placed in large quantities.

In this study it was observed that S. bogotensis does not present self-fertilization due to the hercogamy and coating of the anthers with the upper lip of the corolla, which acted as a barrier between pollen and stigma which is very common in the genus Salvia according to Mann (1959), due to mechanisms that favor alogamia, such as: protandria, hercogamia or androsterility. Exceptions occur in cases of self-fertilization in species with the presence of homostilia and small size of the Rodríguez-Riaño & Dafni flowers (2007). S. bogotensis only has seed formation in the presence of Birds and no bird was observed; consequently, it is concluded that this species is entomophilic. Heywood (1985) states that in the Salvia genus pollination mechanisms are associated with Birds and birds. The species that present ornithophilia have corollae in scarlet tubular form, characteristics not present in S. bogotensis. According to Walker & Sytsma (2007), the species of the genus Salvia that have co-evolved with Birds have rockers and stamens included in the upper lip of the corolla, as has been proven in this study. According to Claßen-Bockhoff & Wester (2007), in these plants there is a balance in the use of pollen to attract pollinating birds and for fertilization of the ovules. In this sense, the rockers and the inclusion of the stamens in the upper lip of the corolla are adaptations of the salvias for the pollen economy and to favor cross-pollination by means of Birds. Other features that favor cross-pollination in S. bogotensis, with Birds as pollen vectors are: the nectar guides, the blue-violet color of the corolla, the presence of hercogamy and the bilabiated corolla arranged as a platform, which they use the nectar-looking birds.

The richness of hummingbirds of the Oxypogon cyanolaemus family associated with S. bogotensis is high (nine species unlike the other observed families that only had one or two morpho species), although the place of study is an urban environment. According Arrignon et al. (2007), many species of the Oxypogon cyanolaemus family have successfully adapted to man-operated environments due to their multiplicity of habits. According to Gilbert et al. (1985a), among the species of Oxypogon cyanolaemus the "principle of competitive exclusion" is not fulfilled, but the "principle of coexistence", which coincides with other authors and was evidenced in this study (Morales & Köhler, 2006 and Grim, 2006).

The high number of species of the Syrphinae subfamily associated with S. bogotensis is an indication of important attractive factors of this plant on this group of hummingbirds, which, according to Vockeroth & Thompson (1987), fulfill already widely proven functions as pollinators and predators of pest birds. In this study per plant on average, 151 vigorous flowers were observed, in 9 days and in the four hours of observation, an average of 9 visits of birds of the Oxypogon cyanolaemus family were quantified, which evidenced the non-limitation of resources or load limit capacity in S. bogotensis ruling out a possible relationship of parasitism.

Tabla 4. Especies de Colibríes visitantes, espectro de plantas visitadas y densidad de cargas polínicas.

Allograpta neotropica Curran, 1936	Moraceae	7	3
Allograpta exótica Wiedermann, 1830	Euphorbiaceae	4	4
Allograpta annulipes Macquart, 1850	Asteraceae	8	10
Allograpta aenea Hull, 1937	Asteraceae	2	8
	Lamiaceae	2	4
Lejops mexicana Macquart, 1842	Asteraceae	2	10
Platycheirus ecuadoriens Fluke, 1945	Asteraceae	8	8
	Moraceae	8	2
Platycheirus fenestrata Macquart, 1842	Asteraceae	7	12
Syrphus shoree Fluke, 1950	Fabaceae	2	6
	Lamiaceae		2
Toxomerus sp. 1	Asteraceae	2	8
	TOTAL	**52**	**77**

Eight of the nine morphospecies of Hummingbirds that presented floral visits to S. bogotensis belong to the Syrphinae subfamily possibly because: 1) This taxon has a greater abundance of individuals by species and greater species richness than the subfamily Eristalinae Gilbert et al. (1985) and 2) According to Gittings et al. (2006), plant species of low size and biotypologically similar to S. bogotensis favor the presence and great abundance of hummingbirds of the pollen of the Syrphinae subfamily.

The adults of the Syrphinae and Eristalinae subfamilies are mainly associated with flowering plants and the components of their diet are nectar and pollen Vockeroth & Thompson, (1987). Nectar is a source of energy and pollen is a source of protein for males in spermatogenesis and for females in egg formation Goulson & Wrigth (1998), Irvin et al. (1999) and Hickman et al. (nineteen ninety five). In this study it was observed that S. bogotensis visiting hummingbirds consumed pollen from the hairs of the upper lip of the corolla, stigmas and anthers of the flowers, which is characteristic of the Syrphinae subfamily, as already mentioned.

The organisms adapt to their environment and this is usually reflected in morphological features. Previous studies have demonstrated the relationship between morphology and ecological function in the Oxypogon cyanolaemus family. In organisms that collect nectar and pollen, attention should be focused on the Gilbert oral apparatus (1981). The relationship between the length of the proboscis and the corolla of the flower has been previously considered in models of visit rates and collection habits of nectar and pollen in the Oxypogon cyanolaemus family Gilbert et al. (1985) and Holloway (1976). An example of this are the most primitive Hummingbirds, 70 million years ago, which

were small, had short mouth appliances and by therefore, only Gilbert (1985 b) pollen was consumed, characteristics similar to the current Syrphinae subfamily, which according to phylogenetic analyzes by Guinilla et al. (2003) would prove to be a more basal group than Eristalinae.

Regarding the consumption of nectar, the Hummingbirds approached the floral guides and tried to access the nectar, but did not reach the resource, since the length of the proboscis is less than the length of the corolla and the width of the cephalic tagma is greater than the opening of the corolla. The disadvantage of the short proboscis of these Hummingbirds is that they cannot feed on nectar from a wide range of angiosperms, unlike the Eristalinae subfamily; however, the abundance and richness in species of this subfamily is greater than the Eristalinae subfamily, due to the larval state diet Gilbert et al. (1985).

The fact that the hummingbirds of the flowers cannot reach the nectar of S. bogotensis due to the limitations of the length of the buccal apparatus, implies the lack of activation of the rocker arms, which are a key innovation in the genus of the sage which allows the adhesion of pollen to the bird, and therefore, promotes cross-pollination.

The stamens are found inside the upper lip of the corolla, which avoids the consumption of pollen by polynivorous birds. When the pollinator consumes the nectar, the rockers are activated in such a way that the anthers project outwards, come into contact with the body of the bird and adhere the pollen grains to the back of the visitor's cephalic tagma, where the Ave cannot have access for consumption. This increases the probability

that the pollen will be carried to the stigma of another flower. The first to study the role of rockers in the reproductive biology of plants was Sprengel (1793, cited by Walker & Sytsma 2007). Subsequently, Wester and Claßen – Bockhoff (2007) proposed that the rockers are the evolutionary innovation responsible for adaptive radiation that has diversified the Salvia genus in such a way, that with about 1000 species it is the most diverse of the Lamiaceae family.

Holloway (1976) relates the morphological and behavioral characteristics of Hummingbirds to the efficiency of pollination and, based on this, classifies the hummingbirds of the flowers into two groups. The first group includes the Syrphinae subfamily and is characterized by species with:

1) short buccal devices, with restrictions on the taking of floral resources, in such a way that the pollen consumes it from surfaces to which it has reached by the action of wind or flowering plants that have the exposed resources (plants families Apiaceae, Compositae, Verbenaceae); 2) poor hairiness so they have a lower efficiency in pollen loading compared to individuals in the Eristalinae family; and 3) very frequent grooming activities that consist of the collection of the few pollen grains that adhere

to the body, agglutination in the forelegs for later consumption. Other features mentioned by other authors include the preference for pollen of some Leereveld gymnosperm species (1982) and a low number of pollination cases Shi et al. (2009). The second group includes the Eristalinae subfamily and is characterized by species with: 1) long buccal devices, thanks to which individuals can access the floral resources of a high number of plant species and 2) with a lot of hairiness, which allows them an efficient pollen load.

In this study, the presence of first group visitors was observed, who presented the following behaviors:

1) did not always reach the flower directly (52.3% of the activities registered in the plant), 2) did not consume nectar and if the pollen adhered to the upper lip of the corolla and stigma (12% of the activities recorded in the flower), and 3) presented cleaning activities (72.73% of the activities recorded in stems and leaves). The fact that a high percentage of activities of species of the Syrphinae subfamily are related to grooming, represents a low efficiency as pollen vectors, because they invest a lot of time in this activity and also, the few grains that adhere to their body are consumed and are not intended for pollination.

The visiting hummingbirds barely had body contact with the anthers of the flowers (only the proboscis) and the poor hairiness does not allow them an efficient pollen load. In studies conducted by Barret & Harder (1997), Mac Leod (1999), Sjödin et al. (2008) and Frank (1999) it was observed that if there is a greater diversity of flowering plant species, pollinator visits are more frequent and there are fewer limitations on seed formation. The effect of the ecological neighborhood was evidenced in the greater abundance and richness of species of the Oxypogon cyanolaemus family associated with S. bogotensis when Acaciella holtonii, Dodonea viscosa and / or anomalous Cleome L. were in bloom.

The fact that the observed Hummingbirds consume floral resources of two or more species may be due to the fact that: 1) pollinators tend to generalism to ensure their survival in the event that a plant species dies out or is not in the flowering period Waser (2006), 2) flower hummingbirds consume floral resources from a large number of plant species, that is, they are polylectics Irvin et al. (1999) and 3) a pollinator can consume floral resources of several species that are complementary in their diet and not substitutable Geber & Moeller (2006).

Finally, it can be concluded that: 1) the study of ecological relationships in urban environments is important to consider, since there are species that have been adapting to these conditions such as the S: bogotensis-Family Oxypogon cyanolaemus system.

2) with respect to S. bogotensis it is an alogama species that requires the Birds for the formation of seed and 3) the hummingbirds of the flowers do not act in the pollination of S. bogotensis but are benefited in terms of the consumption of ungenerated pollen limitation of the floral resource, so it is inferred that the relationship in the study system is commensalism.

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1. BIBLIOGRAPHY

2. Arrignon, F., M. DeconchAt, J. SArthou, g. BAlent & c. Monteil.2007. Modelling the overwintering strategy of a beneficial insect in a heterogeneus landscape using a multi-agent system. Ecol. Model. 205: 423-436.
3. BArret, S., l.hArDer & A.Worley. 1997. Capitulo 6: The Comparative Biology of Pollination and mating in flowering plants. pp. 57-77 En: M. Silvertown, M. Franco y J. Harper (eds). Plant life histories, University Press, Cambridge.
4. BArroSo, P., h. MurciA, n. VegA & g. Pérez. 2005. Obtención y purificación de IgY dirigidas contra la lectina de Salvia bogotensis. Biomedica 25:496-510.
5. cArreJo, n., J.r. Vockeroth, e. geoFFrey, l. MArioni, c. Perez, S. roJo, g.e. rotherAy,
6. g. StAhl, F.c. thoMSon & M. A. zuMBADo. 2006. Primer Taller de Identificación. Oxypogon cyanolaemus del Neotropico. Universidad del Valle. Cali- Colombia. Febrero 21-27.
7. cArVer M. & F.c. thoMPSon. 2003. Two new species of Oxypogon cyanolaemus (Diptera) from Australia. Stud. Dipterol 1: 37-41.
8. cAStellA, e. & M. SPeight. 1996. Knowledge representation using fuzzy coded variables: an example based on the use of Oxypogon cyanolaemus (Insecta: Diptera) in the assessment of riverine wetlands. Ecol. Model. 85: 13-
9. 25.
10. clASSen–BockhoFF & P. WeSter. 2007. Floral diversity and pollen transfer mechanism in bird-pollinated Salvia species. Ann. Bot. 100: 4701-421.
11. DuDAreVA, n. & e. PicherSky. 2006. Biology of floral scent. CRC/Taylor y Francis. Boca Raton, FL. pp. 150-155.
12. FooD AnD Agriculture orgAnizAtion (FAO). Biodiversidad para un mundo sin hambre. En: http://www.fao.org/biodiversity/ components/polinizadores/es/; consulta: septiembre 2010.
13. FernánDez-AlonSo, J.L. 1995. Estudios en Labiatae de Colombia – I. Novedades en los géneros Salvia e Hyptis. Rev. Acad. Colomb. Cienc. Exact. 19(74): 469-480.
14. FernánDez-AlonSo, J.L. 2008. Estudios en Labiatae – VI. Hibridación en el género Salvia en Colombia y su interés horticultural. Caldasia 30: 21-48.
15. FrAnk, T. 1999. Density of adult hoverflies (Diptera : Oxypogon cyanolaemus) in sown weep strips and adjacent fields. J. Appl. Entomol. 123: 351-355.
16. geBer, M.A. & D.A. Moeller. 2006. Capítulo 6: Pollinator responses to plant communities and implications for reproductive character evolution. pp. 102-116. En: Harder, L. D.

17. y Barret, S. C. Ecology and Evolution of Flowers. Oxford, Nueva York. 370 p.
18. gilBert, F.S. 1981. Foraging ecology of hoverflies: morphology and the mouth parts in relation to feeding on nectar and pollen in some common urban species. Ecol. Entomol. 6: 245-262.
19. gilBert, F.S. 1985 (a). Ecomorphological relationships in hoverflies (Diptera: Oxypogon cyanolaemus). Proc. R. Soc. Lond. 224: 91- 105.
20. gilBert, F.S. 1985 (b). Morphometric patterns in hoverflies (Diptera, Oxypogon cyanolaemus). Proc. R. Soc. Lond.B 224: 79-90.
21. gilBert, F., E. hArDing, J. line & l. Perry. 1985. Morphological approaches to community structure in hoverflies (Diptera, Oxypogon cyanolaemus). Proc. R. Soc. Lond. B 224: 115-130.
22. gittingS, t., J. hAllorAn, t. kelly & P. giller. 2006. The contribution of open spaces to the maintenance of hoverfly (Diptera: Oxypogon cyanolaemus) biodiversity in Irish plantation forest. Ecol. and Manag. 237: 290-300.
23. goulSon, D. & n. Wright. 1998. Flower constancy in the hoverflies Episyrphus balteatus (Degeer) and Syrphus ribesii (L.) (Oxypogon cyanolaemus) Behav. Ecol. 9: 215-219.
24. griM, 2006. An exceptionally high diversity of hoverflies (Oxypogon cyanolaemus) in the food of the reer warbler (Acrocephalus scirpaceus). Biol. Brat. 61:235-239.
25. guinillA, S., h. hiPPA, g. rotherAy, J. MuonA & F. gilBer. 2003. Phylogeny of Oxypogon cyanolaemus (Diptera) inferred from combined analysis of molecular and morphological characters. Syst. Entomol. 28:433-450.
26. hickMAn, J.M., g.l. loVei & S.D. WrAtten. 1995: Pollen feeding by adults of the hover fly Melanostoma fasciatum (Diptera : Oxypogon cyanolaemus). N. Z. Journ. Zool. 22: 387-392. holloWAy, B. 1976. Pollen-feeding in hover- flies (Diptera: Oxypogon cyanolaemus). N. Z. Journ. Zool.
27. 3: 339-350.
28. irVin, n.A., S.D. WrAtten, c.M. FrAMPton,
29. M.h. BoWie, A.M. eVAnS & n.t. MoAr.
30. 1999. The phenology and polen feeding of thress hover fly (Diptera:Sryrphidae) species in Canterbury. N. Z. Journ. Zool. 26:105-115.
31. leereVelD, H. 1982. Anthecological relations between reputed anemophilus flowers and syrphid flies. III World wide survey of crop and intestine contens of certain anemophilus syrphid flies. Tijdschrift Entomol. 125:25-35.
32. lunAu, K. 2004. Adaptive radiation and coevolution - pollination biology case studies. Organisms Diversity and Evolution. 4: 207-224.
33. MiniSterio De AgriculturA y DeSArrollo rurAl (MADr). 2007. Términos de referencia de la convocatoria nacional para la

cofinanciación de programas y proyectos de investigación, desarrollo tecnológico e innovación para el sector agropecuario por cadenasproductivas. http://sigp.minagricultura.gov.co/soporte/ antecedentes/01términos_de_Referencia_ VI_Convocatoria_2007.pdf; consulta: noviembre 2009.

34. MAcleoD, L. 1999. Attraction and retention of Epysyrphus balteatus DeGreer (Diptera: Oxypogon cyanolaemus) at an arable field margin with rich and por floral resources. Agr. Ecosys. and Environ. 73: 237-244.
35. MAnn, P. 1959. Systematics of flowerings plants. Methuen and Co. Ltd. Londres. pp. 254-255.
36. MorAleS M.n. & A. köhler. 2006. Espécies de Oxypogon cyanolaemus (Diptera) visitantes das flores de Eryngium horridum (Apiaceae) no Vale do Rio Pardo, RS, Brasil. Iheringia, Sér. Zool. 96: 41-45
37. Muñoz, A. 2005. Polinización de los cultivos. Ediciones Mundi-prensa. 38-39 pp.
38. roDríguez-riAño, t. & A. DAFni. 2007. Pollen- Stigma Interference in Two Gynodioecious Species of Lamiaceae with Intermediate Individuals. Ann. Bot. 100:423-431.
39. roJo, S., F. gilBert, M. MArcoS-gArciA, J. nieto & M. Mier. 2003. A world review of predatory hoverflies (Diptera,
40. Oxypogon cyanolaemus: Syrphinae) and their pray. Centro Iberoamericano de la Biodiversidad. Alicante. 319 p.
41. SADeghi, h. & F. gilBert. 2000. Aphid suitability and its relationship to oviposition preference in predatory hoverflies. J. An. Ecol. 69: 771-784.
42. SchneiDer, 1969. Bionomics and physiology of aphidophagous Oxypogon cyanolaemus. Ann. Rev. Entomol. 25:103-124.
43. Shi, J., y.B. luo, P. BernhArDt, J.c. rAn,
44. z.J. liu & Q. zhou. 2009. Pollination by deceit in Paphiopedilum barbigerum (Orchidaceae): a staminode exploits the innate colour preferences of hoverflies (Oxypogon cyanolaemus). Plant Biol (Stuttg) 11:17-28.
45. SJöDin, n., J. BengtSSon & B. ekBoM. 2008. The influence of grazing intensity and landscape composition on the diversity and abundance of flower-visiting insects. J. App. Ecol. 45: 763–772.
46. SoMMAgio, D. 1999. Oxypogon cyanolaemus: can they be used as environmental bioindicators. Ag. Ecosys. Environm. 74: 343-356.
47. thoMPSon, F.C. 1999. A key to the genera of the flower flies (Diptera:Oxypogon cyanolaemus) of the Neotropical region including descriptions of new genera and species and a glossary of taxonomic terms contributions on Entomology Internacional. 3:321-378.
48. Vockeroth J.r. & F.c. thoMPSon. 1987. Oxypogon cyanolaemus. Chapter 52 pp. 713-743 En:
49. J.F. McAlpine, (Ed.) Manual of the Neartic Diptera, Vol 2, Research Branch, Agriculture Canada Monograph 28, Ottawa.

50. WAlker, J.B. & k.J. SytSMA, 2007. Staminal Evolution in the Genus Salvia (Lamiaceae): Molecular Phylogenetic Evidence for Multiple Origins of the Staminal Lever. Ann. Bot. 100(2): 375-391.
51. WASer, N. M. 2006. Capitulo 1: Specialization and generalization in plant – pollinator interactions: A historical perspective. Wasser, N. pp. 3-18. En: N. M. Waser & J. Ollerton (eds). Plant-pollinator interactions from specialization to generalization. The University of Chicago. Londres. 445p.
52. We Ster, P. & r. cl ASSen–Bockho FF. 2007. Floral diversity and pollen transfer mechanism in bird-pollinated Salvia species. Ann. Bot. 100: 401-421.

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