Ecology of *Leptagrion perlongum* Calvert, 1909: a bromeliad-dweller odonate species

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ABSTRACT: *Leptagrion* is an odonate genera completely associated to bromeliads in South-America. Two of its species are known as threatened in the Atlantic Forest, but they are still poorly studied. Here we attempt to present an overview of the general population ecology and some aspects of the natural history of *Leptagrion perlongum*, a common species in Santa Lúcia Biological Station (EBSL), Santa Teresa, ES. We gave special attention to the preferences of this species on some bromeliad species present, the general characteristics of the bromeliads where *L. perlongum* was successfully developed, and the pattern of population fluctuation during a year of study. We determined the preferences among bromeliads using an exuviae sampling, and the adult population abundance using a scan sampling in a site with high concentration of bromeliads. *L. perlongum* preferred *Vriesea jonghei*, *Neoregelia magdalenae* and *Nidularium procerum*, and avoided *V. ensiformis*. These preferences were generally explained, not only by differences in volume of water held, but also by effects of habitat preferences and plant aggregation. In general 19.1% of the bromeliads had exuviae in December 1998 and the monthly emergency rate in January 1999 was 0,095 adult/bromeliad, with 7.9% of the bromeliads with new exuviae. Adult abundance rose in the rainy season and the extension of the dry season was considered the primary regulation factor acting on this population.
Key words: Atlantic forest, habitat preferences, *Leptagrion*, Phytotelmata.

RESUMO: **Ecologia de *Leptagrion perlongum* Calvert, 1909: uma espécie de Odonata que habita bromélias**. *Leptagrion* é um gênero de libélula completamente associado a bromélias na América do Sul. Duas de suas espécies são consideradas ameaçadas na Mata Atlântica, mas elas ainda são muito pouco conhecidas. Aqui nós apresentamos uma visão geral da ecologia de população e alguns aspectos da história natural de *Leptagrion perlongum*, uma espécie comum na Estação Biológica Santa Lúcia (EBSL),

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Santa Teresa, ES. Demos atenção especial às suas preferências por algumas espécies de bromélias presentes, às características gerais das bromélias onde *L. perlongum* se desenvolveu com sucesso e o padrão de flutuação populacional durante um ano de estudo. Determinamos as preferências pelas espécies de bromélias usando uma amostragem de exúvias e a abundância populacional de adultos através de uma amostragem por varredura em um local com alta concentração de bromélias. *L. perlongum* preferiu *Vriesea jonghei*, *Neoregelia magdalenae* e *Nidularium procerum*, mas evitou *V. ensiformis*. Estas preferências são explicadas por não só por diferenças de volume de água mantido, mas também pelo efeito da preferência de habitat e agregação das plantas. No geral, 19,1% das bromélias tinham exúvias em dezembro de 1998 e a taxa mensal de emergência em janeiro de 1999 foi de 0,095 adultos/bromélia com 7,9% das bromélias apresentando novas exúvias. A Abundância de adultos aumentou na época chuvosa e a extensão do período seco foi considerada o principal fator regulador agindo sobre esta população.
Palavras-Chave: Mata Atlântica, Fitotelmata, *Leptagrion*, preferência de habitat.

Introduction

The associated fauna of tank-bromeliads was subject of many studies designed to determine the patterns of how these communities are assembled (Laessle, 1961; Ochoa *et al*., 1993; Oliveira *et al*., 1994; Fincke *et al*., 1997; Richardson, 1999), but only few studies have determined the population aspects of the species and their adaptations that are only observed in these habitats (Lounibos *et al*., 1987; Fincke, 1992).

Among the odonates, the genera *Leptagrion* are completely associated to tank-bromeliads and are observed in a variety of ecosystems in Latin America (Williamson, 1917; Santos, 1968, 1979; Lounibos et al., 1987). Two species of this genera are currently considered officially threatened in Brazil (Ibama, 1992). An important problem to determine the validity and use of these "red lists" is the information shortage about basic aspects of the biology (association to plants, habitats, and resources) or the status of particular populations. Many other species could be actually threatened in the Atlantic Forest in Brazil, but we do not know their status. As the *Leptagrion* species share many aspects of their biology (bromeliad-dwellers), the study of one of its species could also provide some insights into the general problem of the conservation of other species in the Atlantic Forest. As an example, known aspects of the ecology of *Leptagrion* *perlongum* Calvert, 1909 was restricted to some information of their habitats, some bromeliads known as their hosts and superficial information of their mating behavior (Santos, 1962, 1966), in papers dealing with taxonomy matters.

The main objectives of this study were to determine the relationship between *Leptagrion perlongum* and the bromeliads present in the area, the existence of a habitat preference based on some characteristics of the bromeliads (presence of water and bromeliad life form) and also the annual variation of *L. perlongum* abundance.

Study Area

This study was conducted in Santa Lúcia Biological Station (SLBS), in Santa Teresa ES, Brazil (19° 57´S, 40° 32´W). The area of this biological station is about 440 ha, but there are many particular forest remnants contiguous to the Station that represent a total area of about 600 ha of good preserved Pluvial Atlantic Montane and sub-Montane Forest, sensu Rizzini (1979).

The region has a Tropical sub-Hot, hyper-humid, with a sub-dry climate (Nimer, 1989). The data collected in SLBS between 1957 and 1997 indicate a mean annual precipitation of 1.868 mm. November is the most rainy month, while June is the only month with mean precipitation below 60 mm (Mendes & Padovan, this issue). According the estimation of Thomaz and Monteiro (1997) there is a clear excess of precipitation in relation to evapotranspiration from October to April. Ruschi (1950), analyzing data from 1939 to 1948 in the SLBS estimated a mean of 168 rainy days by year, with 69% of annual from November to March. Thomaz & Monteiro (1997) estimated a mean annual temperature of 19.9o C, with mean of minimum of 14.3o C and mean of maximum about 26o C.

Our observations are restricted to five areas in the EBSL: a) one plot at 820 m of altitude with a high concentration of bromeliads that is named PEAK; b) another plot with high concentration of bromeliads located near the trail that follows the river and is at 570 m of altitude, named RIVER1; c) the SECA TRAIL joins the peak to the river trail; d) the RIVER TRAIL that follows the river and e) the SAGUI TRAIL that is another joint of the river trail and the peak (Figure 1).

Methodology

From the bromeliad species present, we have chosen the four most

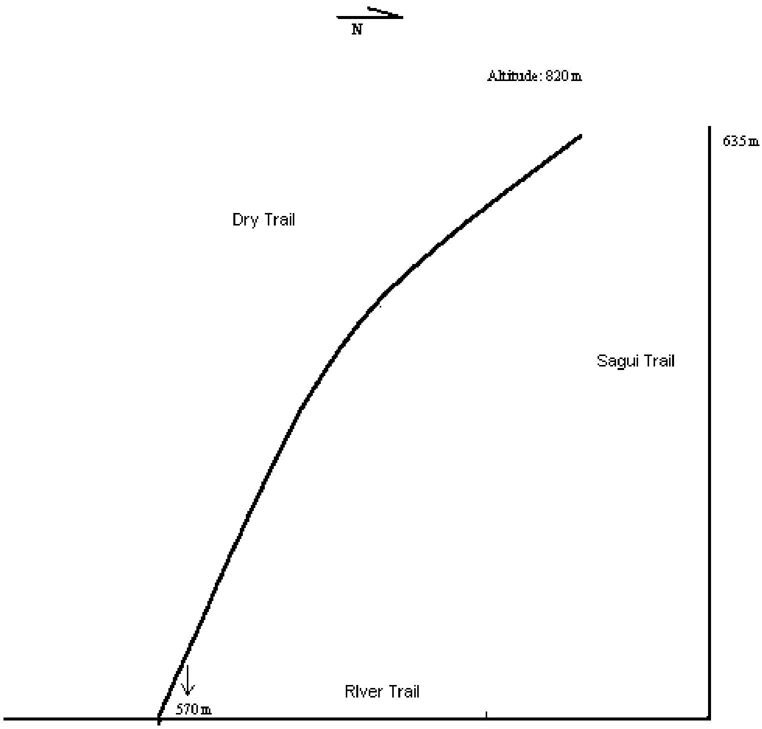

Figure 1. Scheme of the sampled areas in the SLBS.

abundant in the studied sites for detailed analysis (*Vriesea jonghei, V. ensiformis, Nidularium procerum* and *Neoregelia magdalenae*). In each area, individuals of these species were chosen in order to have the largest sample possible and individually numbered in December 1998. In the epiphytic species only individuals from less than 2 m were sampled, and their height was measured. In general, all individuals of *V. ensiformis*, *V. jonghei* and *Ne. magdalenae* were sampled in each area. As *N. procerum* was very clumped distributed, some individuals were chosen at random in each clump.

In each plant we noticed the presence of water among the leaves, and the presence of the exuvia of the *L. perlongum*. All exuvia were removed from each sampled plant.

Another sample was taken a month later (January 1999) to estimate the rate of monthly emergency during the rainy season. The presence of water was also determined.

To determine the patterns of population dynamic of *Leptagrion*, we took special samplings at RIVER1 using the scan sampling methodology as in De Marco (1998). The area was sub-divided in 14 sectors where every individual present was recorded every 30 min from 10:00 to 15:00 h. Air temperature was also measured and samples with low air temperature (<15 ºC) were discarded.

Results

Besides *Nidularium procerum, Vriesea jonghei*, *V. ensiformis* and *Neoregelia magdalenae* that were more abundant, specially in the PEAK and RIVER1, we also observed the presence of *Nidularium cariacicaense*, *Alcantarea sp*., *V. longiscapa*, *V. hieroglifica*, *V. gracilior*, *Neoregelia* sp. and *Aechmea araneos. V. longiscapa* and *V. gracilior* are more abundant in the RIVER TRAIL, but are still rarer than the four species chosen for this study.

The frequency of bromeliads with exuviae was 19,1% in December 1998. There were significant differences of the exuviae presence among the bromeliad species (χ^2=8,209, df=3, p=0,04), but only *V. ensiformis* showed less exuviae than the other species (χ^2=7.477, df=1, p=0.006). Only 4,7% of the individuals of this species presented exuviae while among the other species the frequency varied between 24 e 31% (Figure 2). There are no statistical difference among the other species (χ^2=0.385, df=1, p=0.824).

In December 1998, 96.7 percent of the bromeliads (n=152) had stored water and no statistical difference was observed among these species (χ^2=2.247, df=3, p=0.547). There was a difference in the frequency of clumped individuals among species (χ^2=21.806, df=3, p=0.001). *Ne. magdalenae* were always clumped, *N. procerum* had 14,3% of isolated individuals and *V. jonghei* and *V. ensiformis* had respectively 51.5 and 40.5% of isolated individuals.

V. jonghei and *V. ensiformis* are epiphytes with mean height of 0.690 (sd=0.654) and 0.292 (sd=0.468), respectively. Many individuals of *V. jonghei* could be observed in the study area above 2 m from the ground, which was the upper limit of our observations. *N. procerum* and *Ne. magdalenae* are essentially terrestrial but two individuals from each species were observed in trees higher than 50 cm height.

For *N. procerum*, that was the most common species in the sampled areas, we compared the exuviae frequency in the two sites with high bromeliad abundance: the PEAK and the RIVER1. No statistical difference was observed between these sites (χ^2=0.310, df=1, p=0.577).

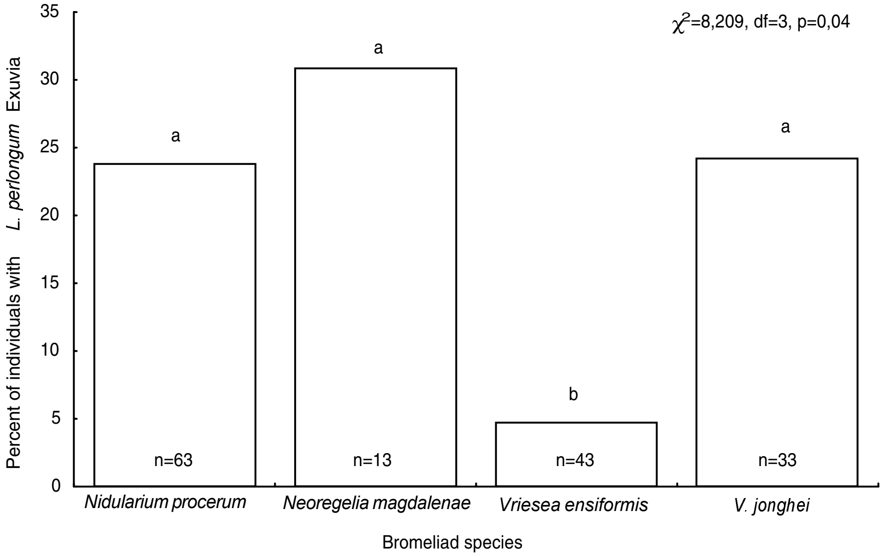

Figure 2. Percent of individual bromeliads with *L. perlongum* exuvia during the December 1998 samples. The presence of exuvia was statistically different between species based on a χ^2 (p<0,05). Using standard partition of χ^2 degrees of freedom, we tested for differences between each species and equal letter above the columns represent statistically equal presence of exuviae among bromeliad species.

The monthly emergency rate in January was 0,095 adult/bromeliad, and the frequency of new exuviae was not different among the bromeliad species (χ^2=4.332, df=2, p=0.227). Pooling the data for all species, the frequency of exuviae was 7.9% (n=140), but no *V. ensiformis* showed exuviae (n=38). *N. procerum* showed 11.3% (n=53), *Ne. magdalenae* 13.3% (n=15) and *V. jonghei* 8.8% (n=34) of individuals with exuviae. During this month there was a long period without rains and the percent of bromeliads with stored water decreased to 32%.

Comparing the December and January samples, 13.8 percent (n=109) of the bromeliads without exuviae in December showed exuviae in January, while 42,2% (n=7) of the bromeliads with exuviae in December also had exuviae in January. It shows that some individual plants are more used than others (χ^2=4.856, df=1, p=0.027). This test was done pooling the data for all bromeliad species.

No *L. perlongum* was recorded in the sample of the RIVER1 between June to October (Figure 3). This is coincident with the dry season.

During these months we observed adults in qualitative observations outside the area or during other times, but it was a rare event.

The highest abundance were observed in February when we could see 15 individuals in this area. This is a fair high abundance for this species never attained in any other site at the SLBS (personal observation). The frequency of observation of females is very low but their highest abundance coincides with the male peak in February.

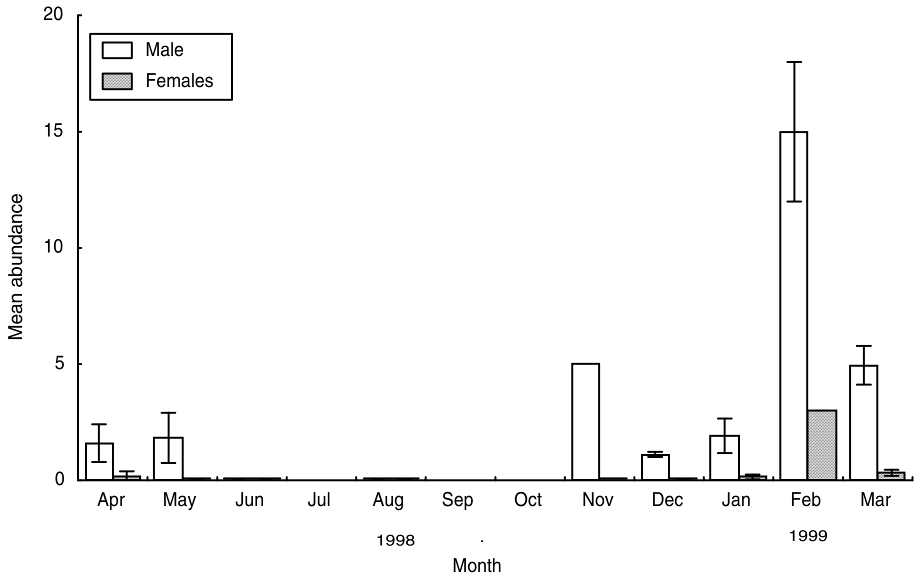

Figure 3. Population dynamic of L. *perlongum* in the RIVER1 site. Mean abundance estimated in scan censuses between 10:00 to 15:00 h.

Discussion

Odonates have caught the attention of researchers due to their elaborate territorial behavior, courtship displays and other mechanisms of male competition (Jacobs, 1955; Fincke, 1984; Alcock, 1987), their importance as aquatic predators (Thorp & Cothran, 1984; Dudgeon, 1989; McPeek *et al.*, 1996; De Marco *et al.*, 1999) and their possibilities as environmental indicators (Castella, 1987; Taylor & Merriam, 1995; Santos-

Peruquetti & De Marco, unpublished results) or biological control (Sebastian *et al*., 1990). Unfortunately, many of these aspects are still poorly understood for neotropical species. One clear example was the concentration of field studies in larval odonates present in the tank-bromeliads and the absence of studies of their adults.

First of all, it is worth to highlight the usefulness of the exuviae sample to study bromeliad-dweller species, as it was already been described for other odonates (Peters, 1994). The *Leptagrion* exuviae is usually found at the bottom face of the leaves, protected by the heavy rains, and appears to stay attached to the plant for more than a month. It is a useful index of odonate abundance because it represents the individual that reaches the reproductive stage and its monitoring could easily demonstrate annual increase or decrease in the total population. Another important advantage of exuviae sampling is that this prevents the intense intervention in the study area not causing any harm to the bromeliads or their fauna, and specially, not affecting the *Leptagrion* population which is usually low (Santos, 1966).

It was a rare case to find two exuviae in the same plant during this study. In a study of *L. siqueirai*, most of the bromeliads have just one individual (Lounibos *et al*., 1987). In *Megaloprepus coerulatus*, a pseudostigmatid odonate that develop their larval stage in tree-holes of the Barro Colorado Island, Panamá, Fincke (1992) demonstrated that tree-holes containing less than one liter of water usually produce just one emerging adult. There are two possibilities to explain this general pattern. First, the cannibalism is a frequent event in odonate species (Wissinger, 1988; Van-Buskirk, 1992; Johansson, 1993) and this behavior could be adaptive in temporary or small habitats where food shortage is frequent. Nevertheless, Lounibos *et al*. (1987) reported that when more than one individual was found they were of the same size class. It was interpreted as a strategy to prevent cannibalism.

Another possibility is the adjustment of the reproductive effort by the female, inserting few eggs per plant in order to maximize their reproductive success. This was observed in females of *Megaloprepus coerulatus* which spend more time ovipositing in large tree holes than in small ones (Fincke, 1992). Acceptance of one of these hypotheses does not exclude the other and they could be tested in the future.

Nevertheless, our sampling demonstrated that some plants have more probability to have *Leptagrion* exuvia between subsequent months. This fact clearly represents differences in suitability among plants that could produce a choice for territory among the males and/or for oviposition by the females. It is still not clear if the male selects a plant and stays there for more time than a female clutch or if individual plant characteristics increase the chance of an individual plant to be repetitively chosen by the females, or both.

The size of the tank and the volume of the water in leaf axil were usually referred as the cause of increase abundance or species richness in these communities (Laessle, 1961; Pimm & Kitching, 1987; Couto, 1999). The increase of the prey species, especially mosquito larvae (Fincke *et al*., 1997), could allow for the successful development of the larval odonate to the adult stage. If there is a relation between water volume and abundance of prey species, odonate females, that select these plants must have a higher reproductive success (Fincke, 1992). As a consequence, we expected that the larger bromeliads, especially *V. jonghei* and *Ne. magdalenae* would be more used by the *L. perlongum* than the others. This had really occurred but also *N. procerum* was intensely used. As it has similar size to *V. ensiformis*, wich was avoided, size alone does not explain the whole result.

The high concentration of bromeliads in the RIVER1 site generated an also high aggregation of *Leptagrion* in the area. This area was also the most important aggregation of *N. procerum* in the SLBS and has a poor representation of *V. ensiformis*. It is possible that the odonates used this area more intensely due to the aggregation of *Ne. magdalenae* and *V. jonghei*, and used sub-optimal *N. procerum* due to a kind of frequency-dependent plant selection related to their interespecific competition.

The above argument is weakened by the fact that the sampling of exuviae shows that *N. procerum* is at least equal in the odonate emergency to the other plants, revealing that, besides its size, it could have a prey abundance that allows the development of these odonates.

Odonate predation could depress their prey abundance in lakes and ponds (Johnson *et al*., 1987), and we expected that it could be more frequent for odonates in tank-bromeliads or tree-holes (Fincke *et al*., 1997). Such depression could determine the death for the odonate larvae if some special adaptations were not achieved in the evolutionary time. One of the most important and poorly studied is the expected adaptation due to the fast endurance hypothesis (Lindstedt & Boyce, 1985). This hypothesis initially produced to explain mammalian adaptations to seasonal environments predicted that larger species could be more tolerant to food shortage due to the positive allometry of their fat reserves. This hypothesis could explain the apparent larger size of tank-bromeliad larval odonate species, similar to the larger size of some temporary pool odonates like *Pantala flavescens and Orthemys* spp.

Another adaptation could be the dispersion of the individuals when their particular habitat was depleted. We observed the movement of a larval *L. perlongum* from one leaf axil to another for two times during the period of study.

L. perlongum was abundant in the area during the rainy season and nearly absent in the dry months. There is also a clear peak in the reproductive activities in the rainy season when the females arrive near the bromeliads for mating. Santos (1966) argues that it is difficult to follow the mating behavior of this species in the field due to their low population sizes. As we observed five copula events in a single day in February, we concluded that the EBSL is a very interesting place to further behavioral studies. In other periods of the year mating appears to be a rare event.

Santos (1966) estimates the period of larval development for *Leptagrion* species, from six to twelve months. Our data suggests that *L. perlongum* must complete its development in near one year, or stay dormant like an egg during the dry season and complete their development faster after rain initiates in October-November.

Due to its dependency on water-filled bromeliads, the most important factor that regulates *L. perlongum* population could be the extent of the dry season. Their highest abundance also occurred in the months of high precipitation (Climatic data in Thomaz & Monteiro, 1997). We predicted that this species could be more abundant and could have many generations during the year in areas with more stable precipitation, and more constant filling of water in the bromeliads. It is also important, in future works, to understand the importance of the short periods of dry in the rainy season, as observed during January 1999, that dried the bromeliads. We expected that many larvae of *L. perlongum*, especially the larger sized ones, could die in such occasions.

L. perlongum must be considered an excellent model for behavioral and ecological studies due to their life history. Many questions about their habitat preference, behavior, adaptations to phytotelmata and evolution have arisen in this simple work. A comparative study of the *Leptagrion* species ecology as a general assessment of their potential habitats and population sizes in the Atlantic Forest, is a keystone action, to a better understanding of their evolutionary biology and to the conservation of these amazing creatures.

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