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Population structure of *Polythore procera* at a Colombian stream (Odonata: Polythoridae)

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Key words: Odonata, dragonfly, *Polythore procera*, population size, life expectancy, daily survival probability, territorial males, precipitation.

Abstract

We studied a population of *Polythore procera* along a stream in the Colombian eastern Andean foothills. Mark and recapture samples were made during January to April 2006, covering both dry and wet seasons. We determined population size, daily survival probability, and longevity during the entire period and compared them with precipitation data. Age and sex proportions along two different sectors of the stream were also analyzed, and notes about their ecology and habitat were taken. Our data suggest this species has a high daily survival probability in comparison with those of other odonates. Males are highly territorial, and exhibit low dispersal capacity. We also conclude that population dynamics of *P. procera* can be affected by an extrinsic factor such as seasonality.

Introduction

Mark and recapture methods can provide good quantitative information about the ecology of odonate species. Their predatory habits, diurnal behavior, large size, as well as their strong association with lakes, ponds or rivers, make them excellent models for these types of studies (Corbet 1952; Moore 1953; Cordero 1987). However, almost all studies have been limited to temperate species of lentic environments (Garrison 1978; Garrison & Hafernik 1981; Cordero 1987, 1989; Córdoba-Aguilar 1994), and only a few have been conducted on Neotropical species in lotic environments (Garrison & González-Soriano 1988; Córdoba-Aguilar 1994; De Marmels 1998).

Members of the Neotropical zygopteran family Polythoridae typically dwell in lotic environments within well-preserved forests (Bick & Bick 1985, 1986; Fraser & Herman 1993; Zloty & Pritchard 2001). The genus *Polythore* Calvert, distributed mainly in western South America, is composed of 19 morphospecies (Bick & Bick 1985, 1986; Burmeister & Börzsöny 2003). Bick & Bick (1985, 1986) proposed two main geographical divisions for these species, Andean and Amazonian, and six morphological clusters, *boliviana-*, *batesi-*, *concinna-*, *picta-*, *victoria-* and *vittata*-groups. *P. procera* (Selys) belongs to the northern Andean species and to the *picta*-group, characterized by a black and white color pattern in both wings (Bick & Bick 1985).

The goal of this study is to increase the information about spatial distribution of a population of *P. procera*, and to further understand relationships between precipitation and population parameter estimates. Using the multiple mark and recapture methods, we obtained the first approximation of important population factors, which will help determine some ecological characteristics for this Neotropical family. Finally, based on population data we can facilitate new strategies for conservation of this species and its habitat.

Material and methods

Study site

The study was carried out at a first order stream called "La Catira", located near the principal road from Bogotá to Villavicencio in the municipality of Guayabetal, Cundinamarca department (Fig. 1). The stream covers the eastern cordilleran foothills (4°15'45"N, 73°49'34"W), at an elevation of 1,246 m a.s.l. The annual rainfall model (IDEAM 2005) is unimodal, with a dry season between November and February, and a wet season between March and October.

Multiple mark and recapture methods

Six samplings were made between January and April 2006, covering the period of increasing higher precipitation. Each sample consisted of ca eight continuous hours, including those of major odonate activity between 09:00 and 12:00 h (Corbet 1999: 304-305). To establish recapture percentage, population size, and survival probabilities, two multiple mark and recapture methods – Jolly-Seber (Jolly 1965) and Manly-Parr (Manly & Parr 1968) – were applied using the stream as a transect. Specimens were marked on Fw with a letter and a number corresponding to sampling date. Using the equations of Garrison & Hafernik (1981), we obtained an approximation of daily survival probability and life expectancy in days for adults. The effect of sex and the accuracy of both estimators (Jolly-Seber and Manly-Parr) in the population estimates were analyzed using analysis of variance (Statistix 2000) for each variable.

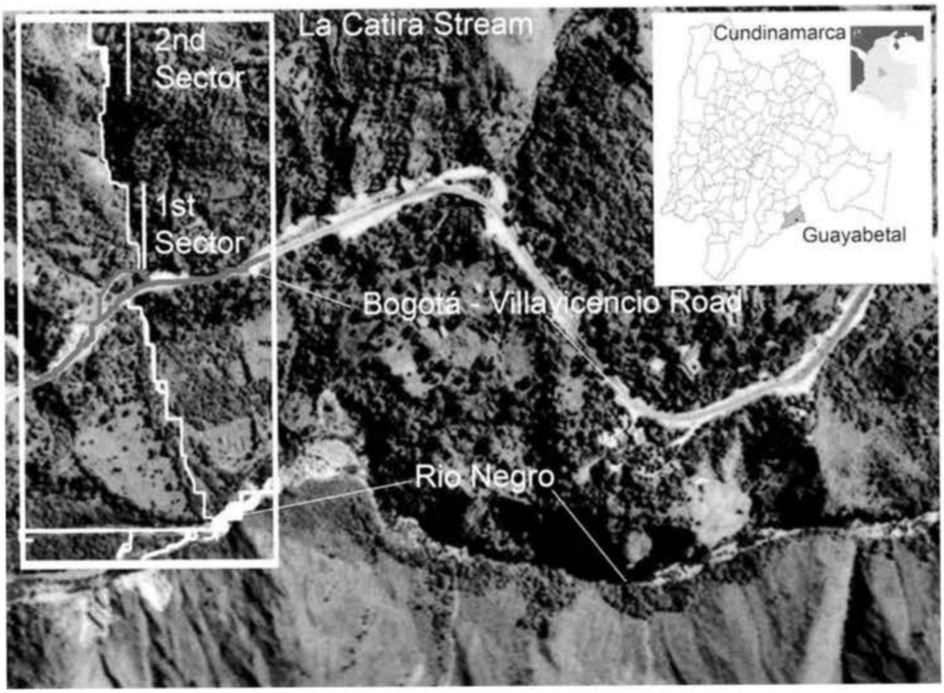

Figure 1: Aerial photograph of the study site of a *Polythore procera* population in Colombia and its geographical position. The two sectors of ca 200 m are plotted; 1st sector: disturbed; 2nd sector: undisturbed.

Anthropogenic intervention, sex, and age

The stream presented variable anthropogenic perturbations (crops, car washing, and houses); two reasonably preserved sectors of ca 200 m were chosen to establish if there was a correlation between anthropogenic intervention and abundance, sex ratio, and age distribution (Fig. 1). The first sector exhibited considerable anthropogenic disturbance, while the second was mostly covered by primary forest. In each sector, sex and age (teneral, juvenile, or mature) of every individual captured were registered. Age of each individual was established using the iridescence of the wings: black and milky white wings were considered indicative of mature specimens, brilliant black wings juveniles, and soft and opaque wings with brown bands indicative of tenerals.

Age and sex distribution were analyzed using a Chi-square analysis (Statistix 2000), and the anthropogenic effects on age and sex on the abundance of individuals was established using Multifactorial Variance Analysis (Statistix 2000).

Results

Multiple mark and recapture

During the entire sampling period 198 individuals of *Polythore procera* were marked, from which 40% (n = 58) were recaptured at least once. Sex showed a significant effect over recapture percentage. Recapture percentage of each capture day for males was above the average in comparison for that of females (Fig. 2, $n = 12$, $F = 5.32$, $p = 0.044$), even though the relative abundance of each sex during each capture did not differ ($n = 12$, $F = 0.163$, $p = 0.694$).

Population size and survival probabilities estimated based on both methods (Jolly-Seber and Manly-Parr) showed different patterns. Population size estimates yielded no significant differences between the models ($n = 11$, $F = 0.151$, $p = 0.707$), implying that these models were valid. However, survival probabilities were different for each model ($n = 10$, $F = 16.558$, $p = 0.004$). Nevertheless, both models yielded similar results for both population size and survival probabilities. Estimated population size decreased with time as precipitation episodes increased (Fig. 3a), but survival probabilities did not significantly change with time. Jolly

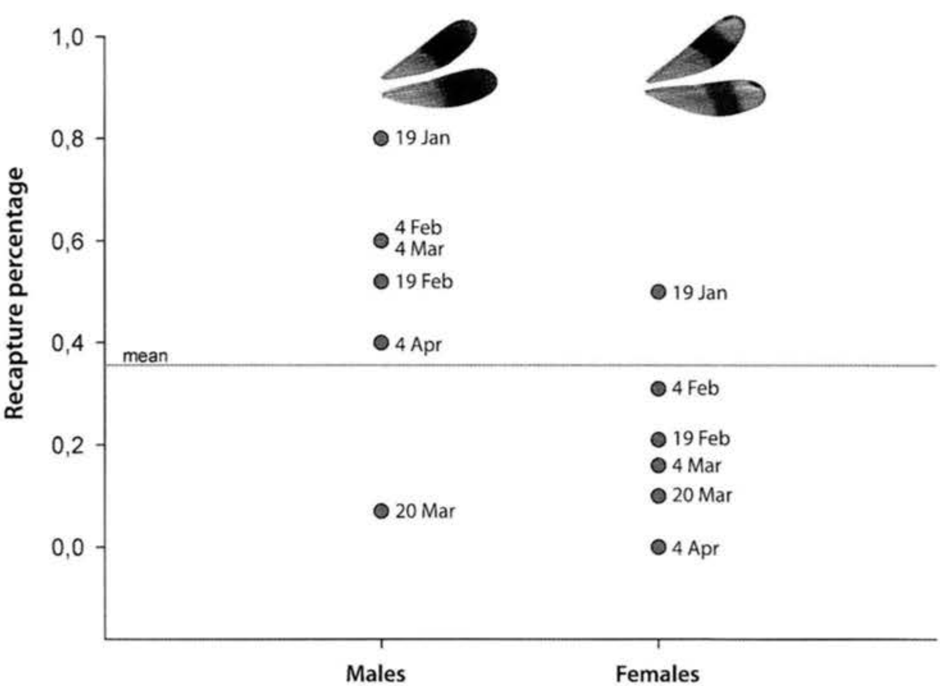

Figure 2: Scatter plot of recapture percentage for each sex in *Polythore procera* (n = 12, F = 5, 32, p = 0.044). Each dot represents a capture day. The line represents the recapture percentage mean value of all population during all sampling days.

survival probabilities are higher at the beginning and end of the study (Fig. 3b). Using survival probabilities, we calculated an average daily survival probability of 96%, and a life expectancy of approximately 31 days. Life expectancy estimated for males was of almost 41 days, and for females of 24 days.

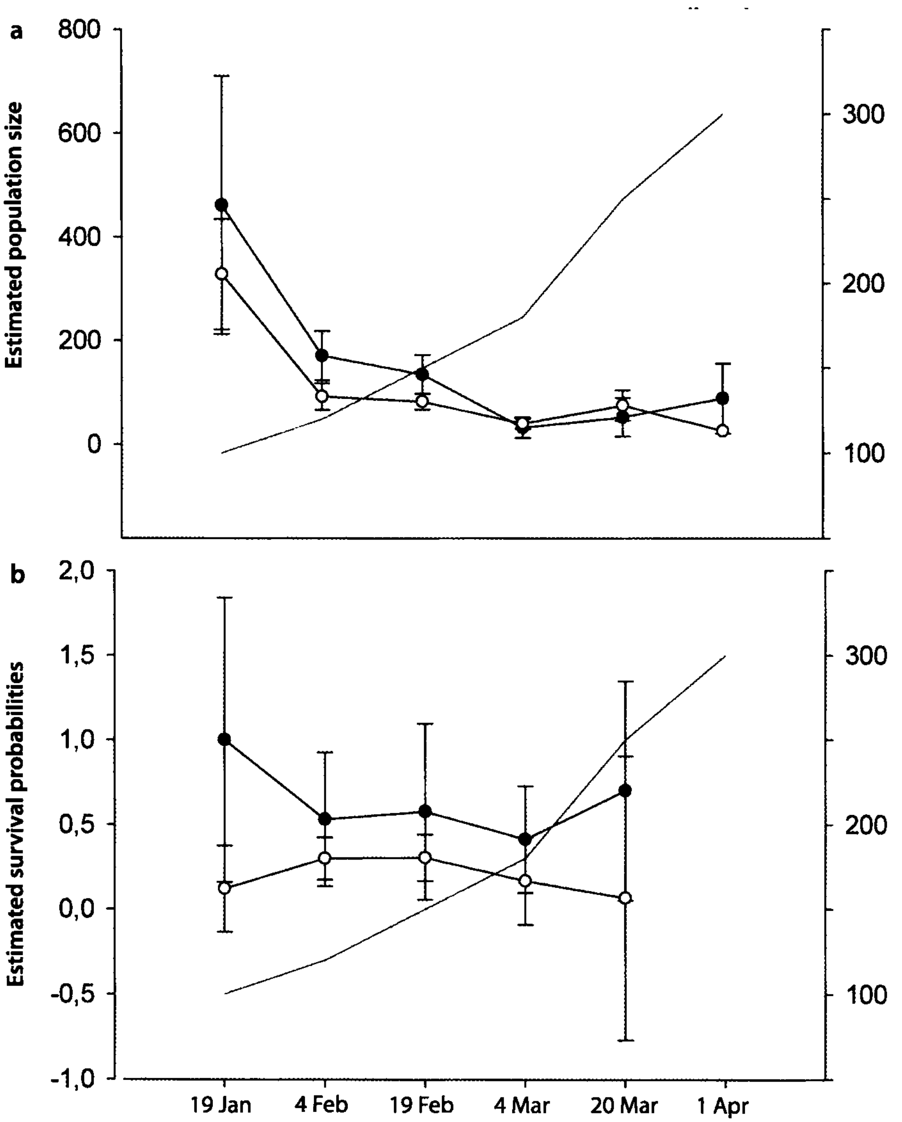

Figure 3: Relation of population parameters of *Polythore procera* and precipitations during each capture day — (a) estimated population size; (b) survival probability using Jolly-Seber and Manly-Parr methods. —●— Jolly-Seber; —○— Manly-Parr; —— Precipitation.

Anthropogenic intervention, sex, and age

During the entire sampling period, sex and age distributions were heterogeneous between disturbed versus undisturbed sites, meaning that male and female abundance declined with overall population size decrease ($\chi^2 = 13.82, p = 0.0317$). Age class abundances (tenerals, juveniles, and mature) also varied among all dates ($\chi^2 = 30.45, p = 0.0007$). However, when analyzing effects of sector on sex, only female distribution was affected, because the relative abundance in the undisturbed sector was greater (Fig. 4) than for the disturbed sector ($n = 12, F = 9.8, p = 0.0259$). Age abundance in both sectors did not differ significantly, although tenerals and juveniles were found in greater proportion in the undisturbed sector than in the disturbed one (Fig. 5).

Discussion

Although survival probability was not affected by the increase in precipitation, estimated population size of *Polythore procera* decreased as precipitation increased

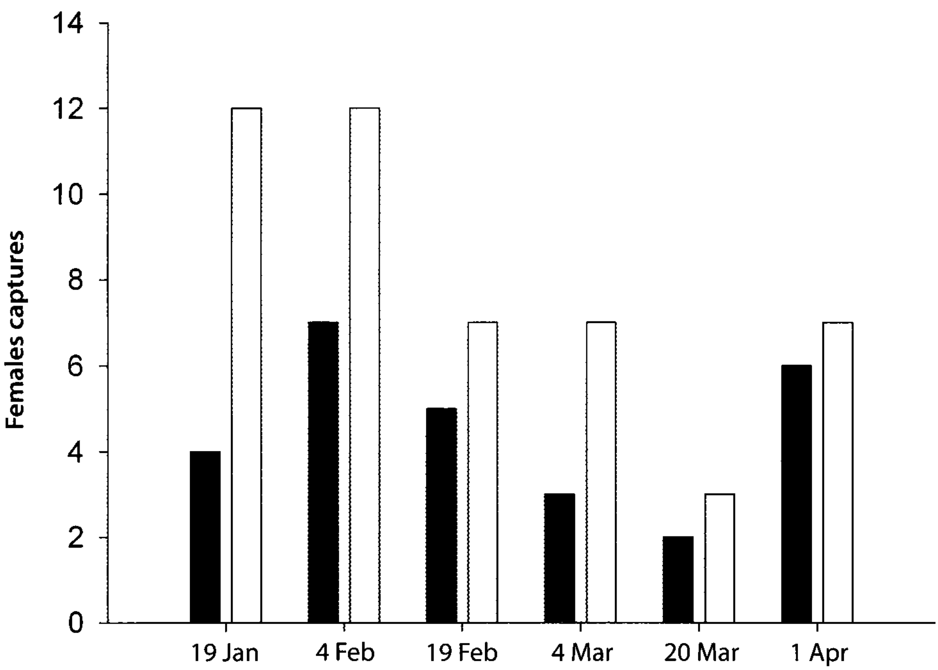

Figure 4: Frequency of captures of female *Polythore procera* at two stream sectors (1st sector: disturbed; 2nd sector: undisturbed) during the six sampling dates. ■ 1st sector; □ 2nd sector.

(Fig. 3a), suggesting a negative effect. However, we cannot assume that precipitation was the only factor related to population size decrease; other as yet undeter-

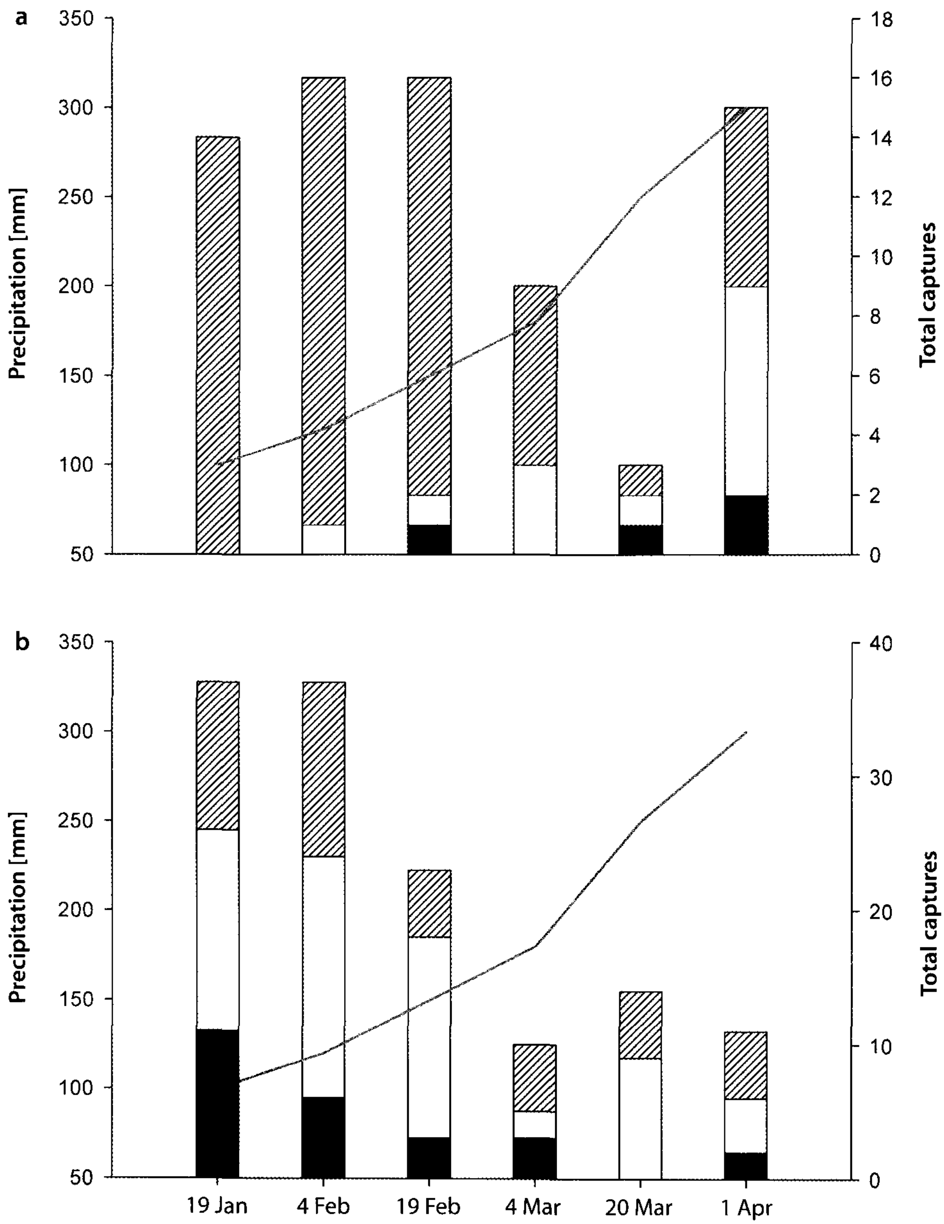

Figure 5: Age distribution of *Polythore procera* along the sampling dates in relation to precipitation — (a) 1st sector: disturbed; (b) 2nd sector: undisturbed. ▬ Tenerals; ▭ Juveniles; ▨ Matures; —— Precipitation.

mined environmental variables may also have affected population size over time. Survival probability was not affected by increased precipitation (Fig. 3b); in fact tenerals (6) and juveniles (6) marked during the two first capture days were recaptured afterwards as mature adults, supporting high survival rates for this species. Even though we observed fewer adults during the rainy season, larval populations may have been increasing. Most adults appeared during the dry season (Fig. 5) supported by greater numbers of emerging tenerals. In contrast, in another polythorid, *Cora marina* Selys, a different emergence pattern was observed, in which most of the adults appeared during the wet season (Pritchard 1996). Pritchard (1996) noted that females of *C. marina* lay eggs during the wet season to avoid egg desiccation during the dry season. Thus, only final instar larvae would be subject to periodic spates but would more likely survive due to their association with large, heavy, water-soaked logs. Our study site, La Catira stream, experiences more or less uniform precipitation rates annually and there is therefore a lower risk of huge floods. During the dry season the stream is reduced to a small seepage, which may make this habitat less hospitable for development. We can infer that *P. procera* adapts its life cycle to this seasonality pattern, with final instar larvae appearing at the beginning of the dry season, subsequently followed by emergence. Finally, we suggest that at the limit of both dry and wet seasons they become sexually active. During this period, when the stream carries a large amount of water, females lay their eggs, providing the best conditions for larval development.

Only a small proportion (2:198) of captured individuals exhibited wing damage, and the high daily survival average and life estimates indicate that predation and competition pressures may have been negligible. However, we saw some spider webs with a large number of female wings, suggesting that females may be more vulnerable to predators like spiders. Garrison & González (1988) reported spider attacks as a common source of mortality for *Palaemnema paulitoyaca* Selys and *P. desiderata* Selys. Females of *P. procera* do not show the territorial behavior (Fig. 2) observed in males; however, sex ratio for all capture days was 1:1, which is a characteristic of many Zygopteran populations (Lawton 1972). Female behavior patterns, including oviposition, microhabitat preferences, or dispersal tendencies might make them more vulnerable to predation (Garrison & González 1988)

In accordance with the male territoriality reported for polythorids (González & Verdugo 1984; Bick & Bick 1985, 1986; Esquivel 2005), we obtained high recapture percentage of males (Fig. 2). Males of this species keep a territory near the stream, which they constantly defend from other males, allowing for a high probability of recapture. Females, however, did not seem to have a strong association with a particular territory, and our data showed a high frequency of females in undisturbed sectors of the river, where access to the forest canopy was greater (Fig. 1). Females may spend most of their time up in the trees and not at the vegetation near the stream border, possibly to avoid active predation or interference of males.

Table 1. Daily Survival Average (DSA) and Life Expectancy (LE) of *Polythore procera* males, in comparison with other reports from the literature.

Species	DSA [d]	LE [d]	Source
Calopteryx aequabilis Say	0.767	3.8	Conrad et al. 1990
C. haemorroidalis (Vander Linden)	0.94	16.2	Cordero 1989
C. virgo (Linnaeus)	0.86	6.6	Cordero 1989
C. xanthostoma (Charpentier)	0.66	2.4	Cordero 1989
Hetaerina cruentata (Rambur)	0.978	44.9	Córdoba-Aguilar 1994
Mnais pruinosa Selys	0.947	18.4	Nomakuchi 1988
Polythore procera (Selys)	0.977	43.6	Present study
Argia vivida (Hagen)	0.72	3.02	Garrison 1978
Enallagma cyathigerum (Charpentier)	0.81	4.68	Garrison 1978
Ischnura gemina Kennedy	–	27	Garrison 1981
Palaemnena desiderata Selys	0.86	7	Garrison & González 1988
P. paulitoyaca Calvert	0.80	4.5	Garrison & González 1988

González & Verdugo (1984) described the territoriality of *C. marina* males as "fully territorial", because 3 of the 5 males they tracked always remained in the same territory. High recapture percentages for male *P. procera*, coupled with recaptures at the same place (38:40) mirror those of *C. marina*. Even though life expectancy of *P. procera* was high compared with that of other odonates (Table 1), the few population studies carried out for Neotropical species generally show higher life expectancies than those for temperate species. Populations from temperate zones are likely subject to more unpredictable abiotic factors, e.g. pronounced seasonal climatic changes, compared to tropical species.

Anthropogenic perturbation did not exhibit a significant relationship to abundance of this species, but our study shows *P. procera* prefers more covered areas during maturation, as most juveniles were found at the undisturbed sector (Fig. 5). In spite of these age preferences, we think that this species can withstand certain degrees of habitat disturbance.

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