Breeding ecology of *Scinax trapicheiroi* (Anura, Hylidae) at a creek in the Atlantic Rainforest of Ilha Grande, southeastern Brazil

Miguel Rico, Carlos F.D. Rocha, Vitor Nelson T. Borges Jr., Monique Van Sluys

Ecologia, Departamento de Biologia Animal e Vegetal, Instituto de Biologia Roberto Alcântara Gomes, Universidade do Estado do Rio de Janeiro, Rua São Francisco Xavier 524, CEP 20550-013, RJ, Brazil

1 Corresponding author; e-mail: vansluys@uerj.br

**Abstract.** We analyzed the breeding biology in a population of the hylid *Scinax trapicheiroi* and evaluated how some environmental and structural factors affect the temporal and spatial distribution of the clutches. Fieldwork was carried out at a small stream running inside the Atlantic Rainforest at Ilha Grande, an island in Rio de Janeiro State, southeastern Brazil, from October 2000 to September 2001. Breeding occurred all year round, but the presence of females and clutches was affected by rain from the previous days. Clutches had an aggregate distribution, because they were mainly laid on lentic waters (with slow water flow). Rain affected the availability, stability and size of ponds. The high numbers of eggs per clutch, and the fast development of eggs and larvae are influenced by an unpredictable environment.

**Introduction**

The diversity of reproductive modes in amphibians is higher than in any other vertebrate group (Caldwell, 1992). Duellman and Trueb (1994) describe the reproductive mode of a species as composed by different factors such as breeding site, egg and clutch characteristics, rates of egg development, size and conditions of the larva at the moment of birth, among others. Neotropical anurans display the greatest diversity of reproductive modes among the amphibians, with more than 30 different modes (Haddad and Sawaya, 2000).

Rain is the primary extrinsic factor affecting the time of the breeding activity for most tropical and subtropical anuran species (Haddad and Sazima, 1992; Duellman and Trueb, 1994). Many hylid species depend on rain to reproduce (e.g. Wiest, 1982; Aichinger, 1987), and most neotropical species have prolonged reproduction during the year or have
it associated to the rainy season (Pombal, 1997) and can reproduce more than once during the breeding season (Wells, 1977; Telford and Dyson, 1990).

Hylids living in the Atlantic Rainforest Biome of eastern Brazil present 11 of the 12 reproductive modes known for the whole family (Haddad and Sawaya, 2000). The genus Scinax is presently divided in five groups of species, the S. rubra, S. rostrata, S. catharinae, S. staufferi and S. perpusilla groups (Pombal and Bastos, 1996; Faivovich, 2002). Species that make up the S. catharinae group (in which S. trapicheiroi is included) are mainly known from the Atlantic Forest of southeastern Brazil. These frogs reproduce in clear waters (mainly streams, but more rarely in standing bodies of water — modes 1 and 2 sensu Duellman and Trueb, 1994 — eggs and feeding tadpoles in lentic (1) and lotic (2) water) inside forested areas (Carvalho e Silva and Carvalho e Silva, 1994; Pombal and Bastos, 1996; Faivovich, 2002).

Scinax trapicheiroi is a small hylid which inhabits mountainous areas in the Atlantic rainforest region of southeastern Brazil (Carvalho e Silva and Carvalho e Silva, 1994). Studies on S. trapicheiroi are scarce and limited to the species’ description, taxonomy, geographic distribution (Lutz, 1954, 1973), tadpole characteristics (Carvalho e Silva and Carvalho e Silva, 1994), and calling activity (Rico, 2002).

We investigated the reproductive biology of a population of S. trapicheiroi at a creek in an Atlantic Rainforest area of southeast Brazil. Specifically our aims were: to describe their breeding system; to evaluate the spatial distribution of clutches along a creek; to evaluate the temporal distribution of clutches along the year; and to analyze size characteristics of eggs and clutches as indicators of the reproductive effort of females.

**Material and methods**

The study was carried out from October 2000 to September 2001 at a small stream in the Atlantic Rainforest of Ilha Grande (23°12' S, 44°13' W). Ilha Grande is located in southern Rio de Janeiro State, being one of the largest continental islands on the Brazilian coast. Landscape of the island is rugged, and the highest peaks reach 1000 m high. The island is covered by Atlantic rainforest in different levels of regeneration due to disturbances caused by human activities (Araújo and Oliveira, 1988). Remnants of primary forest can be found in the less accessible areas of the island (Araújo and Oliveira, 1988). The study area was located in a regenerating forest, about 80 years old. The origin of the creek was a steep forested hillside. Current in the creek was highly variable, and during periods of no rainfall the stream was reduced to a linear series of disjunct pools fed by subsurface flow. Part of that creek (150 m) was selected as study area.

Seven days per month the stream was searched for clutches deposited during the nights. Date and position in the creek were recorded for each clutch found, as well as the number of eggs, and the time (in days) from spawning to hatching. We collected samples of 30 clutches, and 15 eggs from each (total 450 eggs) were measured, with digital callipers to the nearest 0.1 mm.

The ratio between the number of females and of males captured in the reproductive aggregations, in three nights each month, was used as an index of the population operational sex ratio (Rico, 2002). We also recorded the presence of adults, tadpoles, clutches and recently metamorphosed individuals, at each month. Opportunistic observations on the reproductive behaviour of S. trapicheiroi were done during these sampling nights.

To evaluate the spatial distribution of clutches along the stream, we recorded, three times per month and every 5 meters, the following variables: depth and width of the stream and intensity of the water flow at each point: dry, sub-surface water flow, pond (no visible current), light water flow or stream with running water. The number of
Breeding of Scinax trapicheiroi

sampling days in which a point was a pond with no visible current (maximum of 36 days) was considered as an index of the stability of the pond at that point.

We used the Elliot Dispersion Index (I) (Krebs, 1989) to analyze the spatial distribution (random, aggregate or uniform) of the clutches along the creek: \( I = \frac{S^2}{x} \), where \( S^2 \) is the observed variance and \( x \) is the observed mean; and \( \chi^2 = I(n - 1) \) for \((n - 1)\) df, in cases of \( n < 51 \).

The Ivlev Index of Electivity (Krebs, 1989) was used to evaluate the electivity of females for clutching sites. Availability of each class of clutch site in the study area was related to the frequency with which those classes were used for spawning:

\[ E_i = \frac{(r_i - n_i)}{(r_i + n_i)} \]

\( E_i \) = electivity for class \( i \); \( r_i \) = % of that class being used; and \( n_i \) = % of that class present in the study area (in 31 sample points and 3 visits per month). The following classes were considered: pond without current; pond with light waterflow; pond with current; and stream with running water.

To evaluate the temporal distribution of the number of clutches laid per day, we considered the influence of four environmental variables. Air temperature and relative humidity were recorded hourly, and length of photoperiod and rainfall were recorded daily. Daily rainfall data were obtained from a tipping bucket pluviometer (Davies Rain) placed approximately 1 km away from the study area. We considered the rain of the two days previous to each sample for the analyses.

We used multiple linear regression (Zar, 1999) to test the effect of the structural and environmental variables on the spatial and temporal distribution (respectively) of the clutches of Scinax trapicheiroi. For the spatial distribution we considered the structural variables of depth, and width of the water body and number of days that point was a pond. For the temporal distribution we considered the environmental variables of rainfall of the two previous days, relative humidity, photoperiod and water temperature Differences in the number of clutches laid between rainy (October to March) and dry (April to September) seasons were tested using Student \( t \)-test (Zar, 1999).

Results

Clutches of Scinax trapicheiroi consist of a circular, laminar gel mass containing the eggs, which are laid on the water surface, sometimes adhered to the superficial or marginal vegetation. Newly laid eggs are pigmented and dark (brown or black), with a white spot in their inferior section. Mean number of eggs per clutch was 394 ± 92.9 (range = 115-609 eggs; \( n = 110 \)) (fig. 1).

Mean diameter of eggs in 30 clutches (15 eggs per clutch) was 1.1 ±0.1 mm (\( \bar{s} \)\( \bar{e} \)), (range = 0.9-1.3 mm; \( n = 450 \) eggs). Larger clutches had significantly smaller eggs \((r = -0.55; F_{1,28} = 11.9; P < 0.002)\) (fig. 2).

We followed 21 clutches, daily, from spawning to egg hatching. In all cases, the stage 15 (Gosner, 1960) was reached at the second day. During the following days, clutches could stay on the surface or sink to the bottom of the water body (usually after rainfall). The minimum period between spawning and hatching was 3 days and the maximum, 5 days. Median and mode of these values were 4 days. After hatching and for a few days, tadpoles (stages 20 to 25) commonly remained aggregated close to remnants of the gel mass, but moved freely when disturbed.

The spatial distribution of clutches along the 31 points showed an aggregate distribution \((I = 9.395; \chi^2 = 281.83; df = 30)\). We found 139 clutches along the stream, 129 of them
were at ponds without current, eight were at ponds with light waterflow, and two were at ponds with current (table 1). Ponds without current were the only breeding location positively selected by females (table 1).

The distribution of clutches, along 31 points of the creek, was significantly related to the number of females and males captured at each point ($r = 0.80$ and $r = 0.77$ respectively; $P < 0.001$). The number of females and males captured at each point were also strongly correlated ($r = 0.91$; $P < 0.001$). The places where we found clutches varied greatly in depth and width (table 2), but less in water temperature (table 2).
Breeding of *Scinax trapicheiroi*

Table 1. Frequency (%) of use and electivity index (E) of different locations selected by females *Scinax trapicheiroi* to spawn along a creek in the Atlantic rainforest of Ilha Grande, Rio de Janeiro, Southeastern Brazil (*n* = 139 clutches).

<table>
<thead>
<tr>
<th>Spawn location</th>
<th>% Use</th>
<th>Electivity index (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pond (no current)</td>
<td>92.8</td>
<td>+0.31</td>
</tr>
<tr>
<td>Pond (light waterflow)</td>
<td>5.8</td>
<td>-0.12</td>
</tr>
<tr>
<td>Pond (with current)</td>
<td>1.4</td>
<td>-0.78</td>
</tr>
<tr>
<td>Streams (small or large)</td>
<td>0</td>
<td>-1</td>
</tr>
</tbody>
</table>

Table 2. Mean values (± 1 s), range and coefficients of variation (CV) of width and depth (in cm), and water temperature (in °C) of 139 sites in the stream where clutches of *Scinax trapicheiroi* were found.

<table>
<thead>
<tr>
<th></th>
<th>Mean ± 1 s</th>
<th>Range</th>
<th>CV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>132.2 ± 60.3</td>
<td>15-300</td>
<td>45.6</td>
</tr>
<tr>
<td>Depth</td>
<td>23.1 ± 9.6</td>
<td>5-45</td>
<td>41.7</td>
</tr>
<tr>
<td>Water temperature</td>
<td>21.5 ± 1.4</td>
<td>18.6-24</td>
<td>6.5</td>
</tr>
</tbody>
</table>

Figure 3. Number of clutches of *Scinax trapicheiroi* according to depth classes (in cm) of a creek at Ilha Grande, Brazil.

Most of the clutches (72.7%) were in ponds with depths from 10 to 30 cm (fig. 3). The class containing the mean and median depth was that between 20 and 30 cm depth.

Our model of multiple linear regression significantly explained the number of clutches per point (*R*² = 0.55; *F*₃,₂₇ = 10.97; *P* < 0.005). The number of days a given point was a pond (*r* = 0.2), and the mean width of the creek at each point (*r* = 0.06) had an additional significant (*P* < 0.05) effect on the number of clutches per point.

The number of clutches in the study area varied throughout the year (table 3). January 2001 was the only month when no clutch was found. Adults were found in the study area...
Table 3. Number of observed clutches (sum of three sampling days) and of captured females, and presence (X) or absence (–) of males, recently metamorphosed and tadpoles of *Scinax trapicheiroi* observed monthly from October 2000 to September 2001, at a creek of Ilha Grande, Southeastern Brazil.

<table>
<thead>
<tr>
<th>MONTH</th>
<th>O</th>
<th>N</th>
<th>D</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of observed clutches</td>
<td>8</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>5</td>
<td>32</td>
<td>1</td>
<td>19</td>
<td>21</td>
<td>2</td>
<td>3</td>
<td>42</td>
</tr>
<tr>
<td>No. of captured females</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>7</td>
<td>11</td>
<td>3</td>
<td>7</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Males</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Recently metamorphosed</td>
<td>–</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>–</td>
<td>X</td>
<td>X</td>
<td>–</td>
<td>X</td>
<td>–</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Tadpoles</td>
<td>X</td>
<td>X</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>X</td>
<td>–</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Figure 4. Number (sum of three sampling days) of observed clutches and captured females of *Scinax trapicheiroi*, from October 2000 to September 2001, in a creek at Ilha Grande, Southeastern Brazil. Each point represents a month.

every month, and tadpoles and recently metamorphosed individuals were observed in eight out of 12 months (table 3).

The number of clutches (*n* = 51) laid during months of the rainy season (October to March) did not differ significantly from that laid in the dry season (April to September, *n* = 88) (*t* = −1.49; df = 10; *P* = 0.147). The number of clutches found during a given month was significantly related to the number of females captured in that month (*r* = 0.69; *F*<sub>1,10</sub> = 9.19; *P* = 0.013) (fig. 4).

Daily variation in the number of clutches along the year was not explained (*R*<sup>2</sup> = 0.1; *F*<sub>4,69</sub> = 1.78; *P* > 0.05) by our model, which included four environmental variables. Only the rain of the two previous days significantly (*r* = 0.09; *P* = 0.03) explained an additional portion of the number of clutches laid per month after we factored out the effect of the other variables.

The number of females present in the choruses per night was significantly related to the number of males present (*r* = 0.47; *F*<sub>1,34</sub> = 9.82; *P* < 0.01), but the Operational Sex Ratio showed a higher number of males (approximately 1 female per 10 males). In four
times we did observe amplexus (always axillary). Two of them occurred on rocks at the ponds’ margin, and in another the couple was 40 cm high on the vegetation and distant 1.5 m from the creek’s border. On February 27, 2002, one of us (VNB) found one couple of _S. trapicheiroi_ during amplexus close to a stream at the secondary forest along a trail. The observation started at 4:55 a.m. and the couple was on a rock 57 cm above the water. After ten minutes, the couple, still in amplexus, climbed down the rock towards the stream, remaining at the water surface. The couple swam to a margin of the stream on a protected site — the water in this microhabitat was lentic. At 5:13 a.m. the female started releasing the eggs at this site. The eggs remained at the water surface involved by a jelly. During egg release the female extended and contracted successively her hindlegs while trembling them. After oviposition, the amplexant couple split and the male moved to the top of another rock at the margin of the stream and re-started calling immediately. Time lag from oviposition to the male re-start calling was approximately 2 minutes.

**Discussion**

The presence of clutches of _Scinax trapicheiroi_ in the creek was continuous throughout the year except for January 2001. During this month most of the creek dried up because of a severe drought. Prolonged reproduction (Wells, 1977) is frequent among neotropical hylids (Haddad and Cardoso, 1992; Pombal, 1997), and in anuran species from regions with poorly marked seasonality (Crump, 1974). However, reproductive outbursts may occur in opportunistic species who take advantage of the occurrence of some environmental factors (such as rainfall) to reproduce (Wells, 1977; Aichinger, 1992). This seems to be the case of the studied population of _S. trapicheiroi_. Although clutches were continuously present through the year, their numbers varied among months depending on environmental conditions.

The intensity of the reproductive activity of _Scinax trapicheiroi_ in the study area, estimated by the number of clutches laid per month, was mainly affected by the sum of the rain of two days before the spawn, which reinforces its opportunistic reproductive behaviour. Anurans from tropical and subtropical regions frequently depend on rain for their breeding activity (Duellman and Trueb, 1994). Periods of rain or drought affect the presence of suitable places to spawn, and thus are a limiting factor for the reproduction of water-dependent species (Ryan, 1985; Díaz-Paniagua, 1990). The unpredictability of reproduction sites can be compensated for by some flexibility in the breeding season (Díaz-Paniagua, 1990).

The spatial distribution of clutches was significantly affected by the temporal stability of the ponds, and by their size (width and depth). Carvalho e Silva and Carvalho e Silva (1994) found that _S. trapicheiroi_ selected ‘dead waters’ of small streams, and also ponds close to them as breeding places in Tijuca mountain range (Rio de Janeiro State, Brazil). Thus, we can consider that the species uses lentic waters for clutch deposition and tadpole
development, which corresponds to reproductive mode 1 (sensu Duellman and Trueb, 1994).

The low operational sex-ratios found in choruses of *S. trapicheiroi* in the study area correspond to those found in other species with prolonged reproduction (Dyson et al., 1992; Pombal et al., 1995; Bastos, 1996). Low operational sex-ratios, in the case of species with prolonged reproduction, can be explained by an asynchrony in female arrival to the breeding sites (Bastos, 1996). Positive relationships observed for *S. trapicheiroi* between the number of males and of females present in the choruses, have also been observed in other anuran species (Bastos and Haddad, 1995; Bastos, 1996). Two reasons may explain this relationship: higher audibility of larger choruses (Wells, 1977), or a female preference for larger aggregations where it may be easier to find and choose a mate (Bradbury, 1981).

Carvalho e Silva and Carvalho e Silva (1994) studying the same species at the Tijuca mountains in Rio de Janeiro (approximately 100 km from Ilha Grande), found a mean number of 600 eggs per clutch and a mean egg diameter of 1.4 mm (sample sizes are not specified by the authors), values higher than those we found at Ilha Grande (394 eggs/clutch and 1.1 ± 0.1 mm, respectively). Dias and Cruz (1993) found interpopulational variation in female body size between two populations of *Hyla bipunctata*, with mean female body size varying from 23.1 to 30.2 mm. For *S. trapicheiroi*, differences in female body sizes among populations might also occur, but Carvalho e Silva and Carvalho e Silva (1994) do not give mean female body size for the population of the Tijuca mountains. To evaluate these differences more studies should be carried out in other populations of *S. trapicheiroi*.

The negative relationship between the number and diameter of eggs is common in anuran species (Crump, 1974; Duellman and Trueb, 1994) and results from the energetic compromise between egg number and size. The threshold of the number of eggs laid by a female is defined by her size and age; larger females usually lay clutches with more and smaller eggs (Martins, 1993; Bastos and Haddad, 1999; Haddad and Sawaya, 2000). Smaller eggs mean a reduction in hatching time and in larva development, a common strategy in species adapted to unpredictable and highly variable breeding sites (Duellman and Trueb, 1994). *Scinax trapicheiroi* in the study area seems to follow, at least in part, this generalization by laying a high number of small eggs and having fast embryo and larva development in an environment where ponds may dry or be flooded, and thus risk egg and tadpole survival. However, the relationship between number of eggs and female body size could not be evaluated in the present study and is still open to testing.

We conclude that *Scinax trapicheiroi* at Ilha Grande has an extended reproduction. The selection of ponds without current to spawn by females results in an aggregate distribution of the clutches. Reproduction is affected mainly by rainfall which determines the availability, stability and size of ponds.

Acknowledgements. This study is part of the results of the “Ecology, Conservation and Management of Southeastern Brazilian Ecosystems Program” and of the Southeastern Brazilian Vertebrate Ecology Project.
Breeding of Scinax trapicheiroi (Vertebrate Ecology Laboratory), both of the Setor de Ecologia, Instituto de Biologia Roberto Alcantara Gomes, Universidade do Estado do Rio de Janeiro. We thank the Coordination of the CEADES/UE RJ for local support and making many facilities available. D. Vecibradic read the manuscript offering helpful suggestions. During the development of this study M.R. received a graduate fellowship (Beca MUTIS) from Agencia Española de Cooperacion Internacional (AECI); V.N.T.B. receive an undergraduate fellowship from UERJ; M.V.S. (Process #302408502-0) and C.F.D.R. (Process #30081994-3) received Research Grants of the Conselho Nacional do Desenvolvimento Científico e Tecnológico — CNPq, FAPERJ and CNPq partially supported the project (grants #E.26/172.383/2000 and 477981/03-8, respectively). This study is also part of the BIOTA/FAPESP Project and was partially supported with a grant from this Agency (process No. 99/08291-5).

References


Received: July 4, 2003. Accepted: September 18, 2003.