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Diet, foraging strategy and reproduction of *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) from a mountainous region of the Atlantic rainforest in southeastern Brazil

(Anura: Hylidae)

Nahrungsspektrum, Jagdstrategien und Reproduktion von *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) von einer bergigen Region im Atlantischen Regenwald Südostbrasiliens (Anura: Hylidae)

ROGÉRIO L. TEIXEIRA & DENNIS RÖDDER

KURZFASSUNG

Scinax argyreornatus (MIRANDA-RIBEIRO, 1926) ist ein kleiner, im Atlantischen Regenwald endemischer Hylide. Ziel dieser Studie war es, das Beutespektrum sowie Aspekte der Reproduktionsbiologie dieser Art zu untersuchen. Nahrungsanaylsen ergaben, daß die dominierenden Beutetiergruppen in der Häufigkeit Asseln (Isopoda), Ameisen (Formicidae) und Zikaden (Homoptera), und in der Anzahl Ameisen, gefolgt von Asseln und Termiten (Isoptera) waren. Die Anteile an Geradflüglern (Orthoptera) und Schaben (Blattodea) dominierten im Feuchtgewicht. Die Art ernährt sich zu gleichen Teilen von terrestrischen, versteckt lebenden (31.1%), terrestrischen, koloniebildenden (30.8%), sowie gut und häufig fliegenden (28.0%) Insekten; terrestrische, bodenbewohnende Insekten machten einen geringeren Anteil der Beute aus (10.1%). Die Clusteranalyse läßt eine Abhängigkeit des Beutespektrums von Alter des Frosches erkennen. Von August bis März wurden Weibchen gefangen, deren Ovarien reife Oocyten enthielten, was auf das Vorliegen einer lang andauernden Fortpflanzungsperiode hinweist. Das Geschlechterverhältnis war auffällig zur Seite der Männchen verschoben und läßt einen starken Wettbewerb um die Weibchen vermuten.

ABSTRACT

Scinax argyreornatus (MIRANDA-RIBEIRO, 1926) is a small hylid endemic to the Brazilian Atlantic rainforest. The aim of this study was to determine the diet and reproductive aspects of this species. In frequency, woodlice (Isopoda), ants (Formicidae) and cicadas (Homoptera) were the dominant prey items ingested. In the number of ingested prey, the main food items were ants, followed by woodlice and termites (Isoptera). Straight-winged insects (Orthoptera) and cockroaches (Blattodea) dominated in prey wet weight. This species feeds on almost all ecological prey guilds in equal percentages (31.1% terrestrial, hidden; 30.8% terrestrial colonial; 28.0% flying well and frequently), only terrestrial ground-active insects are represented in a smaller percentage (10.1%). Cluster analysis points to some trophic ontogeny occurring in *S. argyreornatus*. Mature oocytes were found in the ovaries of females caught from August to March allowing the hypothesis that *S. argyreornatus* has a protracted reproductive period. Sex ratio was strongly biased towards males suggesting strong competition for access to females at mating sites.

KEY WORDS

Anura: Hylidae; *Scinax argyreornatus*, diet, feeding ecology, trophic ontogeny, reproductive cycle, fecundity, reproductive biology, Atlantic rainforest, Brazil

INTRODUCTION

In their great majority, anurans are arthropod generalist predators, and their diet depends mainly on prey availability (DUELLMAN & TRUEB 1994). Within species, the diet can vary greatly according to latitudinal gradients, or due to altitudinal differences. The prey choice of anurans is usually influenced by the size of the species, and/or individual, and ontogenetic diet shifts may be very common (WOOLBRIGHT & STEWART 1987; LIMA & MOREIRA 1993; DE BRUYN et al. 1996; GIARETTA et al. 1998; BIAVATI et al. 2004). In contrast to their dietary generalism, anurans have developed many different reproductive modes, which are very diverse in the Atlantic rainforest of Brazil (HADDAD

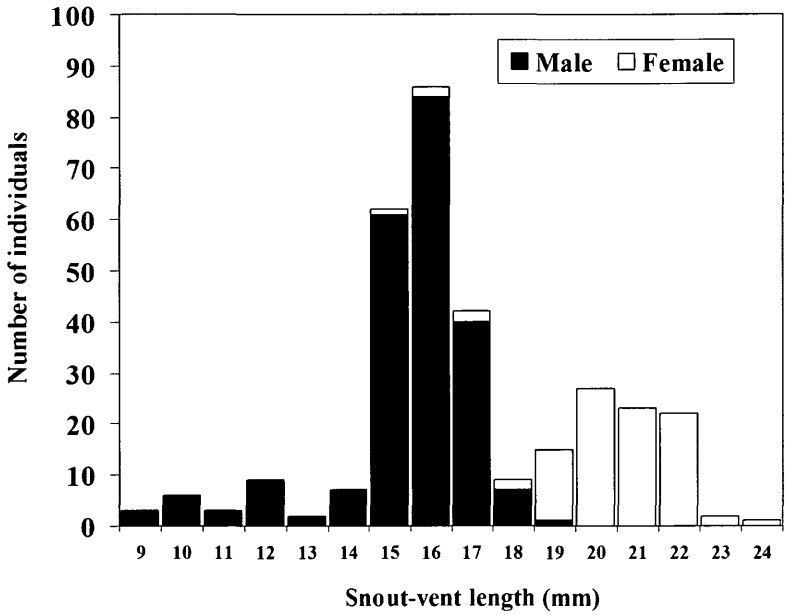

Fig. 1: Frequency distribution of snout-vent-length classes in 221 male and 96 female *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) from the Atlantic rainforest (Santa Lúcia Reserve, Espírito Santo, SE Brazil).

Abb. 1: Häufigkeitsverteilung der Kopf-Rumpf-Längen Größenklassen bei 221 Männchen und 96 Weibchen von *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) aus dem Atlantischen Regenwald (Santa Lúcia Reservat, Espírito Santo, SO Brasilien).

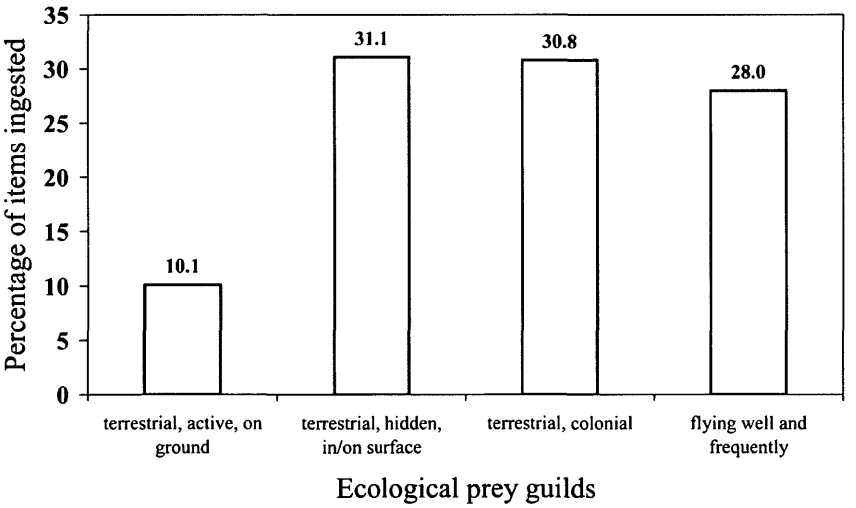

Fig. 2: Percentages of 415 prey items (wet weight), according to ecological prey guilds, found in 265 stomach contents of *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) from the Atlantic rainforest (Santa Lúcia Reserve, Espírito Santo, SE Brazil). For classification of guilds see Table 1.

Abb. 2: Prozentuale Verteilung (Feuchtgewicht) von 415 Beuteobjekten auf ökologische Beutegilden anhand von 265 Mageninhalten von *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) aus dem Atlantischen Regenwald (Santa Lúcia Reservat, Espírito Santo, SO Brasilien) gefunden wurden. Zur Einteilung der Gilden siehe Tab. 1.

& PRADO 2005) and can also differ within species from mountains to coastal plains, as well as due to microclimate conditions that have a great impact on calling times and seasons (RÖDDER et al. 2006).

The small hylid frog, *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926), is a member of the *Scinax catharinae* group according to (FAIVOVICH et al. 2005), and endemic to the Brazilian Atlantic rainforest, where it occurs from the state of Bahia to the state of São Paulo (FROST 1985; SILVANO & PIMENTA 2001). Reproduction takes place in temporary or in semi-permanent ponds on the forest floor, and the frogs' calls can be heard from September through March (CARVALHO-E-SILVA & CARVALHO-E-SILVA 1998). Available information on the ecology and biology of *S. argyreornatus* is limited to observations of their reproductive behavior (CARVALHO-E-SILVA & CARVALHO-E-SILVA 1998), data on mating calls (POMBAL et al. 1995), feeding habits, and fecundity in a cacao plantation in the coastal plain (TEIXEIRA & VRCIBRADIC 2003).

The main object of this study was to determine the diet and reproductive aspects of *S. argyreornatus* from a mountainous region inside the Atlantic rainforest of southeastern Brazil. We assessed the diet shift, trophic seasonal variation and differences in diet between the sexes, and we analyzed the reproductive cycle and fecundity of this hylid frog.

MATERIALS AND METHODS

Study Site. – This study was carried out at the Santa Lúcia Biological Station (19°58'S, 40°32'W, 740 m a.s.l.), located in the municipality of Santa Teresa, Espírito Santo State, southeastern Brazil. The area covers approximately 440 ha, and consists of an important fragment of the Atlantic rainforest in the mountainous region of Espírito Santo (MENDES & PADOVAN 2000).

Inside the Santa Lúcia Reserve, a sampling site of approximately 2500 m^2 was selected, including only the forest edge habitat at the Timbuí River crossing the reserve. The climate is tropical, extremely wet, and has a drier winter season. The minimum annual mean temperature is about 14.3 °C, whereas the maximum annual mean is about 26.2 °C during the day. According to KÖPPEN (1936), the climate is characterized as the "Cwa" type: meso-termic, with dry periods in the winter (June, July, and August), with strong rain periods during the summer (December, January, and February) (THOMAZ & MONTEIRO 1997).

Samples. – Fieldwork was carried out by R. L. TEIXEIRA. Specimens were collected monthly, nocturnally, by hand (from 20:00 through 22:00 h) along randomized transects in the selected area of the rainforest, from August 1988 through July 1989. Specimens of *S. argyreornatus* were measured for their snout-vent length (SVL mm) using veneer calipers, put in a small bag and weighed using a balance of 0.1 g precision. Stomach contents of males and non-gravid females were assessed applying the stomach flushing method (JOLY 1987); specimens were released afterwards.

Gravid females were identified in the field, collected, euthanasized with a chlorobutanol solution and put in 10% formalin for fixation. Formalin was injected into the abdomen to avoid any further digestion. After a week, they were rinsed in running water and transferred to an ethanol solution (70%). Females were dissected, their ovaries weighed to determine the gonadosomatic index [GSI = (ovary weight / total body weight) x 100]; in mature ovaries oocytes were counted. Specimens, which were suggested to have already spawned because their ovaries contained only few mature oocytes, were excluded from the analysis. The stomach contents of these females as well as the prey items obtained from male stomach flushing were spread on a Petri dish for identification under a stereo microscope.

The prey was identified down to the lowest possible taxonomic level. The importance of each prey group found was determined using frequency (= number of frogs containing items of this prey group), number (= number of prey items belonging to this prey group), and prey wet weight (= collective wet weight of items of this

Table 1: Definition of ecological prey guilds (after SCHMITZ 2001, modified) to estimate the habitat preferences of *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) by analysis of the taxonomic composition of its prey.

Tab. 1: Definition ökologischer Beutegilden (nach SCHMITZ 2001, verändert) zur Beurteilung der Habitatwahl von *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) nach der taxonomischen Zusammensetzung des Beutespektrums.

Guild Nr. Gilde Nr.	Characterization of Prey Beutecharakterisierung	Hunting Method of Predator Jagdmethode des Räubers	Prey Taxon Beutetiergruppe
1	terrestrial, active, on ground terrestrisch, bodenaktiv	sit-and-wait predators Ansitzjagd	Blattodea, Coleoptera
2	terrestrial, hidden, in / on surface terrestrisch, verborgen, in / auf Oberflächen	active searching aktive Suche	Araneae, Collembola, Isopoda, Chilopoda, Pseudoscorpiones, Opiliones, Acarina
3	terrestrial, colonial terrestrisch, kolonienbildend	active searching, sit-and-wait while sitting near pathways aktive Suche, Ansitzjagt an Wanderwegen	Formicidae, Isoptera
4	flying well and frequently guter und häufiger Flieger	active hunting aktive Jagd	Diptera, Hemiptera, Homoptera, Lepidoptera, Odonata, Orthoptera, Apiidae

Table 2: Prey found in 265 stomach contents of *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) from the Atlantic rainforest (Santa Lúcia Reserve, Espírito Santo, SE Brazil). F = frequency (= number of frogs containing items of this prey group), n = number (= number of prey items belonging to this prey group), W = wet weight (= collective wet weight of all items of this prey group).

Tab. 2: Zusammensetzung des Beutespektrums von *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) aus dem Atlantischen Regenwald (Santa Lúcia Reservat, Espírito Santo, SO Brasilien) aufgrund der Analyse von 265 Mageninhalten. F = Häufigkeit (Anzahl Frösche, die solche Beuteobjekte beinhalteten); n = Anzahl (Anzahl Beuteobjekte aus dieser Beutetiergruppe); W = Feuchtgewicht (gemeinsames Feuchtgewicht aller Objekte dieser Beutetiergruppe).

Prey Group / Beutetiergruppe	F	F (%)	n	n (%)	W (g)	W (%)
Insecta						
Apiidae	2	0.8	2	0.5	0.0022	0.2
Blattodea	20	7.5	20	4.8	0.1820	13.6
Coleoptera	21	7.9	22	5.3	0.0325	2.4
Collembola	7	2.6	9	2.2	0.0026	0.2
Diptera	21	7.9	22	5.3	0.0187	1.4
Formicidae	47	17.7	72	17.3	0.0563	4.2
Hemiptera	1	0.4	1	0.2	0.0014	0.1
Homoptera	45	17.0	53	12.8	0.0701	5.2
Isoptera	31	11.7	56	13.5	0.1216	9.1
Lepidoptera	10	3.8	10	2.4	0.1305	9.7
Odonata	1	0.4	1	0.2	0.0014	0.1
Orthoptera	27	10.2	27	6.5	0.4427	33.0
Arachnida						
Araneae	24	9.1	28	6.7	0.0980	7.3
Acarina	2	0.8	2	0.5	0.0092	0.7
Opiliones	9	3.4	10	2.4	0.0262	2.0
Pseudoscorpiones	8	3.0	8	1.9	0.0124	0.9
Crustacea						
Isopoda	58	21.9	70	16.9	0.1298	9.7
Myriapoda						
Chilopoda	2	0.8	2	0.5	0.0029	0.2
Total	—	—	415	100.0	1.3405	100.0

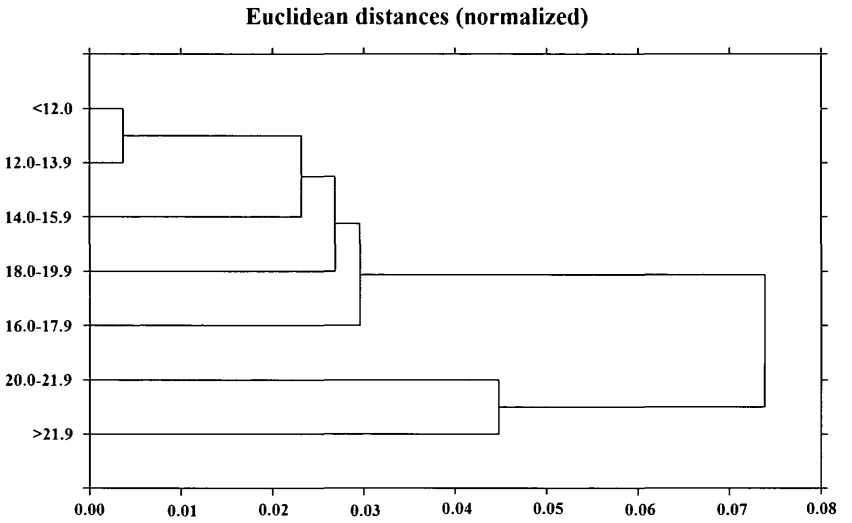

Fig. 3: Cluster analysis showing the similarities of prey composition according to size classes (SVL, mm) in *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) from the Atlantic rainforest (Santa Lúcia Reserve, Espírito Santo, SE Brazil). The analysis is based on 415 prey items from 265 stomach contents.

Abb. 3: Clusteranalyse zur Veranschaulichung der Ähnlichkeiten in den Beutespektren verschiedener Größenklassen (Kopf-Rumpf-Längen, mm) von *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) aus dem Atlantischen Regenwald (Santa Lúcia Reservat, Espírito Santo, SO Brasilien). Die Untersuchung betrachtet 415 Beuteobjekte aus 265 Mageninhalten.

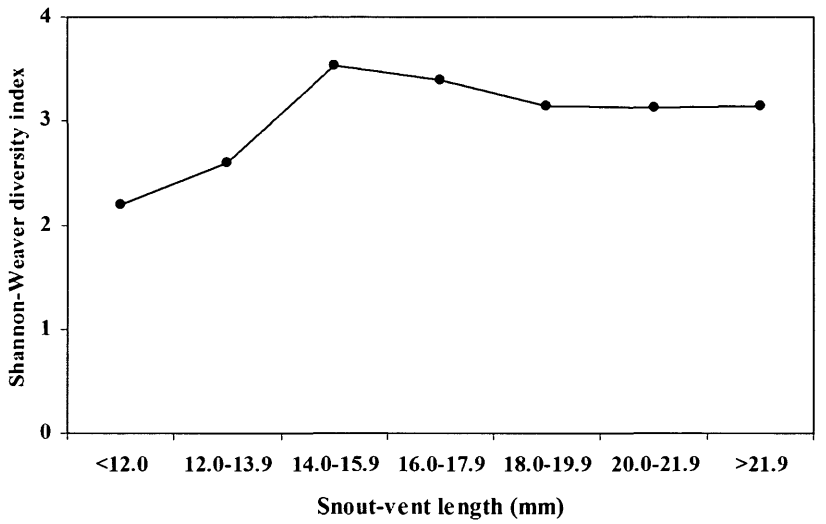

Fig. 4: Prey diversity (Shannon-Weaver diversity index) according to size classes (SVL mm) in *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) from the Atlantic rainforest (Santa Lúcia Reserve, Espírito Santo, SE Brazil). 415 prey items from 265 stomach contents were analyzed.

Abb. 4: Die Beutediversität (Shannon-Weaver Diversitätsindex) in sieben Größenklassen (SVL mm) von *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) aus dem Atlantischen Regenwald (Santa Lúcia Reservat, Espírito Santo, SO Brasilien). 415 Beuteobjekte aus 265 Mageninhalten wurden untersucht.

Table 3: Proportion of prey groups (in % wet weight) in the stomach contents of *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) according to anuran size classes (SVL mm) (Santa Lúcia Reserve, Espírito Santo, SE Brazil).

Tab. 3: Die Anteile der Beutetiergruppen (in % Feuchtgewicht) am Mageninhalt von *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) in Abhängigkeit von der Größenklasse der Frösche (Kopf-Rumpf Länge, mm) (Santa Lúcia Reservat, Espírito Santo, SO Brasilien).

Prey Group / Beutetiergruppe	Size Classes (mm) / Größenklassen (mm)						
	< 12.0	12.0-13.9	14.0-15.9	16.0-17.9	18.0-19.9	20.0-21.9	>21.9
Acarina	-	-	-	3.2	-	-	-
Apiidae	-	-	0.3	0.0	-	-	0.6
Araneae	17.6	2.5	5.6	9.8	0.6	9.0	5.0
Blattodea	0.0	0.0	12.3	7.5	0.6	15.4	26.2
Chilopoda	0.0	0.0	0.0	0.7	0.0	0.0	0.3
Coleoptera	0.0	1.6	0.8	5.0	0.2	2.3	1.9
Collembola	0.0	0.8	0.3	0.7	0.0	0.0	0.0
Diptera	0.0	0.0	4.4	3.7	0.6	0.0	0.0
Formicidae	23.5	0.8	8.8	12.4	0.4	0.8	0.5
Hemiptera	0.0	0.0	0.8	0.0	0.0	0.0	0.0
Homoptera	11.8	4.9	11.2	16.1	4.5	1.1	1.4
Isopoda	23.5	3.3	12.8	9.3	47.4	4.4	1.7
Isoptera	23.5	18.0	16.7	5.7	2.9	9.7	8.0
Lepidoptera	0.0	0.0	18.7	8.2	0.2	14.7	0.0
Odonata	0.0	0.0	0.8	0.0	0.0	0.0	0.0
Opiliones	0.0	0.0	0.8	3.9	10.2	0.4	0.0
Orthoptera	0.0	68.0	4.5	13.6	32.5	41.7	51.7
Pseudoscorpiones	0.0	0.0	1.3	0.1	0.0	0.5	2.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

prey group). Before weighing (0.0001 g precision), the prey was put on an absorbent paper to take off the excess humidity. For the analysis of prey variation according to size classes (e.g., SVL 12.0 - 13.9 mm; 14.0 - 15.9, etc), by month, and between sexes, we opted to use only the prey wet weight data.

Statistical Procedures. – The chi-square test (χ^2) was used to identify possible significant differences in the sex-ratio. One-way analysis of variance (ANOVA) was used to compare means of SVL and body weight between sexes. Sex was the independent variable, and means of SVL and weights the dependent one. Data normality was assessed using the Kolmogorov-Smirnov test, and homogeneity of variances was assessed using the Scheffé test (NETER et al. 1990). Simple linear regression analysis was used to compare the relationship of the number of mature oocytes in the ovaries with SVL. Normalized cluster analysis based on Euclidian distances was used to detect possible trophic ontogeny of *S. argyreornatus*. Only data of prey wet weight were used here. In addition, we used the Shannon-Weaver diversity index (SHANNON & WEAVER 1949) to compare variations in prey ingested according to size classes and merged taxonomic prey groups found into ecological guilds according to their way of life to get information about the predominant foraging strategy and microhabitat of *S. argyreornatus*. Guild definitions have been provided in Table 1.

RESULTS

Scinax argyreornatus occurred in the herbaceous vegetation in altitudes from 0.20 to 1.5 m at our study site. A total of 318 individuals were collected of which 221 were males, 96 females, and one small specimen whose sex could not be identified. The male to female ratio was 2.3:1.0, and significantly different from the expected 1.0:1.0 ratio ($\chi^2 = 49.3$; $P < 0.01$). Males varied in SVL from 10.0 to 19.4 mm (mean = 15.9 ± 1.5 mm),

Table 4: Proportion (in % wet weight) of prey taxa in the diet of *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926), according to month. Monthly maxima in bold italics. (Santa Lúcia Reserve, Espírito Santo, SE Brazil).

Tab. 4: Anteile der Beutetiertaxa (in % Feuchtgewicht) an der Nahrung von *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) in Abhängigkeit vom Monat. Monatsmaxima in kursiver Fettschrift. (Santa Lúcia Reservat, Espírito Santo, SO Brasilien).

Prey Group / Beutetiergruppe	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Acarina	-	-	-	-	6.7	0.2	-	-	-	-	-	-
Apiidae	-	-	-	-	0.0	0.0	-	-	-	1.9	-	2.1
Araneae	-	0.4	-	10.7	6.7	3.2	14.1	17.1	-	10.4	31.8	0.0
Blattodea	-	14.9	1.3	14.7	0.0	31.7	***67.2***	6.9	13.7	16.5	0.0	***48.3***
Chilopoda	-	0.0	0.0	0.4	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0
Coleoptera	0.7	0.0	0.0	0.3	5.3	8.4	3.2	5.5	0.0	1.2	0.0	3.3
Collembola	0.0	0.7	0.0	0.0	0.0	1.0	0.4	0.0	0.0	0.0	1.2	0.0
Diptera	0.2	0.9	0.0	0.7	8.9	0.0	0.4	0.1	1.3	1.7	0.8	0.8
Formicidae	11.5	1.4	3.5	1.1	14.1	1.3	0.0	2.2	1.6	1.1	0.0	6.7
Hemiptera	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0
Homoptera	0.0	4.7	0.4	2.6	6.7	11.1	7.8	1.7	0.8	***30.0***	2.7	2.1
Isopoda	26.5	1.1	34.5	5.4	***18.6***	0.6	0.4	5.3	1.4	12.1	4.3	11.3
Isoptera	0.0	0.0	***54.0***	12.0	14.9	0.9	1.9	1.9	***41.2***	7.8	0.0	15.0
Lepidoptera	0.4	8.5	0.0	0.0	7.4	0.0	0.0	17.0	38.8	14.9	***55.7***	4.6
Odonata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8
Opiliones	0.0	0.0	0.9	7.5	0.0	0.0	0.0	4.1	1.3	0.9	3.5	0.0
Orthoptera	***60.8***	***67.6***	4.6	***44.5***	10.6	***38.3***	0.0	***33.9***	0.0	1.5	0.0	0.0
Pseudoscorpiones	0.0	0.0	0.7	0.0	0.0	3.3	2.5	3.4	0.0	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

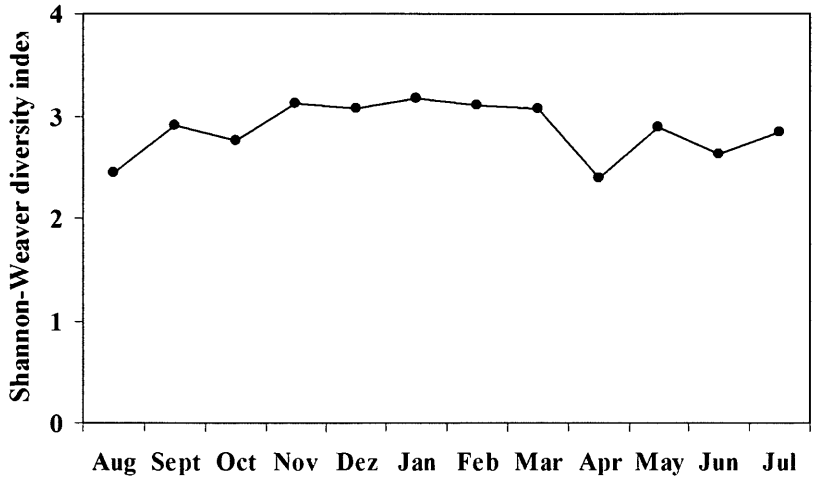

Fig. 5: Prey diversity (Shannon-Weaver diversity index) according to sampled month in *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) from the Atlantic rainforest (Santa Lúcia Reserve, Espírito Santo, SE Brazil). 415 prey items from 265 stomach contents were analyzed.

Abb. 5: Die Beutediversität (Shannon-Weaver Diversitätsindex) in den Monaten der Untersuchung bei *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) aus dem Atlantischen Regenwald (Santa Lúcia Reservat, Espírito Santo, SO Brasilien). 415 Beuteobjekte aus 265 Mageninhalten wurden untersucht.

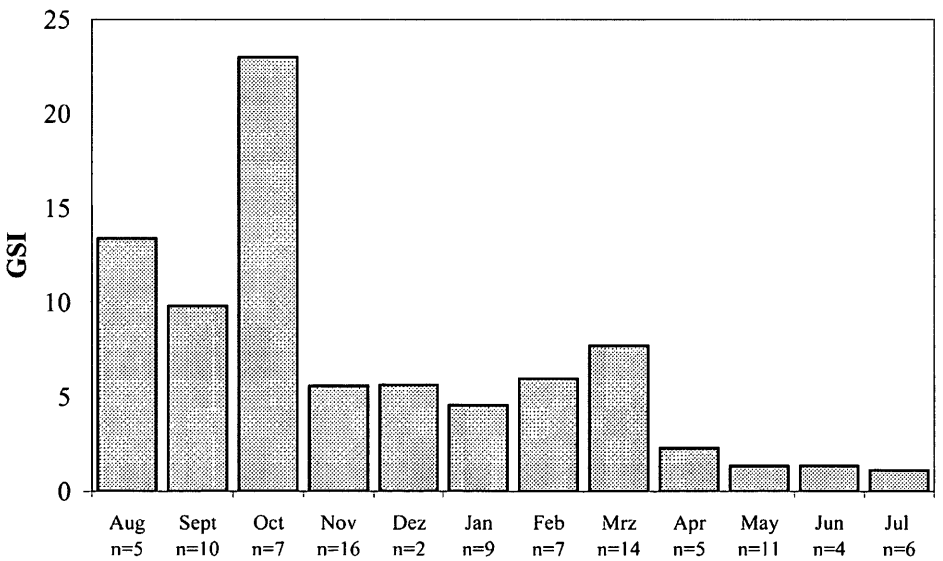

Fig. 6: Mean values of the gonadosomatic index (GSI) by month of 96 female *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) caught through the year in the Atlantic rainforest (Santa Lúcia Reserve, Espírito Santo, SE Brazil).

Abb. 6: Mittelwerte des Gonadosomatischen Indexes (GSI) von 96 weiblichen *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) aus dem Atlantischen Regenwald (Santa Lúcia Reservat, Espírito Santo, SO Brasilien), gefangen im Jahresverlauf.

Table 5: Proportion of prey groups (wet weight and % wet weight) in the stomach contents of *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926), according to sex. W – Wet weight. (Santa Lúcia Reserve, Espírito Santo, SE Brazil).

Tab. 5: Die Anteile der Beutetiergruppen (in Feuchtgewicht und % Feuchtgewicht) am Mageninhalt von *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) in Abhängigkeit vom Geschlecht. W – Feuchtgewicht. (Santa Lúcia Reservat, Espírito Santo, SO Brasilien).

Prey Group / Beutetiergruppe	Males / Männchen		Females / Weibchen	
	W (g)	W (%)	W (g)	W (%)
Acarina	0.0092	2.1	-	-
Apiidae	0.0005	0.1	0.0017	0.2
Araneae	0.0384	8.6	0.0596	6.7
Blattodea	0.0329	7.4	0.1491	16.7
Chilopoda	0.0021	0.5	0.0008	0.1
Coleoptera	0.0159	3.6	0.0166	1.9
Collembola	0.0026	0.6	-	-
Diptera	0.0183	4.1	0.0004	0.0
Formicidae	0.0489	11.0	0.0074	0.8
Hemiptera	0.0014	0.3	-	-
Homoptera	0.0566	12.7	0.0134	1.5
Isopoda	0.0453	10.2	0.0845	9.4
Isoptera	0.0471	10.6	0.0745	8.3
Lepidoptera	0.0550	12.4	0.0755	8.4
Odonata	0.0014	0.3	-	-
Opiliones	0.0126	2.8	0.0136	1.5
Orthoptera	0.0545	12.2	0.3882	43.4
Pseudoscorpiones	0.0024	0.5	0.0100	1.1
Total	0.4451	100.0	0.8953	100.0

whereas the females varied from 15.6 to 24.1 mm (mean = 20.8 ± 1.5 mm)(Fig. 1). There were significant differences in the mean SVL between the sexes (ANOVA: $F_{1.315}$ = 698.8; $P < 0.01$). Males varied in weight from 0.1 to 0.9 g (mean = 0.4 ± 0.2 g), whereas females varied from 0.2 to 1.7 g (mean = 1.0 ± 0.3 g). There were also significant differences in mean weight between sexes (ANOVA: $F_{1.315} = 636.5$; $P < 0.01$).

From the 318 individuals examined, 265 (83.3%) had at least some type of food remains in their stomachs. *Scinax argyreornatus* fed mainly on small arthropods (Table 2). In frequency, Isopoda, Formicidae, and Homoptera were the dominant prey items ingested. In the number of ingested prey, the main food items were Formicidae followed by Isopoda and Isoptera. Orthoptera and Blattodea dominated in prey wet weight (Table 2). This species feeds on almost all ecological prey guilds in equal percentages (31.1% terrestrial, hidden; 30.8% terrestrial colonial; 28.0% flying well and frequently), only terrestrial ground-active insects are represented in a smaller percentage (10.1%) (Fig. 2).

Total number of prey items found was 415, they weighed 1.3405 g (wet weight); mean number of prey items per individual was 1.31, mean prey wet weight per individual was 0.0042 g, mean wet weight per prey item was 0.0032 g.

Cluster analysis (based on prey item numbers within prey groups according to anuran size classes) visualizing the similarities in the prey composition of frogs of the various size classes (Fig. 3) allows the hypothesis that trophic ontogeny occurs in *S. argyreornatus*. Specimens smaller than 20.0 mm SVL fed mainly on Orthoptera, Isopoda, Formicidae, Isoptera and Homoptera. Larger individuals fed more often on Orthoptera and Blattodea (Table 3). The smallest individuals had the smallest Shannon-Weaver diversity index values, and specimens between 14.0 mm and 15.9 mm had the largest. We observed a trend in increasing towards stagnating values of the Shannon-Weaver diversity index according to the largest specimens of *S. argyreornatus* (Fig. 4)

The diet changed according to the different sampling months (Table 4). However,

we did not detect that any particular prey group was consistently of greater seasonal importance. During the summer months diversity of ingested prey was highest (Fig. 5). Dominant prey differed between sexes (Table 5). In males the wet weight percentages were more balanced among taxonomic prey groups while the females fed mainly on Orthoptera and Blattodea.

Scinax argyreornatus has a protracted reproductive period. Except for June and July, mating calls occurred throughout most of the year at our study site. The gonadosomatic index results show that ovaries were heaviest from July (late winter), through February (early fall) (Fig. 6). The mature ovaries can represent 64.0% of the body weight at the peak of the reproductive period. Ovaries of 96 females were analyzed and 61 of them contained mature (maximum developed) oocytes (Fig. 7). Of these 61 specimens 29 contained only few oocytes suggesting that these females had already spawned, so they were excluded and only 32 specimens used for the linear regression analysis. The number of oocytes was linearly and positively related to the SVL (Fig. 8). The number of oocytes varied from 217 to 740 (n = 32), showing a high fecundity for this small hylid frog.

DISCUSSION

Scinax argyreornatus is one of the most abundant frogs in the lowlands of the Santa Lúcia Biological Station, and can be found all year round on the leaves of small plants close to the Timbuí River. An overall sex ratio close to 1:1 was expected, but the number of males of *S. argyreornatus* was much higher than of females. This suggests that males may compete strongly for access to females during the mating season. An imbalanced sex ratio has been observed in many frogs of Espírito Santo state, such as in *Proceratophrys boiei* (WIED-NEUWIED, 1825) (TEIXEIRA & COUTINHO 2002), *Hypsiboas albomarginatus* (SPIX, 1824), *Dendropsophus branneri* (COCHRAN, 1948), *Dendropsophus elegans* (WIED-NEUWIED, 1824), *Hypsiboas faber* (WIED-NEUWIED, 1821), *Scinax alter* (B. LUTZ, 1973), *Scinax fuscovarius* (A. LUTZ, 1925) (all M. T. A LINO 2003), *Leptodactylus ocellatus* (TEIXEIRA & VRCIBRADIC 2003), *Pseudis bolbodactyla* (TEIXEIRA et al. 2004), and in *S. argyreornatus* populations studied at the coastal plain in a cacao plantation in the municipality of Linhares (TEIXEIRA & VRCIBRADIC 2003).

Arthropods dominated the diet of *S. argyreornatus*, as observed in a great variety of frogs occurring in the Atlantic rainforest (GIARETTA et al. 1998; VAN-SLUYS & ROCHA, 1998; TEIXEIRA & COUTINHO 2002; TEIXEIRA et al. 2002; TEIXEIRA & VRCIBRADIC 2003; SANTOS et al. 2004; TEIXEIRA et al. 2004; TEIXEIRA & VRCIBRADIC 2004). Formicidae, Isopoda, Blattodea, Homoptera, and Orthoptera were the main prey ingested, revealing that this hylid frog uses a great variety of prey available and is not specialized in any ecological prey guild. Its microhabitat seems to be arboreal as well as terrestrial, since in the diet the percentage of ground dwelling arthropods is smaller than that of other guilds, which occur in almost equal amounts (Fig. 2). The great amount of terrestrial isopods, that normally live on the leaf litter as well as flying prey items suggest that *S. argyreornatus* is a very active predator. Similar results were found by TEIXEIRA & VRCIBRADIC (2003).

Since only one juvenile was collected, it appears that adults and juveniles have different micro-habitats. This may be one reason for the trophic ontogeny observed in *S. argyreornatus*. However, trophic ontogeny is known to be important for food partitioning between adults and juveniles allowing them to avoid competition, and it has been found in many anurans (e.g., GIARETTA et al. 1998; LIMA 1998; TEIXEIRA & COUTINHO 2002; TEIXEIRA & VRCIBRADIC 2003; BIAVATI et al. 2004; TEIXEIRA et al. 2004). Also, foraging activity may change with ontogeny as suggested by LIMA & MAGNUSSON (2000). Mouth size, which is usually positively related to SVL, is an important factor for prey availability as frogs with wider jaws can prey upon larger prey items (EMERSON 1985). Due to this relation, differences in the diet according to sex may be due to the significant differences in size

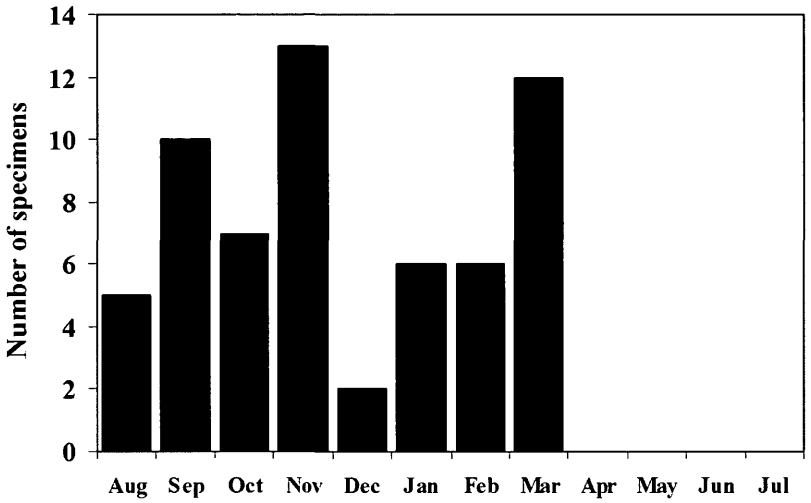

Fig. 7: Number of female *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926)(n = 61) having mature oocytes, as found by month in the Atlantic rainforest at Santa Lúcia Reserve, Espírito Santo, SE Brazil.

Abb. 7: Anzahl der pro Monat mit reifen Oocyten gefundenen Weibchen von *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926)(n = 61) aus dem Atlantischen Regenwald (Santa Lúcia Reservat, Espírito Santo, SO Brasilien).

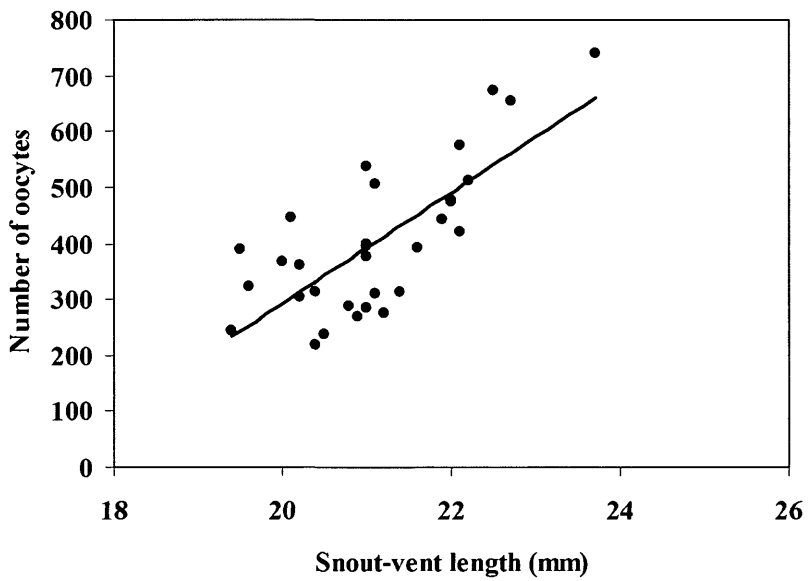

Fig. 8: Relationship of the number of oocytes against the SVL in mature female *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) of the Atlantic rainforest (Santa Lúcia Reserve, Espírito Santo, SE Brazil). $y = 99.28x - 1693$; $R^2 = 0.56$; $P < 0.05$; $n = 32$.

Abb. 8: Zusammenhang zwischen der Oocytenanzahl und der Kopf-Rumpf-Länge bei reifen Weibchen von *Scinax argyreornatus* (MIRANDA-RIBEIRO, 1926) aus dem Atlantischen Regenwald (Santa Lúcia Reservat, Espírito Santo, SO Brasilien). $y = 99.28x - 1693$; $R^2 = 0.56$; $P < 0.05$; $n = 32$.

between males and females. Differences in the diet according to different months suggest differences in prey availability throughout the year, considering that *S. argyreornatus* seems to prey on all arthropods available without favoring one specific group.

Relative to its small size, *Scinax argyreornatus* showed a high fecundity, and one female spawning may represent the total recovery of a population, without taking the natural mortality into account. LINO (2003, unpubl. data) obtained similar results for different small frogs around the town of Anchieta (Espírito Santo State). The fecundity of *S. argyreornatus* from the mountainous region studied here was much higher than that obtained in the coastal plain of Linhares by TEIXEIRA & VRCIBRADIC (2004). This may suggest that the population of the mountainous areas has a less protracted spawning season due to microclimatic conditions, and consequently spend more energy to obtain a higher fecundity in a shorter time span. One could expect differences in SVL and weight due to different climatic conditions between lowland and mountainous populations, but means of SVL and weight were similar to these of the population studied at a coastal plain by TEIXEIRA & VRCIBRADIC (2003).

The great abundance of *S. argyreornatus* at the study site, the wide prey spectrum, and the high fecundity results in a greater ecological plasticity for this frog, which may in turn explain the success of its population. Additional studies on this frog species should be directed towards obtaining information on the degree of the relations to other anurans that make up the community, which is very diverse along the Atlantic rainforest.

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AUTHORS: Rogério L. TEIXEIRA, Museu de Biologia Prof. Mello Leitão, Av. José Ruschi, 4, Centro, 29650-000, Santa Teresa, Espírito Santo, Brazil < rogeteix@terra.com.br >; Dennis RÖDDER, Zoologisches Forschungsmuseum Alexander Koenig, Adenauerallee 160, D-53113 Bonn, Germany < d.roedder.zfmk@uni-bonn.de >