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Amphibians occurring in soybean and implications for biological control in Argentina

Andrés M. Attademo[a], Paola M. Peltzer[b], Rafael C. Lajmanovich[b,c,*]

[a]Biological and Exact Sciences Faculty, National University of Córdoba (UNC), Av. Vélez Sársfield 299, (5000) Córdoba, Argentina
[b]National Institute of Limnology (INALI-CONICET-UNL), José Macias 1933, (3016) Santo Tomé-Santa Fe 3016, Argentina
[c]High School of Health, Faculty of Biochemistry and Biological Sciences, EES-FBCB-UNL, (3001) Santa Fe, Argentina

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Abstract

The diversity and diet composition of amphibians were examined in soybean of the Córdoba and Entre Ríos Provinces of Argentina, investigating their potential as biological control agents of herbivores species. A total of 15 anuran species belonging to three families were detected in the two crops. The numbers of individuals found in soybean and the variety of arthropods they consumed suggest that anuran populations could be important biological control factors of soybean arthropods.

Keywords: Amphibian; Argentina; Cropland; Soybean

1. Introduction

Over the past few years the traditional, dairy-oriented Argentinean agriculture characterized by a mosaic of pastures and woodlots has been replaced by a more specialized large-scale production, based on glyphosate-tolerant (GT)-soybean (*Glycine max*(L) Merril). The majority of GT-soybean is being produced in the Santa Fe, Entre Ríos, Buenos Aires, and Córdoba Provinces (Hin et al., 2001). Patches of natural vegetation remain embedded in the agricultural matrix whereas amphibians depend on altered wetlands or ephemeral ponds for their survival and reproduction (Peltzer and Lajmanovich, 2001).

The dynamics of amphibians in agroecosystems (Guerry and Hunter, 2002), in particular soybean is poorly known. This paper examines the diversity and the diet composition of anurans in GT-soybean of Argentina with a view to answer the following questions: (1) what are the anuran assemblages of soybean and (2) are they likely to contribute to biological control of herbivores of soybean.

2. Material and methods

The study took place in two 10 ha soybean fields of mid-eastern Argentina (31°14′46″S–63°33′8″W Cór-

* Corresponding author. Tel.: +54 342 4740152; fax: +54 342 4750394.
E-mail address: rafalajmanovich@yahoo.com.ar (R.C. Lajmanovich).

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doba, and 31°44′36″S–60°19′40″W Entre Ríos), under annual rainfall of 800–1000 mm, mean annual temperature of 18–20 °C.

Amphibian occurrence was estimated using pitfall trapping (Corn, 1994; Melbourne, 1999). Four transects were arranged in each soybean field, two on the edge and two in the center. Transects were separated from each other by 50 m and consisted of four pitfall traps. Each trap was a 10 l plastic bucket with 10% formalin 10 cm deep placed in the ground with the opening flush with the surface, the fixative being necessary to stop alimentary canal clearance (Caldwell, 1996).

Each field was surveyed for 2 h each week from December to March 2003 (summer season) depending on crop height. The surveys were conducted during the soybean-cropping period to coincide with the activity of anurans in this region.

Two persons recorded four habitat variables: air temperature 1.5 m high, temperature under soybean plants (<10 cm high), height of 20 soybean plants, and weekly rainfall. Distance to urban sites and protected forest, time since agriculture activity started in the field, and breeding ponds were also recorded.

Diversity was calculated using Shannon's index (Shannon and Weaver, 1949). The evenness was also calculated. To evaluate the significance of the differences in the amphibian diversity between the fields, a test "*t*" according to Hutcheson (1970) was used. Data were square root transformed and fields were compared using the Jaccard index (Magurran, 1987). The average weight and biomass per individual were estimated using a spring balance (0.1 g precision). A one-way ANOVA was used to test the effect of transect position, and a Spearman correlation test to relate anuran diversity, evenness and richness to habitat variables.

The diet of the two main anuran species per field was analyzed by removing the digestive tract. Prey items were classified by taxon (prey category) using a binocular microscope, their body length and numbers per digestive tract were recorded. Frequency of occurrence was determined as the proportion of all gastrointestinal tracts containing a particular prey category (Lescure, 1971). Amphibian specimens were deposited in the herpetological collection of the National Institute of Limnology (INALI-CONICET-UNL) of Santa Fe Province (Argentina).

Table 1
Total amphibian abundance (*N*), diversity (H) evenness (E), richness (R) of Córdoba and Entre Ríos soybean fields over the study period

Species considered	Córdoba soybean			Entre Ríos soybean		
	N	Average weight (g)	Anuran biomass (kg)	*N*	Average weight (g)	Anuran biomass (kg)
Bufo arenarum Hensel	312	98 (±50.7)	30.59	–	–	–
Bufo paracnemis Lutz	–	–	–	7	6.6 (±1.2)	0.04
Leptodactylus latinasus Jiménez de la Espada	225	6.5 (±1.2)	1.48	32	2.3 (±1.2)	0.07
Leptodactylus mystacinus (Burmeister)	48	7.4 (±1.1)	0.35	15	0.4 (±0.3)	0.006
Leptodactylus gracilis (Boulenger)	26	7.1 (±1.5)	0.18	70	3.2 (±5)	0.22
Leptodactylus chaquensis Cei	13	18.6 (±8.5)	0.24	39	14.1(±1.2)	0.55
Leptodactylus ocellatus (Linnaeus)	–	–	–	17	9.6 (±4.2)	0.16
Physalaemus biligonigerus Cope	96	7.5 (±3.3)	0.72	9	1.2 (±0.7)	0.01
Physalaemus albonotatus (Steindachner)	–	–	–	114	1 (±0.7)	0.11
Physalaemus riograndensis Milstead	–	–	–	2	x	x
Ceratophrys cranwelli Barrio	1	x	x	–	–	–
Odontophrynus americanus (Dumeril & Bibron)	5	20.8 (±15.2)	0.1	–	–	–
Pleurodema tucumanum Parker	12	5.8 (±2.1)	0.07	–	–	–
Pseudopaludicola falcipes (Hensel)	–	–	–	1	x	x
Elachistocleis bicolor (Valenciennes)	2	x	x	27	0.6 (±0.2)	0.02
Diversity		1.48			1.89	
Evenness		0.68			0.79	
Richness		10			11	

(x) Few data; (–) no data.

Table 2
Diet composition of amphibians in Córdoba (*B. arenarum* and *L. latinasus*) and Entre Ríos (*L. chaquensis* and *P. albonotatus*) soybean fields

Prey category	Córdoba soybean				Entre Ríos soybean			
	B. arenarum		*L. latinasus*		*L. chaquensis*		*P. albonotatus*	
	N	%FO	*N*	%FO	*N*	%FO	*N*	%FO
Coleoptera								
Elateridae								
Agriotes sp.[a]	9	20	12	33.3	2	13.3	4	13.3
Conoderus sp.[a]	1	6.7	–	–	4	26.6	–	–
Lagriidae								
Lagria villosa	67	73.3	1	6.7	9	13.3	–	–
Scaraboidae								
Diloboderus abderus[a]	26	26.7	1	6.7	1	6.7	–	–
Phanaeus splendidulus[a]	4	20	–	–	–	–	–	–
Anomala sp.[a]	4	13.3	3	20	2	13.3	–	–
Carabidae								
Oriozapylus sp.	24	40	–	–	6	33.3	–	–
Tenebrionidae								
Scotobius sp.	2	13.3	–	–	–	–	–	–
Curculionidae[a]								
Adult (n.i.)	3	6.7	–	–	–	–	–	–
Chrysomelidae								
Diabrotica speciosa[a]	1	6.7	1	6.7	–	–	–	–
Cicindelidae								
Adult (n.i.)	1	6.7	–	–	–	–	–	–
Dytiscidae								
Adult (n.i.)	–	–	1	6.7	–	–	–	–
Lepidoptera								
Arctiidae								
Spilosoma virginica[a]	2	6.7	–	–	13	40	2	13.3
Noctuidae								
Spodoptera sp.[a]	23	13.3	–	–	–	–	–	–
Peridroma saucia[a]	8	13.3	–	–	–	–	–	–
Anticarsia gemmatalis[a]	23	33.3	3	13.3	4	26.7	4	13.3
Rachiplusia nu[a]	–	–	2	6.7	3	20	–	–
Erebus sp.[a]	–	–	–	–	3	20	–	–
Ortoptera								
Acridiidae								
Schistocerca sp.[a]	4	20	–	–	3	20	–	–
Gryllidae								
Gryllus argentinus[a]	2	6.7	1	6.7	1	6.7	–	–
Anurogryllus muticus[a]	–	–	1	6.7	–	–	1	6.7
Gryllotalpidae								
Scapteriscus borelli[a]	–	–	3	20	–	–	–	–
Homoptera								
Delphacidae								
Delphacodes kuscheli[a]	2	6.7	2	6.7	–	–	–	–

Table 2 (*Continued*)

Prey category	Córdoba soybean				Entre Ríos soybean			
	B. arenarum		*L. latinasus*		*L. chaquensis*		*P. albonotatus*	
	N	%FO	*N*	%FO	*N*	%FO	*N*	%FO
Cicadellidae								
Empoasca fabae[a]	–	–	–	–	1	6.7	–	–
Cercopidae								
Zulia entrerriana	–	–	–	–	1	6.7	–	–
Hemiptera								
Pentatomidae								
Edessa meditabunda[a]	8	40	–	–	–	–	–	–
Nezara viridula[a]	4	20	–	–	–	–	–	–
Reduviidae								
Adult (n.i.)	1	6.7	–	–	–	–	–	–
Hymenoptera								
Formicidae								
Solenopsis sp.	12	6.7	–	–	9	6.7	–	–
Acromyrmex sp.[a]	28	20	–		–	–	–	–
Pheidole sp.	7	33.3	4	26.7	–	–	–	–
Ectatomma sp.	8	13.3	–	–	–	–	–	–
Camponotus sp.	4	13.3	–	–	–	–	–	–
Eciton (Labidus) praedator[a]	–	–	–	–	1	6.7	–	–
Crematogaster quadriformis	–	–	–	–	2	6.7	4	40
Atta sp.[a]	–	–	–	–	2	6.7	–	–
Wasmannia sp.	–	–	–	–	–	–	52	60
Vespidae								
Polistes sp.	–	–	–	–	6	13.3	–	–
Dermaptera								
Doru lineare	6	6.7	–	–	–	–	–	–
Blattaria								
Blattidae								
Blatta orientalis	1	6.7	–	–	–	–	–	–
Crustacea								
Isopoda								
Armadillium vulgare[a]	149	66.6	17	20	–	–	1	6.7
Animal parts (n.i.)	x	20	x	40	x	46.6	x	33.3
Plant parts (n.i.)	x	26.6	x	13.3	x	26.7	x	6.7
Diversity	1.09		1.1		1.25		0.53	
Average prey size (mm)	20		13		13.5		7.5	
Gastrointestinal tracts analyzed	15		15		15		15	

N, total number of organisms in the digestive tracts; FO, frequency of occurrence (%); x, no numerical value; n.i., not identified; (–) absent.
[a] Herbivore species.

3. Results

A total of 15 anuran species belonging to three families (Bufonidae, Leptodactylidae, and Microhylidae) were observed (Table 1). Anuran diversities were significantly different between fields (Hutchenson, $t = 7.19$, $P < 0.001$). The Jaccard index similarity values of anuran species composition was low (0.40). No statistical difference was found among interior-edge transects and anuran diversity and richness (Córdoba $F = 0.60$, $P > 0.05$; Entre Ríos $F = 0.40$, $P > 0.05$).

Of the four habitat variables considered, only soybean crop height was positively associated with anuran diversity in both croplands (Córdoba $r_s = 0.61$, $P < 0.05$; Entre Ríos $r_s = 0.64$, $P < 0.05$). Soybean plant height was related to anuran evenness and richness in Córdoba ($r_s = 0.65$, $P < 0.05$; $r_s = 0.48$, $P < 0.05$, respectively). No relationship was found among diversity, evenness or anuran richness and air temperature, temperature under soybean plants, and weekly rainfall.

The diet composition found in anurans from Córdoba (*Bufo arenarum* and *Leptodactylus latinasus*) and Entre Ríos (*Leptodactylus chaquensis* and *Pysalaemus albonotatus*) soybean is shown in Table 2.

4. Discussion

Intensive cropping is less favorable to amphibians than forests (Ray et al., 2002). A large number of terrestrial (*B. arenarum*, *B. paracnemis, O. americanus, L. gracilis, P. tucumanum, C. cranwelli, E. bicolor, L. latinasus*, and *L. mystacinus*) and semi-aquatic-species (*L. ocellatus, L. chaquensis, P. albonotatus, P. biligonigerus, P. riograndensis*, and *P. falcipes*) were nevertheless recorded, suggesting that soybean was likely to maintain large anuran populations. This is particularly interesting because the main anuran breeding and feeding occurs during soybean cropping.

The high anuran diversity and richness in Entre Ríos may be explained by the proximity to protected forest (1 km), the distance to urban development (35 km) and the time since agricultural activity started in this field (2 years) compared to Córdoba. By contrast, the Córdoba soybean had a lower anura diversity, number of species and larger biomass probably due to the distance to protected forest (>100 km), vicinity of urban development (10 km), and presence of breeding ponds.

The present results provide the first data on anuran diet in agroecosystems of Argentina, with a view to understand their role in controlling pest insects (Premo and Atmowidjojo, 1987). Anurans may be beneficial because they feed on noxious arthropods (Okada, 1938) particularly on soybean (Brewer and Arguello, 1980; PIF, 1999; Morrone and Coscarón, 1998; Saini, 2001). *P. albonotatus* had the lowest prey diversity, *L. chaquensis* the highest whereas *B. arenarum* fed on 18 and *L. latinasus* on 11, *L. chaquensis* on 13 and *P. biligonigerus on* five herbivores of soybean. A wide range of insecticides is still used against soybean arthropods in Argentina, despite their negative effects on anurans (Izaguirre et al., 2000; Venturino et al., 2003; Lajmanovich et al., 2004), other animals and human health (Hin et al., 2001).

The number of individuals found in soybean and the variety of arthropods they consumed suggest that anuran populations could be important biological control factors of soybean arthropods. However, additional studies are necessary to validate this hypothesis, with a view to better use of insecticides and conserve anurans in these agroecosystems.

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