



The critically endangered Amphibians from the small Escudo de Veraguas Island Panama

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Abstract

Escudo de Veraguas, a small island in Western Panama, is home to the maritime worm salamander *Oedipina maritima* and the Costa Rica Stream-welling Frog *Craugastor ranoides*, both species are in continuing decline in the extent and quality of their habitat. During three monitoring surveys of the island, 50 plots were installed, 25 in forest and 25 in swamps. The population was estimated at 88 ind./ha for *O. maritima* and 59 ind./ha for *C. ranoides*. As a conservation measure, we recommend long-term monitoring to guarantee the survival of these Critically Endangered species.

Keywords

Climate change, *Craugastor ranoides*, habitat degradation, *Oedipina maritima*

Resumen

Escudo de Veraguas es una pequeña isla en el oeste de Panamá, hogar de la salamandra lombriz marítima *Oedipina maritima* y la rana de los arroyos *Craugastor ranoides*, ambas especies están en continuo declive en la extensión y calidad de su hábitat. Durante tres estudios de monitoreo en la isla, se instalaron 50 parcelas, 25 en hábitat forestal y 25 en pantanos. La población se estimó en 88 ind./ha para *O. maritima* y 59 ind./ha para *C. ranoides*. Como medida de conservación, recomendamos realizar estudios de seguimiento a largo plazo para garantizar la supervivencia de estas especies en Peligro Crítico.

Palabras clave

Cambio climático, *Craugastor ranoides*, degradación del hábitat, *Oedipina maritima*

Introduction

Despite its small size (4 km²) in Escudo de Veraguas, there are 13 species of amphibians (Batista, 2015, unpublished data). The isolation of this land mass, about 3.5-1.8 million years ago (Coates et al. 2005) has led to the speciation of some species that until now are known to be endemic to the island. This is the case of the maritime worm salamander (*Oedipina maritima*), a critically endangered (CR) species of which there is only one record and very little is known about its biology (García-París & Wake, 2000; Zumbado-Ulate et al. 2011; IUCN SSC Amphibian Specialist Group 2020b). The island is also home to the CR Costa Rica Stream-dwelling Frog (*Craugastor ranoides*), a species for which about 80 % of its populations have disappeared (IUCN SSC Amphibian Specialist Group, 2020), with only one stable population in the Guanacaste Conservation Area of Costa Rica (Zumbado-Ulate et al. 2011). Currently, these species are under continuing decline in the extent and quality of their habitat (IUCN SSC Amphibian Specialist Group 2020a, b). This work aimed to estimate the population status and conservation of the *O. maritima* and *C. ranoides* in Isla Escudo de Veraguas, Panama.

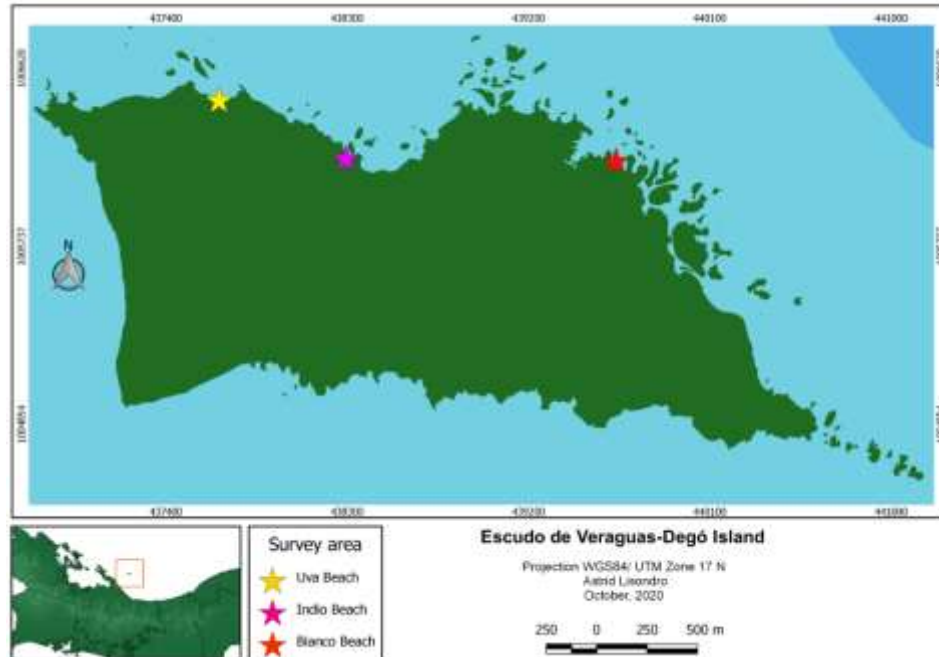


Figure 1.
Map of Escudo de Veraguas Island, showing the three surveyed areas.



Materials and Methods

Study site

Three surveys were conducted to Escudo de Veraguas Island (figure 1) Comarca Ngäbe Buglé, Panama (9.0984° N, 81.5564° W), on September, October 2019, and March 2020, visiting three different sites on each trip, to the beaches Uva, Indio and Bianco, at the North and Northeast part of the island, all with the same type of ecosystem, the lowland tropical forest (hereafter: forest; figure 2A) and the Freshwater swamp forest (hereafter: swamp, figure 2B). The sampling was carried out in two types of habitats: forest and swamp. The forest habitat is mainly composed of hilly areas, and large trees up to more than 20 m in height, from 100 to 200 m from the coastal zone. The swamp area consisted of flooded areas in contact with the coastal zone, mainly with the presence of ferns, mangroves and palm trees (*Cocos nucifera* and *Manicaria saccifera*).

Density and habitat occupancy

To evaluate the density of the species we set 50 plots of 8x8 m, located in each habitat, 25 in the swamp and 25 in the forest, each plot was revised once, by two to three persons walking in zigzag, turning logs, checking epiphytes and sites suitable to the presence of these animals (Heyer et al. 2001). The number of individuals and ecological data of the species was recorded. To estimate the relative density, the total of individuals found was divided by the total area among plots. We use the program PRESENCE 2.13.12 to estimate patch occupancy and the probability of detecting at least one individual in every plot on the three different surveys, using a single season occupancy model (Hines, 2006; MacKenzie et al. 2002).

Results and Discussion

Estimations of the populations showed a relative density of 88 ind./ha for *O. maritima* (figure 2C) and 59 ind./ha for *C. ranoides* (figure 2D). There were no differences in the number of individuals found in both habitats ($\chi^2=1.04$; $p>0.05$; table 1). The two types of habitat models, forest ($\psi(\text{forest.})$, $p(\cdot)$; 30%) and swamp ($\psi(\text{swamp})$, $p(\cdot)$, 35%) explain the 65% of the variation found in the habitat occupancy



analysis for *O. maritima* (table 2), while the individual detection model ($\psi(\cdot), p(\cdot)$; 42 %) with the swamp habitat model ($\psi(\text{swamp}), p(\cdot)$; 32%) explained the 74 % of the variation for the analysis for *C. ranoides* (table 3). The probabilities of occupancy for *O. maritima*, was 50% (SD: 0.0) in forest and 25% (SD: 0.17) in swamp. For *C. ranoides* the probabilities of occupancy, was 100% (SD: 0.0) in both types of habitats.

Table 1.
Detailed information of amphibians found on each type of habitat at Escudo de Veraguas Island, Comarca Ngäbe Bugé, Panama

Habitat	Trait	<i>Oedipina maritima</i>	<i>Craugastor ranoides</i>
Forest	Total indiv.	13	6
	plots with records	7	5
Swamp	Total indiv.	15	13
	plots with records	3	6
Overall	Total indiv.	28	19
	plots with records	10	11

Before this study, the *Oedipina maritima* was known from only eight adult specimens and two clutches of eggs, used for the description of the species (García-París & Wake 2000). We have been able to observe 28 individuals and seems that it could prefer a certain type of microhabitat. In a single plot, we found 13 individuals in the swamp habitat, close to the coastal line, in coconut palm grove and decomposing palm leaves. We also have found a concentration of specimens around coconut palm grove, in a more recent expedition (in August 2021) we found five individuals during a 10 minutes search in about 1 m².



Figure 2.

Surveyed habitat and the critically endangered species from Escudo de Veraguas Island. A) Forest; B) swamp; C) Maritime Worm Salamander (*Oedipina marítima*); D) Costa Rica Stream dwelling Frog (*Craugastor ranoides*).

Table 2.

Occupancy modeling for Maritime Worm Salamander (*Oedipina marítima*) in Escudo de Veraguas Island

Model	AIC	deltaAIC	AIC		
			C	wgtMode	Likelihood
			l	d	no.Par.
psi(.),p(.)	56.69	0.00	0.4212	1.0000	2
psi(swamp.),p(.)	57.23	0.54	0.3215	0.7634	2
psi(forest+swamp.),p(.)	58.40	1.71	0.1791	0.4253	3
psi(forest.),p(.)	60.06	3.37	0.0781	0.1854	2



Table 3.

Occupancy modeling for Costa Rica stream-dwelling frog (*Craugastor ranoides*) in Escudo de Veraguas Island

Model	AIC	deltaAIC	AIC		
			wgtMode	Likelihood	no.Par.
psi(swamp),p(.)	50.12	0.00	0.3474	1.0000	2
psi(forest.),p(.)	50.37	0.25	0.3066	0.8825	2
psi(forest+swamp),p(.)	51.46	1.34	0.1778	0.5117	3
psi(.),p(.)	51.57	1.45	0.1683	0.4843	2

Although *Craugastor ranoides* have been usually found along fast-flowing streams and usually sit on boulders (Zumbado-Ulate et al. 2011; Puschendorf et al. 2019), in Escudo de Veraguas Island, there are no fast-flowing streams, neither rocks, instead slow flowing streams or merely stagnant water areas. The frog was found also far from any water source in the forest plots. Although *C. ranoides* is a stream dwelling species, it has been reported also far from streams during rainy season (Zumbado-Ulate et al. 2011). However, the climate around the Escudo de Veraguas island is more humid than the North Pacific side of Costa Rica, without a marked season throughout the year. The habitat occupation was similar for both types of habitats during all the survey.

Very few populations of *C. ranoides* appears to be stable (Puschendorf et al. 2019) and it has declined in mostly all areas of its distribution, with last known records for populations at Península de Santa Elena, Costa Rica and Escudo de Veraguas Island in Panama (this study). Seems that these two populations could be refuges for the species. However, there is a need to corroborate its identity through molecular genetic analysis. Given that a genetic variation and haplotype differentiation, have been found within populations in Santa Elena region. There is evidence of a close phylogenetic relationship with the related species *C. evanesco* of the *C. punctariolus* species group from Panama, with samples of the Cerro Cacao (cloud forest), near to the Santa Elena dry forest (Puschendorf et al. 2019). Then, the inclusion of any other population of *C. ranoides* from the rest of its distribution in molecular analysis is determinant to establish effective conservation actions.

State of conservation

Unfortunately, one of the habitats with presence of both species is located, the swamp, is right in the transition between the flooded area and the beach, which is also the site of greatest public use on the



island. This area is used also by local fishermen who stay temporarily on the island (usually between August to October), they cut the leaves of the palms and trees for the construction of ranches, the excessive cutting of these leaves and trees every year, could significantly increase the entry of sunlight and have consequences in the biology and distribution of these amphibians.

There are urgent measures that must be taken to guarantee the conservation of the species that inhabit the island. In the first place, make an exhaustive and detailed evaluation of the diversity present in the area, also it is a priority to carry out molecular genetic studies to determine the relationship between the island species with those on the mainland. Because many amphibians have accelerated evolutionary rates, some of the already identified species may have unique genetic characteristics, which could lead to the recognition of new species for science. As a conservation measure, it is suggested to allocate the areas with the highest density of species, to areas with restricted access and thus guarantee the survival in the long term for these Critically Endangered species.

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