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Life-table analysis of *Dendrobates auratus* (Anura: Dendrobatidae) in two isolated populations from Costa Rica

Análisis de tablas de vida de dos poblaciones aisladas de *Dendrobates auratus* (Anura: Dendrobatidae) en Costa Rica

José F. González-Maya, MSc[1,2,3*], Marianela Calvo, BSc[2], Marco Aguilar, BSc[2], Iván Cruz-Lizano, BSc[1], Armando H. Escobedo-Galván, PhD(c)[1,3]

Abstract

Life-tables are important tools for population knowledge and conservation. This study analyzes life-tables for two isolated populations of *Dendrobates auratus* from Costa Rica. A direct visual survey with direct capture was completed at La Suerte Biological Station in a secondary Humid Tropical Forest on the Caribbean coast and Playa Hermosa Wildlife Refuge, a primary Very Humid Tropical Forest on the Pacific coast. A size-based classification was made based upon natural history information for the species. Static life-tables were built and statistical comparisons were made to analyze trends in life expectancy and mortality. The results showed some differences in survival, life-expectancy, and mortality rates; however, the overall population characteristics were fairly similar. Threats on their habitat and populations and isolation do not seem to have significant impacts on the life history of these populations.

Keywords: Life table; Populations; Mortality; Life expectancy; Survival.

Resumen

Las tablas de vida son herramientas importantes para el conocimiento y conservación de poblaciones silvestres. El presente estudio analizó las tablas de vida de dos poblaciones aisladas de *Dendrobates auratus* en Costa Rica. Se realizó una evaluación visual directa con captura en la Estación Biológica La Suerte en un bosque húmedo tropical de la costa Caribe y en el Refugio de Vida Silvestre Playa Hermosa, un bosque muy húmedo tropical en la costa pacífica. Se realizó una clasificación basada en tamaños a partir de información de historia natural. Se construyeron tablas de vida estáticas y se realizaron comparaciones estadísticas entre tendencias como mortalidad y esperanza de vida. Los resultados mostraron algunas diferencias entre las tasas de sobrevivencia, esperanza de vida y mortalidad; sin embargo, las características de las poblaciones en general fueron bastante similares. El asilamiento y la presión sobre sus hábitats y poblaciones no parecen tener impactos significativos sobre las historias de vida de estas poblaciones.

Palabras clave: Tabla de vida; Poblaciones; Mortalidad; Esperanza de vida; Sobrevivencia.

Introduction

Dendrobatidae is a representative family from the tropics, represented in Costa Rica by eight species in five genera: *Dendrobates, Oophaga* (Solis *et al.* 2008a, b, c), *Allobates* (Coloma *et al*. 2008), *Silverstoneia* (Solis *et al.* 2008d, Bolaños *et al.* 2008) and *Phyllobates* (Savage 2002). *Dendrobates auratus* (Girard 1855) is distributed in tropical rainforests along the Caribbean and south Pacific coasts of Costa

[1] Proyecto de Conservación de Aguas y Tierras – ProCAT Internacional & Sierra to Sea Institute, Las Alturas, Coto Brus, Puntarenas, Costa Rica & Frederick, Maryland, USA. e-mail: jfgonzalezmaya@gmail.com icruz@procat-conservation.org

[2] Universidad Latina de Costa Rica, Escuela de Ciencias Biológicas, San Pedro, Costa Rica. e-mail: nela99@gmail.com marcoaguilarh@gmail.com

[3] Instituto de Biología e Instituto de Ecología, Universidad Nacional Autónoma de México, México DF, México. e-mail: elchorvis@gmail.com

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Rica ranging from 0 to 800 masl. *D. auratus* is the biggest poison dart/arrow frog in Costa Rica with an average size of 30-39 mm (Savage 2002), and it has a high variability in colors and patterns (Figure 1) (Heselhaus 1992). The populations of the species in Costa Rica have been historically isolated by the Talamanca mountain range (Savage 2002).

Information about mortality, survivorship and population life history is important part of understanding the natural history of a species and is useful for conservation (Meffe and Carroll 1994). However, there is little information on life-tables of tropical amphibians; therefore, this information can inform conservation planning for at risk species such as amphibians in tropical ecosystems. The main objective of this study is to analyze the static life-tables of *D. auratus* in two isolated populations, with highly differentiated morphologies, in Costa Rica.

Methods

Study area. This study was carried out in two isolated populations from the Caribbean and Pacific slopes of Costa Rica (Figure 2). The Caribbean population was sampled at La Suerte Biological Station (LSBS; 10°26'30" N, 83°46'15" W), located in northwestern Costa Rica, comprises a tropical secondary rainforest in the humid tropical forest life zone (Holdridge 1977), with a mean annual precipitation of 3000 mm and a mean annual temperature of 25ºC. The Pacific population was sampled at Playa Hermosa Wildlife Reserve (PHWR, 9°11'45.15" N and 83°47'05.81" W), located in central Pacific lowlands of the country, comprises a tropical primary rainforest in the very humid tropical forest life zone (Holdridge 1977) with a mean precipitation of 4000 mm and a mean annual temperature of 29ºC. These populations are considered under severe threat, both inside and outside of the reserves, from habitat conversion, illegal collection for the pet trade, and pollution. However, PHWR potentially has a lower level of disturbance, and the threats and disturbance patterns are different. LSBS is heavily affected by chemical pollution from banana plantations and extensive mono-culture agriculture. There is a possibility of gene flow between populations on the Pacific and Caribbean sides, but there is no evidence of contact across the Talamanca or central volcanic ranges of Costa Rica.

Figure 1. Individuals of *D. auratus* from the two populations under study in the Caribbean (right) and Pacific (left) slopes of Costa Rica (Credits: Joseph Vargas- Senckenberg Forschungsinstitut und Naturmuseum).

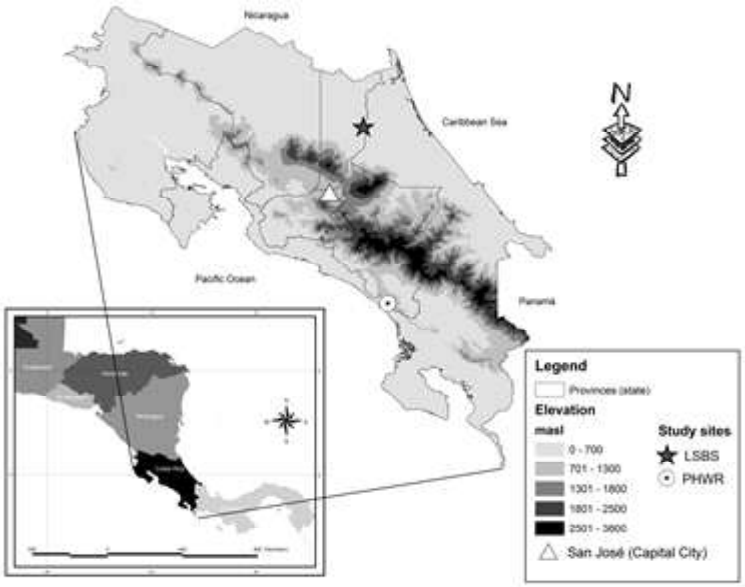

Figure 2. Study sites for *D. auratus* life tables analyses of two populations in Costa Rica (LSBS: La Suerte Biological Station; PHWR: Playa Hermosa Wildlife Refuge).

Methodology

In both study areas, site was stratified by habitat type, and transects were selected randomly and sampled with visual encounter surveys and direct catch (Crump and Scott 1994). Five people performed daily surveys in two hour periods from sunset until dawn (Jaeger 1994).

All the individuals were then measured with standard calipers from snout to the apical bone (Norman 1998), they were classified by sex and age (based on size), and static life-tables were calculated for each population (Krebs 1985). A t-student test was applied to evaluate differences between life-expectancies and mortality rate. Pearson coefficients were used to evaluate the relationship between life-table variables.

Individuals were classified by age from the second to the eighth year according to literature reports of maximum and minimum sizes for the species and juvenile growth and timing (Savage 2002). There is little information on the conservation status of these populations; however, they are likely declining as a result of the multiple threats listed earlier. Therefore, it was decided to use non-lethal methods to measure age based on information available in the literature. While not as rigorous as measuring bones, this method has a low error rate and provides the necessary information without placing additional stress on the population.

Results

A total of 75 individuals were captured and measured, 44 from the Caribbean population (Table 1) and 31 from the Pacific (Table 2). There were significant differences among life-tables between males and females for both populations, mainly for life expectancies and mortality rates (Figure 3). Females from both populations showed a higher life expectancy than males ($p<0.01$), while mortality rates were not significantly different between sexes and populations ($p<0.01$).

The overall population comparison did not show significant differences in mortality rates and life

Table 1. Individuals of *D. auratus* collected in La Suerte Biological Station (LSBS) ordered by age-sex class

Age group	Females		Males		Total population	
Year	Classes	Frequency	Classes	Frequency	Classes	Frequency
2	15.9-18.9	1	16.7-19.8	2	15.9-19.1	3
3	19.0-22.0	0	19.9-23.0	0	19.2-22.4	0
4	22.1-25.1	2	23.1-26.2	2	22.5-25.7	5
5	25.2-28.2	5	26.3-29.4	1	25.8-29.0	4
6	28.3-31.3	0	29.5-32.6	4	29.1-32.4	5
7	31.4-34.4	5	32.7-35.8	6	32.5-35.7	16
8	34.5-37.5	12	35.9-39.0	4	35.8-39.0	11
Total		**25**		**19**		**44**

Table 2. Individuals of *D. auratus* collected in Playa Hermosa Wildlife Reserve (PHWR) ordered by age-size classes

Age group	Females		Males		Total population	
Year	Classes	Frequency	Classes	Frequency	Classes	Frequency
2	27.0-28.4	2	16.3-19.5	2	16.3-19.5	2
3	28.5-29.9	0	19.6-22.8	0	19.6-22.8	0
4	30.0-31.4	0	22.9-26.1	3	22.9-26.1	3
5	31.5-32.9	3	26.2-29.4	1	26.2-29.4	3
6	33.0-34.4	3	29.5-32.7	1	29.5-32.8	3
7	34.5-35.9	3	32.8-36.0	6	32.9-36.1	13
8	36.0-37.4	2	36.1-39.3	5	36.2-39.4	7
Total		**13**		**18**		**31**

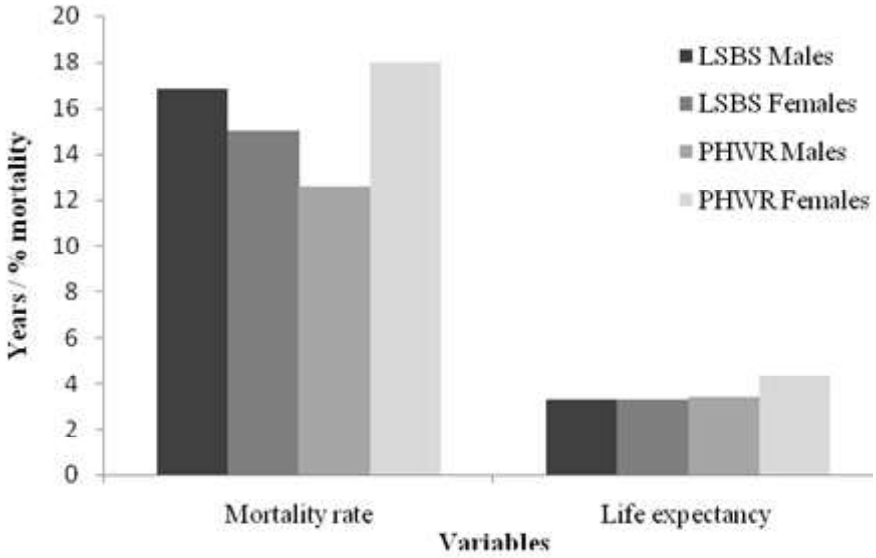

Figure 3. Life expectancy and mortality rates for males and females of *D. auratus* in LSBS and PHWR populations in Costa Rica (LSBS: La Suerte Biological Station; PHWR: Playa Hermosa Wildlife Reserve).

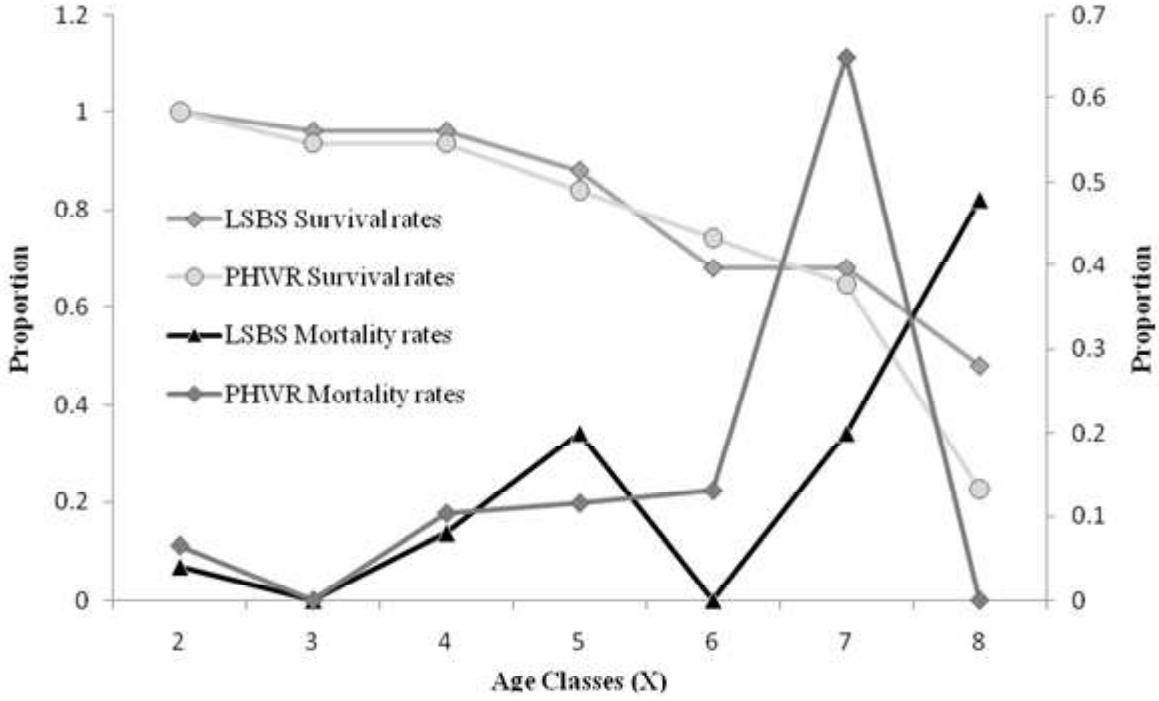

Figure 4. Survival and Mortality rates across the age ranges (X) in both populations of *D. auratus* in two populations in Costa Rica (LSBS: La Suerte Biological Station; PHWR: Playa Hermosa Wildlife Reserve).

expectancies between populations (p=0.72, p=0.96). However, for LSBS there was a significant negative correlation between mortality and survival rates (r=-0.73), where both populations showed the typical mortality/survival trends (Figure 4).

Discussion

The results did not indicate marked differences between the two populations, but there are slight differences, probably related to habitat conditions. Both followed the typical survival rate declines, where LSBS had relatively higher survival rates and longer life expectancies.

Females showed higher life expectancies than males in both populations which are common for polygynous species like this one, but the variation was smaller for PHWR (Silverstone 1975). All of these characteristics have an important impact on rates of reproduction because female amphibians are reproductive until they die (Schad 2008). Also, the differential number of individuals per age has important impacts on population growth, especially when the species have been probed to have low growth rates because the costs of parental care, furthermore, where females have higher reproductive rates but these are not entirely successful as population growth promoters in polygynous species are not enough to provide successful care to the entire pool of tadpoles (Summers 1990).

The mortality rates were higher in the fifth and seventh year (0.23 and 0.29, respectively) for the LSBS population and in the sixth and seventh year (0.13 and 0.65, respectively) for the PHWR population, where this difference is usually related with resource availability and stochastic events mainly for PHWR population.

Many factors can be related with those differences, these are generally related with density-dependence factors, where competence for resources can have a direct influence on mortality and survival rates, which can explain the behavior of the PHWR population (Clarke 1987). Also, previous studies on the species have shown that increase in density affects negatively growth rate and survivorship (Summers 1990) as results indicate.

Isolation, disturbance, pollution, and differing pressures on these populations in Costa Rica do not seem to represent an important influence on their life histories. Even with the long term isolation separating these populations, according to this study their life history characteristics remain quite similar and reflect an ability to adapt to different pressures, a critical characteristic for their long term persistence, and a factor to consider in conservation planning. Furthermore, it is important to consider habitat fragmentation as a major threat to both populations within both Pacific and Caribbean populations could severely affect the long term viability and persistence of the populations. The lack of published data on life history tables for the Dendrobatidae is a problematic gap for conservation efforts particularly given their popularity in the pet trade, and this study provides only a first look at this important information.

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