

**COLLABORATION FOR ENVIRONMENTAL EVIDENCE**

**SYSTEMATIC REVIEW No. 58**

**WORKING TITLE: EFFECTIVENESS OF THE RELEASE OF INDIVIDUALS  
REARED IN CAPTIVITY AS A TOOL TO RESTORE CROCODILE POPULATIONS  
(ORDER CROCODYLIA, GENUS *CROCODYLUS*) IN THE NEOTROPICS**

**REVIEW PROTOCOL**

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## COVER SHEET

Title	<b>Working title: Effectiveness of the release of individuals reared in captivity as a tool to restore Crocodile populations (Order Crocodylia, Genus <i>Crocodylus</i>) in the Neotropics</b>
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## 1. BACKGROUND

In the Neotropics there are four crocodile species (Order Crocodylia, Genus *Crocodylus*): the American crocodile, *Crocodylus acutus*, that has a distribution that encompasses most countries of the Caribbean as well as the South of the United States; the Morelet's crocodile (*C. moreletii*) which is found in Belize, Guatemala and Mexico; the Cuban crocodile (*C. rhombifer*) is endemic to a restricted area of Cuba, and the Orinoco crocodile (*Crocodylus intermedius*) which inhabits the Orinoco Basin in Colombia and Venezuela. In the last century, the populations of these species were exploited for commercial reasons. Today they are however included in the Appendix I of CITES so that they may be protected from international trade (Ross 1998). Moreover, they appear in the IUCN Red List as "Critically endangered" as is the case for *C. intermedius* and "insufficiently known" for *C. moreletii*. ([www.iucnredlist.org](http://www.iucnredlist.org)).

A strategy that has been widely used to restore or reinforce crocodilian populations is captive breeding or rearing in order to produce individuals to be released in their natural habitats (Hussain 1998, Chabreck and Wright 2002, Jayson et al. 2006, among many others). This strategy has been used in Latin-American countries, sometimes as part of ranching programs with commercial purposes with Alligatorids (Seijas et al. 2003, Larriera et al. 2008).

Rearing in captivity for conservation purposes has also been carried out in the region with the more threatened species of the genus *Crocodylus* (Arteaga y Herrera 1997, Sigler 2002, Seijas 2003, Hernández 2007) even though this strategy has not been considered to be a priority. In the Status Survey and Conservation Action Plan of the Crocodile Specialist Group (IUCN/SSC) highest conservation priority is given to projects related to the monitoring status and distribution of the species in the different countries (Ross 1998). In situations where this conservation strategy has been implemented, few studies seem to have documented its success. Muñoz and Thorbjarnarson (2000) monitored the survival of individuals through the use of radio-transistors. This study is however an exception. In most of the cases, studies rely on post-release night counts of different durations, and on the occasional recaptures of a few individuals. This provides information on the movement of individuals from the release site and on their growth patterns in their natural habitat.

Restoring a population from a just a few individuals that have been bred in captivity can be a costly as well as ineffective (Griffiths et al. 1989, Dodd & Siegel 1991), for its assessment can encompass unnecessary costs and efforts. A systematic review of reinforcement efforts of crocodile populations in the Neotropics will determine which of the methods have worked in the past, and which factors have prevented the projects from attaining a positive result.

## **2. OBJECTIVE OF THE REVIEW**

To determine the extent to which the release of individuals reared in captivity has contributed to the restoration of crocodile (Genus *Crocodylus*) populations in the Neotropics.

### **2.1. Primary question**

Are captive rearing and release programs of crocodiles (*Crocodylus* spp) effective at restoring populations in their natural habitat?

### **2.2. Secondary question**

What factors (ecological, anthropogenic, conservation and others) influence the success of crocodile (*Crocodylus* spp) reintroductions in the Neotropics?

## **3. METHODS**

### **3.1. Search strategy**

#### ***3.1.1. Specialised data bases***

Information reports of the meetings held by the IUCN's Crocodile specialist group (Proceedings of the working meetings of the crocodile specialist Group, Species Survival Commission, CSG/SSC). Another specialised source is the Newsletter of the above group.

#### ***3.1.2. Data bases of general scientific literature***

The following data bases and catalogues will be revised.

General sources:

- ScienceDirect ([www.sciencedirect.com](http://www.sciencedirect.com))
- Science.gov ([www.science.gov](http://www.science.gov))
- Copac
- Grey literature database BIODOC ([www.una.ac.cr/biodoc.gris.html](http://www.una.ac.cr/biodoc.gris.html)).

Specialised sources:

- Crocilian Internet Resources ([www.flmnh.ufl.edu/cnhc/cir.html](http://www.flmnh.ufl.edu/cnhc/cir.html))
- Conservation Breeding Specialist Group ([www.cbsg.org/cbsg/](http://www.cbsg.org/cbsg/))
- Herpllit database ([www.herpllit.com](http://www.herpllit.com))

The Internet search will be performed using the following search engines:

- Google Académico ([www.scholar.google.com](http://www.scholar.google.com))
- Google ([www.google.com](http://www.google.com))
- Intute ([www.intute.ac.uk](http://www.intute.ac.uk))

- FAO Library databases (www.fao.org)

The first 50 documents found will be revised and from each of the searches we will determine which contain information that is relevant to the study.

Search terms:

The following keywords, in Spanish and in English will be used in the searches (Table 1).

**Table 1.** Terms in English and Spanish

English	Spanish
Reintroduction, re-introduction	Reintroducción
Reinforcement	Reforzamiento
Release	Liberación
Captive rearing	Cría en cautiverio
Repatriation	Repatriación
Orinoco crocodile	Caimán del Orinoco
	Cocodrilo del Orinoco
American crocodile	Caimán de la costa
	Caimán de aguja
	Caimán agujero
	Cocodrilo de río
Morelet's crocodile	Cocodrilo de pantano
Cuban crocodile	Cocodrilo cubano
<i>Crocodylus acutus</i>	<i>Crocodylus acutus</i>
<i>C. acutus</i>	<i>C. acutus</i>
<i>Crocodylus intermedius</i>	<i>Crocodylus intermedius</i>
<i>C. intermedius</i>	<i>C. intermedius</i>
<i>Crocodylus rhombifer</i>	<i>Crocodylus rhombifer</i>
<i>C. rhombifer</i>	<i>C. rhombifer</i>
<i>Crocodylus moreletii</i>	<i>Crocodylus moreletii</i>
<i>C. moreletii</i>	<i>C. moreletii</i>

During the searching process the words indicating the intervention will be combined with the common and scientific names of the species, one species at a time.

### 3.1.3. Specialised journals

Journals that frequently publish articles on crocodile conservation (*Conservation Biology*, *Biological Conservation*, *Oryx*, *Herpetologica*, *Journal of Herpetology*, *Copeia*), as well as journals of the region (*Vida Silvestre Neotropical*, *Caribbean Journal of Science*) will be revised/reviewed in detail. The review of the cited bibliography will enable the finding of articles not previously found in prior searches.

### 3.1.4. Consulting with researchers and research institutions

The following groups will be consulted: Venezuelan Crocodile Specialist Group (Grupo de Especialistas en Cocodrilos de Venezuela - GECV), Comité de Manejo de los crocodilianos de México (COMACROM), la Asociación Mesoamericana de Investigadores de los Cocodrilos (AMICRA), Crocodile Specialist Group (CSG/SSC), the Captive Breeding Specialist Group of the IUCN and the Estación de

Biología Tropical Roberto Franco, in Colombia. Other crocodylian expert and scientist working in the region will be consulted.

### 3.2. Study inclusion criteria

1. **Relevant subject:** Species of the genus *Crocodylus* of the Neotropics.
2. **Types of intervention:** (Table 2).

**Table 2.** Types of intervention to be included in the systematic review

<b>Intervention type</b>	<b>Definition</b>
Captive rearing	The process of maintaining young individuals (generally hatchlings) in a human controlled environment until they attain a specific size, age and/or physical conditions so that they may be released in the wild with a higher survival probability.
Re-introduction	An attempt to establish a species in an area which was once part of its historical range, but from which it has been extirpated or become extinct.
Population re-inforcement	The addition of individuals to an existing population of conspecifics.
Repatriation	Returned to the site of origin. When referred to a species is often used as a synonymous of reintroduction.

3. **Types of comparator:** Natural populations that are not subject to any type of management.
4. **Types of outcome:** Population trends, growth and survival rates, age at which individuals reproduce and reproductive success of released and wild individuals.
5. **Types of study:** All those studies that convey information on the number, dates and areas where individuals were released as well as their survival, growth and reproduction rates
6. **Potential reasons for heterogeneity:** The success or failure of the liberations may be dependent on a number of variables as are the ones mentioned in Table 3.

**Table 3.** Factors that may cause heterogeneity or biases that may make the comparison of results difficult

<b>Factors/variables</b>	<b>Values to assess</b>
<b>Related to the released individuals</b>	
Size (Overall length)	Proportion of released individuals in size categories. Survival probability according to size.
Physical Condition	Survival probability according to the relative amount of body fat at the time of release.
Sex	Sexual ratio and the moment of release vs sexual ratio of survivors
Age	Survival probability according to age
<b>Related to the release site</b>	
Local human population	Density, cultural factors/aspects, socio-economic aspects/factors. Accessibility
Area extent or length (of rivers)	Surface (ha), length (km)
Protection status	Status legal, guardería,
Human pressure	Hunting, collection of eggs and young, death in fishing nets

<b>Ecological</b>	
Habitat quality	Productivity indicators, nesting habitat
Competitor and predator abundance	Density of spectacled caiman ( <i>Caiman crocodilus</i> ) and piranhas ( <i>Pygocentrus cariba</i> )
<b>Release events</b>	
Nro. released individuals	Number and characteristics (size, age, gender) of individuals
Nro. release events	Number of times released
Release date	Time of year of release event

With the objective of filtering the most relevant studies, we will use the following inclusion criteria in three phases

1. Title and keywords: only those studies whose title and keywords are associated to the objective of this review will be included
2. Abstract: All the abstracts from the selected studies will be revised and only those satisfying the review criteria will be considered.
3. 3. Entire manuscript: All the studies selected above will be read in full to determine which are suitable for data extraction.

### **3.3. Study quality assessment**

The studies will be assessed according to the following extracted information: place, date and number of released individuals, individual characteristics (size, sex and physical condition), assessment of the population status before and after treatment, survival rates and reproductive performance of the released individuals.

During the data extraction, the following data must be recorded: study type (experimental, theoretical), locality, date, sources of heterogeneity, study quality categories and others.

To evaluate the quality of the studies, we will carry out the extraction of the data. It will be necessary to compile information on the possible sources of bias and the methods that the researchers have used to mitigate them. In this way we will consider the following sources of experimental error and bias:

- In the procedures, and methods used to mitigate any of these biases
- In the detection of the object of study and methods used to mitigate these
- Of omission and methods to mitigate these
- In the scale of the procedure and in the scale of the analysis
- In the use of comparators
- In the decision of which statistical analyses need to be used
- In the probability of making Type II errors (statistical power)

### **3.4. Data extraction strategy**

All of the selected studies will be analysed, and the information will be extracted and organised in spreadsheets. The type of data to be extracted may be found in Table 4.

**Table 4.** Data will be extracted from each of the selected studies

<b>Data</b>	<b>Information to be extracted</b>
Type of study	Theses, technical reports, articles in refereed journals
Species	Crocodile species on which the study was carried out
Dates of study	Year and time of year in which liberation and assessment activities of the managed population were carried out. Time passed between liberation and evaluation activities.
Release events	Number of release events that have been carried out
Number and characteristics of released individuals	Sizes and weights (Maximum, minimum and average). Sex.
Characteristics of release site	Extension, habitat quality. Predators, competitors
Human presence	Human population density. Hunting pressure. Negative interactions with humans. Protection level.

Once the selected studies have been analysed, the above list may be extended or modified.

During the data extraction, the following data must be recorded: study type (experimental, theoretical), locality, date, level of the researchers, sources of heterogeneity, study quality categories and others.

### **3.5. Data synthesis**

The analyses and synthesis methods of the extracted data will vary according to the type of data that is extracted from the studies included in the review. From a general point of view, summary tables will be created to compile the information on the authors, organisation, year and area of study, bibliographical sources and others.

For each of the analysed studies, summary tables or cards where the most important extracted information will be inserted: characteristics and quality of the study, sources of heterogeneity, most important results (qualitative and quantitative) and others. These summary tables will include a narrative synthesis that describes the study.

If important and sufficient data are extracted, quantitative analyses will be carried out as far as possible: semi-quantitative syntheses, secondary analyses or meta-analyses. The statistical treatments that will be used to analyse the data will vary according to the type and amount of data. All of the quantitative data will be summarised in tables, so that they may be compared and analysed in an orderly fashion

## **4. POTENTIAL CONFLICTS OF INTEREST AND SOURCES OF SUPPORT**

No conflicts of interest declared. This systematic review was financed by PROVITA-ConocoPhillips.

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