PROPOSED RESEARCH OUTLINE

Title: Reproductive biology and social behavior of Caiman crocodilus crocodilus in a wet/dry season climatic régime in the llanos of Venezuela.

Investigator: Scott Jay Maness

Institution: National Zoological Park, Smithsonian, Washington, D.C. 20009. University of Kansas, department of systematics and ecology, Lawrence, Kansas, 66045.

Location of Study: Venezuela; field studies at Hato El Frio, state of Apure and the Centro Nacional de Investigaciones de Fauna Silvestre, state of Aragua.

Duration of Study: January 1978 - January 1979.

Introduction:

- General geographic conditions.
- General characteristics of crocodilian biology.
- Brief review of Caiman fossil history in S. America.
- Distribution of Caiman in Venezuela.

Nature of the Problem:

- Reproductive biology.
  Key areas of investigation:
  Courtship and copulation
  Nest construction
  Eggs
  Incubation
  Behavior of female at nest site
  Hatchlings
  Nesting success
  Comparison of "open savanna" and "mata" nest types

- Social behavior.
  Key areas of investigation:
  Territoriality and related activities
  Differences in activity cycles
  Feeding strategies

Preliminary Progress:

- Peace Corps job description.
- Three years practical field experience.
- Familiarity of study area.
- National Zoological Park, Smithsonian project on basking behavior.
- 100 marked yearling caimans.
- 50 marked juvenile caimans.
- Preliminary nesting data.
- Preliminary observations on social behavior.
- Detailed review of the literature.

PROPOSED RESEARCH OUTLINE

Proposed Investigation:

- To describe and characterize reproductive behavior and nesting ecology of Caiman in the llanos of Venezuela.

Courtship and copulation:
- Characterize behavior

Nest construction:
- Habitat preference
- Location from water
- Structure and materials
- Behavior of female
- Egg deposition
- Relation between size of female and clutch size

Eggs:
- Description
- Variability
  - weight
  - diameter
  - length
  - fertility

Incubation:
- Duration
- Temperature and humidity
  - ambient
  - nest chamber
- Embryo mortality

Behavior of female at nest site:
- Guarding behavior
- Duration of attendance
- Behavior at hatching time

Hatchlings:
- Description
- Variability
  - weight
  - length
- Parental care
- Formation and behavior of "pods"
- Duration of parent "pod" relationship
- Duration of "pod" relationship
- Introduction of hatchlings from mixed nests
- Dispersal of young
- Predation by vertebrates

Nesting success:
- Egg mortality
  - non-predatory
    - fertility
    - egg breakage
    - flooding
  - predation
    - aves
    - reptiles
    - mammals

Comparison of "open savanna" and "mata" type nests:
- Comparative nesting ecology

PROPOSED RESEARCH OUTLINE

Proposed Investigation:

- To describe and characterize in detail the social behavior of Caiman.

Territoriality:
- Define in Caiman
- Agressive interactions
- Postures
- Vocalizations

Differences in activity cycles:
- Diurnal
  - basking
  - social interactions
- Nocturnal

Seasonal migrations
- changes in population density

Feeding strategies
- hunting behavior
- frequency
- easonal composition of diet
- gastroliths
- parasites
  - endo-
  - ecto-

Resources Available:

- Centro Nacional de Investigaciones de Fauna Silvestre, El Limón: a former fish hatchery with large cement holding tanks, several of which have been converted to accomodate Caiman. Area will be used to carry out certain aspects of the study, particularly captive rearing and breeding, artificial nesting and thermoregulation.

- Hato El Frio, state of Apure: a large cattle ranch in the llanos that has protected its fauna for over twenty years. One of the few remaining places left in Venezuela where one can see most of the native llanos animals. Large, healthy Caiman population. Full cooporation of the owners. Area of 70,000 hectares.

- National Zoological Park, Smithsonian, Washington, D.C.: full cooporation, interest, support, equipment and financial backing for a years field work.

- Ministerio de Agricultura y Cria, Oficina Nacional de Fauna Silvestre, Caracas: cooporation in terms of collecting permits and use of the El Limón facility.

D. The Role of Annual Flooding in the Distribution of Turtles and Caimans in the Llanos: D. L. Marcellini

Introduction

In the FY 1975 report of the Smithsonian Venezuela Research Project, a commitment was made to the study of reptiles as a part of the project's broad ecological studies. This is a report of the reptile research done during FY 1976. It includes a summary of the year's research activities, a brief report on some of the results obtained, some speculations concerning future research and a budget request for the next fiscal year.

Summary of Research Activities

Research efforts were concentrated on the population ecology and behavior of the caiman (Caiman crocodilus) and the South American pond turtle (Podocnemis vogli). These reptiles occur in large numbers in ponds in the inland plains of Venezuela (llanos). Three investigators were involved in the work. Dr. Dale Marcellini, herpetologist with the project, spent approximately $2\frac{1}{2}$ months in the field. Mr. Jeff Wyles, field assistant, participated in the project for over 3 months. Mr. Scott J. Maness, field assistant, worked for over one month.

The study was initiated on Fundo Pecuario Masaguaral owned by Mr. Tomas Blohm, near Calabozo, Venezuela, in early September 1975. Four ponds were chosen for study sites. These ponds were mapped, depth profiles were made and water chemistry tested. A capture-mark-and-recapture program was begun on the turtles, and caiman were counted and observed. Work continued at Masaguaral for about three months.

The investigation began again at Masaguaral in February 1976. The four ponds were re-mapped and water chemistry again tested. Turtles and caiman were censused in an effort to determine their diel activity and basking cycles. A month later the study moved to Rancho El Frio (owned by the Maldonado family) near Apure, Venezuela. There additional censuses were taken for caiman and turtles. One pond was mapped, water chemistry tested, and depths taken. The investigation at El Frio was terminated on March 3, 1976.

Work began again on April 1, 1976, at Masaguaral. Diel censuses of turtles and caiman were made and pond data obtained for the four study ponds. In mid-April the study again moved to Rancho El Frio where additional censusing was performed.

The above schedual allowed the investigators to work both during the wet season (May-October) and during the dry season (November-April). Working at two study sites resulted in an increase in the types of ponds censused and in greater variety in reptile population densities.

Results

Study Ponds.--The llanos of Venezuela is a broad flat plain and, during the rainy season, much of it is under water. The water is shallow and quickly dries up, except in depressions where it remains for varying lengths of time. Deep depressions result in ponds which never dry up, very shallow ones produce ponds that dry up each year, other ponds in depressions may or may not dry up, depending on the amount of annual

rainfall. The study ponds were chosen because they included examples of all the pond types mentioned above and had turtles and caiman in them. Pond 1 dries out yearly, pond 2 dries up in low rainfall years, ponds 3, 4, and Manurito are permanent. Dimensions for the five study ponds are shown in Table 1.

Density and Biomass.--The numbers of caiman and turtles in a pond varied with the season and with pond type. Table 2 shows counts of caiman and turtles for the five study ponds in the wet and dry seasons. Temporary ponds have smaller populations of reptiles than do permanent ponds. Turtles will frequent temporary ponds and then apparently move to other ponds as the dry season progresses. Both caiman and turtles move out into the flooded llanos during the wet season and then back to the ponds during the dry season. This is shown by the significantly lower pond counts in the wet season (Table 2). The drying of the temporary ponds combined with movement to ponds from the drying plains results in large concentrations of caiman and turtles. At the height of the dry season, estimates of density and biomass were made for three of the study ponds (Table 3). The density of turtles varied from .003 to .540 individuals per cubic meter, while caiman ranged from .007 to .330 individuals per cubic meter. Biomass estimates were made using conservative weight figures of 1.5 kg for turtles and 15 kg for caiman. Biomass for turtles ranged from .004 to .810 kg per cubic meter, while caiman varied from .105 to 4.89 kg per cubic meter. Combined biomass for the Manurito pond was an astonishing 5.42 kg per cubic meter.

Table 1. Mean dimensions and calculated volumes for five ponds.

Location	Pond	Mean Dimensions*			
		Length m	Depth m	Width m	Volume m^3
Rancho Masagueral	1	45	.87	10	392
	2	200	.82	30	4920
	3	120	.66	24	1900
	4	685	.34	92	21426
Rancho El Frio	Manurito	29	1.0	20	580

* Dimensions for ponds 1 and 2 were obtained in the wet season while those for ponds 3, 4 and Manurito are for the dry season.

Table 2. Numbers of Caiman (C) and Turtles (T) censused in five ponds during wet and dry seasons.

Date	Season	Ponds									
		1 Temporary		2 Temporary		3 Permanent		4 Permanent		Manurito Permanent	
		C	T	C	T	C	T	C	T	C	T
9/20/75	wet	1	1	0	30	2	0	30	50		
3/4/76	-	0	0	0	0	31	5	60	93		
4/7/76	dry	-	-	-	-	47	7	186	146		
1/16/76	wet									28	17
4/13/76	dry									189	314

Table 3. Maximum numbers of caiman and turtles censused with calculated density and biomass for three ponds.

Locality	Pond	Date	Turtles			Caiman			Combined	
			Maximum Censused	Number m^3	Weight Kg/m^3	Maximum Censused	Number m^3	Weight Kg/m^3	Number m^3	Weight Kg/m^3
Rancho Masagueral	3	2/29	5	.003	.003	31	.02	.30	.023	.304
	3	4/7	6	.003	.004	46	.024	.36	.027	.364
	4	3/2	93	.004	.006	145	.007	.105	.011	.111
	4	4/7	146	.007	.011	204	.009	.135	.016	.146
Rancho El Frio	Manurito	3/12	205	.350	.530	139	.240	3.59	.780	4.40
		4/18	314	.540	.810	189	.330	4.89	.680	5.42

If the biomass estimates above are compared to consumer biomass estimates in other ecological systems, it is apparent that figures in this study are some of the highest ever recorded. Tropical reefs, which are one of the richest ecological systems, produce animal biomass estimated at approximately .132 kg per square meter. Many of the biomass figures in this paper are higher and they are calculated for cubic meters.

It should be pointed out that these estimates are for the dry season when the animals are concentrated in the ponds. Density and biomass should be calculated for the area that these reptiles occupy during the wet season, but data are not yet available concerning animal numbers and movements in the wet season.

Activity Cycles.--Hourly censuses of turtles and caiman were made. The numbers basking and in the water were tabulated for 10 sites. A 24-hour period was covered but more data were taken from 6:00 a.m. to 10:00 p.m. Counts for each hour at each site were expressed as a percentage of the highest number censused at that site. These percentages were then averaged for each hour and graphed in Figures 1 and 2.

The activity cycles of the two species differ. Caiman are active in the water at night as evidenced by the high percentages. During the day the caiman can be seen either basking on the shore or resting at the surface of the water. It is apparent from the percentages that many caiman must also spend much of the day under water. Turtles are active largely during the day, basking or floating at the surface of the water.

Figure 1. Percent of total caiman and turtle populations in water per hour for a 24 hour period.

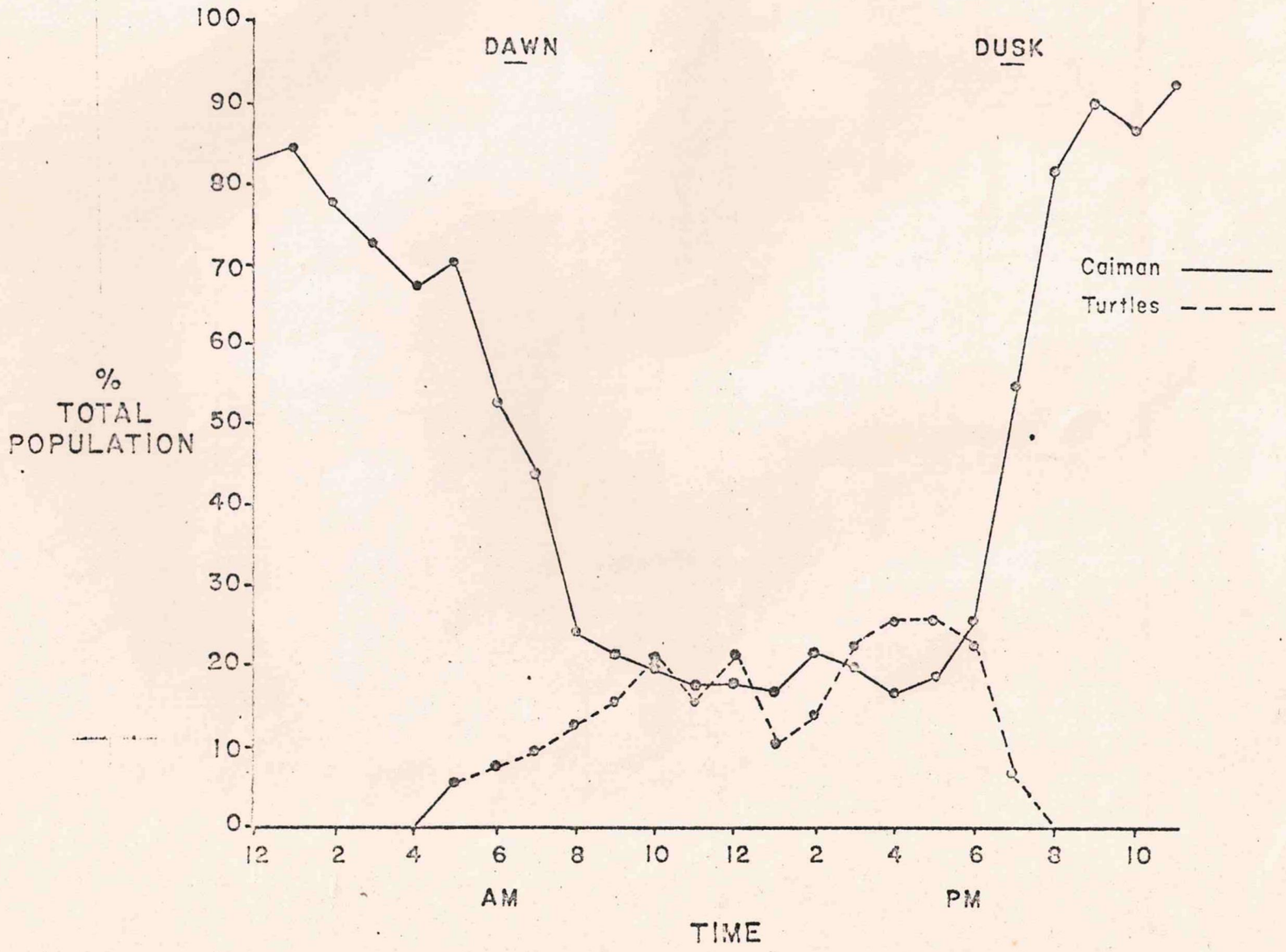
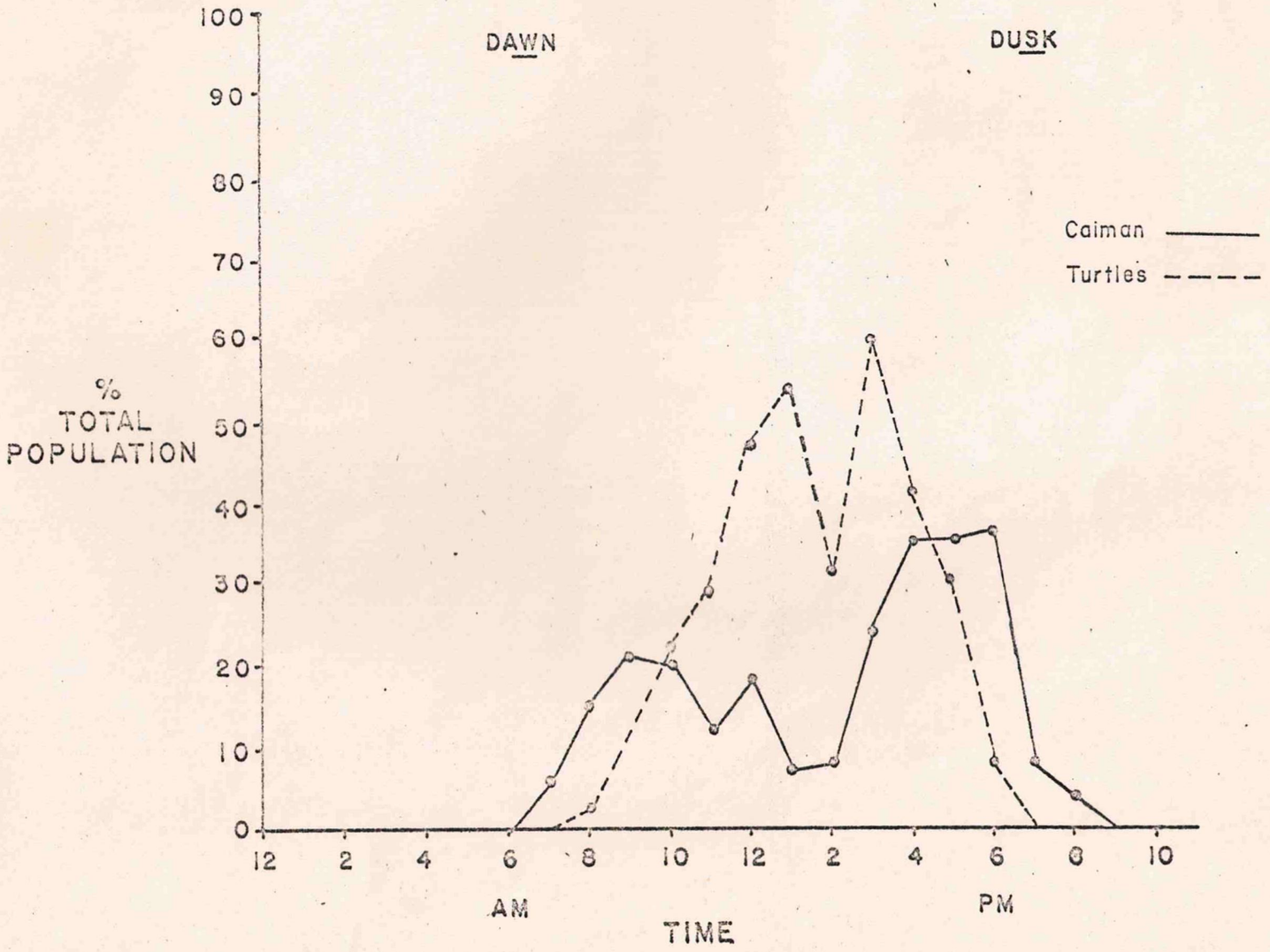


Figure 2. Percent of total caiman and turtle populations basking per hour for a 24 hour period.



Many turtles must also remain under water during the day. At night they are submerged and only occasionally a head is seen.

The basking cycle of the two species is very similar with the greatest number basking during midday (10:00 a.m. to 6:00 p.m.). Turtles and caiman both show two basking peaks; one in the morning, and one in the afternoon. They differ in that basking begins earlier for caiman (before dawn) and lasts later (until after dusk). The daily basking peaks for caiman also occur a bit earlier in the morning and a bit later in the afternoon than those for turtles.

Data Collected but not Reported.--Preliminary data were also obtained on turtle and caiman sex ratios, sizes, nesting, growth, feeding, movements, territoriality, basking site preferences, basking behavior, and social behavior.

Future Research

The first year's work on the reptiles in the llanos of Venezuela has resulted in a realization that in the llanos are found some unique and interesting ecological systems. The pond with its associated animals is one such system. Here we have a classic situation in which animal populations are affected by each other and by very strong and cyclic abiotic factors. Summarized below are some of the interactions which probably occur during an annual cycle in the pond ecological system.

In the wet season the llanos is flooded and the animals are dispersed. Aquatic getation is abundant at this time and the primary consumers

(turtles and herbivorous fishes) are probably feeding heavily during this period. Populations of herbivorous fish, no doubt increase greatly at this time. The caiman are also dispersed in the wet season and are known to nest at this time. The caiman are probably not feeding very often in the wet season because their fish food is widely dispersed over the flooded plains.

As the dry season approaches and the water recedes, the fishes are the first to be forced back into the ponds. The turtles (who are known to nest at the end of the wet season) return to the ponds soon after the fish. The large concentrations of herbivorous fish are easy prey for carnivorous fishes whose populations now begin to grow as they successfully feed on the herbivores. The caiman begin to return to the permanent ponds. There they find a ready food source in the huge fish populations and hatchling turtles. The dry season is a heavy feeding time for the caiman, but the turtles find little plant food in the muddy ponds and must fast. As the rains begin, the cycle starts again.

This fascinating cycle is of course not restricted to plants, fish and reptiles, but also involves birds, other vertebrates and invertebrates. The reptiles, however, play an important part in the system and are relatively easily studied.

In future research, an attempt will be made to obtain hard data to substantiate the speculations given above. This data can be obtained only by extended periods of field work which will include mark-recapture studies and behavioral observations of caiman and turtles. It must also

include telemetry studies in order to track animals as they disperse during the wet season.

A minimal budget for additional preliminary work is presented for FY 1977 because the funds for an extensive study are not available. It is hoped that the necessary funding will be provided for FY 1978 so that this unique ecological system can be studied in detail.

Schedule of Operations - FY 1976-1977

Activity and Location	Dates
Preliminary telemetry studies on captive turtles and caiman at the National Zoological Park, Washington, D. C.	1 July 1976-1 Sept. 1976
Field work in Venezuela	1 Sept. 1976-1 Oct. 1976
Planning for all-out research effort in 1977	1 Oct. 1976-1 June 1977

Family: Alligatoridae

Genus: (1) Caiman

Species
- crocodilus / crocodilus (baba) throughout Venezuela
- (6) → fuscus (Falcon, Zulia)

Genus: Paleosuchus (dwarf Caiman)

Species
- (2) trigonatus — Bolivar, Terr. Amazonus.
- (3) palpebrosus — Bolivar, Terr. Amazonus,

Crocodilidae

Crocodylus

- (4) intermedius (Orinoco basin Venezuela-Colombia)
- (5) acutus (coastal Venezuela wherever there are mangroves)