The Influence of Weather Conditions on Caiman Night-counts

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Abstract

Although often assumed as imprecise and inaccurate, most surveys on crocodilians' populations are based on night counts. At the present study, two observers conducted 52 night counts of broad-snouted caimans (*Caiman latirostris*) in a 12-month period at the facilities of the Caiman Project of the University of São Paulo in Piracicaba, State of São Paulo, Brazil (22°42.557' S, 47°38.246' W). Besides possible individual observers' bias we evaluated the influence of the following weather variables on the precision and accuracy of night counts: air and water temperature, rain, wind, and moonlight (phase and visibility). Night-counts can be precise, highly correlated with real population size, and reliable in long-term studies even with different observers. Weather conditions such as rain, wind, and ambient temperature did not influence night-counts in the controlled conditions of the present study. Moonlight and caiman body-size influenced the number of animals counted (the darker the better, and the smaller the animal the more accurate the counting). Future studies on the influence of aquatic vegetation on the efficiency of night counts are urged.

Introduction

Although species are internationally recognized as the legal unity of conservation (Hemley 1994; Moulton and Sanderson 1997), populations are possibly the most adequate unities of management (Caughley and Gunn 1996). According to Caughley (1977), wildlife management should have one of the following goals: raise a population that has been depleted, control a population that is too dense, harvest a population for a continuous yield, or leave it alone but with an eye on it. The last applies to populations that do not fit into any of the former categories. The first is usually the main goal of conservation programs, the second is usually the main goal of wildlife control programs, and the third is the main goal of harvest programs. However, to diagnose the population status and its best management option among the four above it is necessary to have a good idea about its abundance in both space and time (Caughley and Sinclair 1994).

Estimating wildlife abundance is a sampling procedure which usually requires scientific approach and statistical methodology involving replication in space and time or at least in one of them depending on what kind of diagnostics is intended to be made (Krebs 1989; Skalski and Robson 1992). Ecological censuses generally involve one or some of the following goals: describing the interest of sites, estimating population size, monitoring population changes, determining the habitat requirements of a species, determining why species have declined, monitoring habitat management, and monitoring population dynamics (Sutherland 1996).

The following techniques have been developed for surveying crocodilians: interviews and opportune personal observations, surveys from artifacts, daylight ground counts, daylight surveys from aircraft, and night counts (Magnusson 1982; Mourão *et al*. 1994). Night counts are usually done from a moving boat with the aid of a spotlight. The reflective tapetum of the crocodilian's eyes glows red in a spotlight and can be seen at a considerable distance (Chabreck 1966).

Although night-counts are reasonably assumed to be an inaccurate abundance index (Abercrombie 1995; Abercrombie and Verdade 1995), they may be relatively precise (ie with a low standard error) when replicated (Bayliss 1987). For these reasons night counts have been extensively used in surveying and monitoring crocodilians populations (Messel *et al*. 1980; Brazaitis *et al*. 1988; Messel and Vorlicek 1989a, 1989b, 1989c; Thorbjarnarson and Hernández 1992; Velasco and Ayarzaguena 1995; Mourão and Campos 1995).

The following information can be reasonably taken from crocodilians night counts: population age/size structure, population sex ratio, and distribution of habitats in the area surveyed (Magnusson 1982, 1993, 1995; Magnusson and Mourão 1997). Those are the basic variables for the establishment of mathematical models of population fluctuation (Nichols 1987; Abercrombie and Verdade 1995; Johnson 1996).

Environmental factors, such as ambient temperature, wind speed, luminosity, vegetation and others can influence the number of animals counted at night (Bayliss 1987). However, since it is virtually impossible to know the real populations of crocodilians in the wild, experimental design has been rarely used to determine the efficiency of the method (Larriera *et al*. 1992; Pacheco 1996). This is the main goal of the present study.

Materials and Methods

Fifty-two night counts of broad-snouted caimans were conducted from May 1996 to May 1997 at the facilities of the Caiman Project of the University of São Paulo in Piracicaba, State of São Paulo, Brazil (22°42.557' S, 47°38.246' W). The night counts were conducted by two observers from 2130 to 2230 h on a weekly basis.

The animals were divided into five separate pens (16 x 4 m) of young (SVL < 50cm) and four pens (12 x 10 m) of adults (SVL ≥60 cm) (Table 1). Each young- and adult-pen contained a cemented pool (12 x 2 m x 75 cm deep and 9 x 6 m x 100 cm deep, respectively). Young-pens were placed in line, as well as the adult-pens, but the two facility groups were located approximately 250 m far from each other. All enclosures were located on fenced areas with restricted visitation and no electric light. The disposition and number of caimans per enclosure remained constant during the period of study (Table 1).

Table 1. Numbers of caimans per enclosure. J1-J5= Young-pens; AR1-AR4= Adult-pens.

Enclosure	No. of Animals
J1	20
J2	16
J3	34
J4	31
J5	10
AR1	4
AR2	5
AR3	6
AR4	6

During night-counts, observers approached quietly and separately and stayed out of the pens focusing the animals with a 12 V 15,000 c.p. sealed-beam spotlight [as described by Woodward and Marion (1978)] at an approximate distance of 10 to 20 m from the animals. Batteries were fully charged upon initiation of each session. Observers counted individually and secretively the animals by the reflection of the spotlight in their eyes. The animals were introduced to the pens at least six months before the beginning of the present study and were previously habituated to the presence of the observers.

Besides possible individual observers' bias we evaluated the influence of the following weather variables on the precision and accuracy of night counts: air and water temperature, rain, wind, and moonlight (phase and visibility). Temperature was measured with a bulb thermometer (1°C precision). Rain and wind were treated as "nominal scale" variables (Freund and Wilson 1992) with the following levels: absent, low, moderate, and strong.

In order to compare observers precision we used correlation analysis (Sokal and Rholf 1995). In order to establish statistical relationships between observers counts and real populations we used regression equations (Brown and Rothery 1993). In order to evaluate the influence of weather conditions on the efficiency of night-counts we used analysis of covariance (ANCOVA) (Zar 1996) having the weather conditions as covariates. Statistical analyses were run in Minitab for Windows 13 (Minitab 2000).

Results

There was a high correlation between observers ($P<0.000$, r= 0.995). There was also a high correlation between observers and real population ($P<0.000$, r= 0.995) and no significant variation between observers along the study period (ANCOVA, $P= 0.677$).

The following linear models could be established between observers' night-counts and real populations (N= real population, Nc= night-count):

N= 2.02711 + 1.09778Nc_1 (P<0.000, r^2 = 0.919 for Observer 1)

N= 2.99757 + 1.07920Nc_2 (P<0.000, r^2 = 0.920 for Observer 2)

Neither air temperature (11°C min., 31°C max.) nor water temperature (12°C min., 30°C max.) influenced night-counts (ANCOVA: *P*= 0.681 to 0.772; ANCOVA: *P*= 0.762 to 0.853, respectively). Similarly, neither rain (ANCOVA, *P*= 0.391) nor wind speed (ANCOVA, *P*= 0.875) significantly influenced night-counts.

On the other hand, moon phases influenced night-counts (ANCOVA, *P*<0.000). The Analysis of Mean (ANOM) (Ott 1983; Ramig 1983) showed the following results: New (a) ≥ First quarter (ab) ≥ Second quarter (bc) ≥ Full (c), with different letters meaning different results at 95% confidence level.

Moon presence/absence influenced night-counts (ANCOVA: *P*= 0.032; ANOM: Absent>Present). Body-size influenced night-counts (ANCOVA: *P*= 0.003; ANOM: Young>Adult).

Discussion

In controlled situations such as the present study night counts can be highly correlated with real population (ie accurate). In addition, night counts from distinct observers can be highly correlated (ie precise), and consistent along time (ie reliable). However, the present study does not take into account the influence of floating vegetation which can significantly affect animals detectability. There was no aquatic plant at the pools during the present study. Vegetation can affect night-counts because they can physically prevent observers of detecting the animals. Since vegetation can drastically change both in time and space even in small scale during monitoring programs this factor should be experimentally tested in future studies.

Surprisingly, at the present study we found different patterns than previous studies involving caimans and other crocodilians. A positive correlation between the number of animals counted and the maximum air temperature of the day was found for non-hatchlings *Alligator mississippiensis* (Woodward and Marion 1978), *Crocodylus niloticus* (Hutton *et al*. 1989), *Caiman latirostris* (Larriera *et al*. 1992), and *Melanosuchus niger* (Pacheco 1996). Small crocodilians seem to thermoregulate differently from the adults being active at lower temperatures (Diefenbach 1975a, 1975b). However, at the present study neither air nor water temperature at the moment of the counting significantly affected the number of animals sighted. The temperature range during the present study (from 11 to 31°C and from 12 to 30°C for air and water, respectively) quite likely covers the normal ambient temperatures the species experience in the wild in São Paulo State, Brazil. Therefore, the captive environment has not dramatically affected this variable.

On the other hand, there is a strong relationship between temperature and feeding behavior in heterotherms such as crocodilians (Lang 1987; Diefenbach 1988; Verdade *et al*. 1992), in a way that animals need to attain certain thermal (ie metabolic) levels in order to favor prey apprehension, ingestion, and digestion. Considering that feeding behavior is drastically modified in captivity - where basically all food is furnished "for free" at roughly regular intervals - thermoregulatory behavior can possibly explain why ambient temperature did not affect night counts, contrary to the pattern found in the wild in other studies.

Wind speed was the environmental variable that had the greatest effect on *Melanosuchus niger* night counts (Pacheco 1996) either because of its association (ie negative correlation) with ambient temperature or because crocodilians actively avoid the wave action caused by strong winds (Mazzotti 1989). However, at the present study the occurrence of wind did not affect the number of animals counted. A possible explanation for this is that there was no significant wave action due to the wind because of the small area of the pools and the possible windbreak action of the fences.

The cloud cover had a consistent negative effect on *Melanosuchus niger* counts either because of its possible association with wind speed (Pacheco 1996) and by extension with ambient temperature or because of possible disorientation of animals (as described by Murphy (1981) for juvenile alligators under full cloud cover). However, at the present study cloud cover and the occurrence of rain did not significantly affect night counts. A possible reason for this is its possible association with ambient temperature, not found correlated with night counts at the present study as described above.

Surprisingly Larriera *et al*. (1992) did not find any significant correlation between moonlight and night counts of *Caiman latirostris*. The most developed sense organ of crocodilians seems to be the vision (Bellairs 1971). Moonlight quite likely increases animals detectability by the observers. However, it also possibly improves observers detectability by the animals which usually results in their retreat or diving which in its turn makes them no longer visible (Bayliss 1987). This agrees with the pattern found at the present study where both moon phase and presence consistently affected the number of animals counted, decreasing from new to full moon. The evident association between moon phase and luminosity is reinforced at the present study by the consistent relationship between moon visibility (ie presence or absence) and the number of animals counted, significantly higher when moon is not visible than otherwise.

The efficiency of night counts at the present study was also influenced by caimans body size similarly to previous studies (Giles and Childs 1949; Woodward and Marion 1978; Pacheco 1996). Young individuals were more detectable than adults possibly because adults tend to be more wary (Webb and Messel 1977; Hutton *et al*. 1987; Pacheco 1993; Verdade *et al*. 2002).

Rarely - to say the least - wild populations of crocodilians can be monitored under controlled situations such as the present study. However, the experimental manipulation of environmental variables in order to better understand how they influence night counts of crocodilians in the "real world" is desirable. It is virtually impossible to assess the real number of individuals from a wild population of caimans or crocodiles, which is necessary to determine the local accuracy - not only precision - of the method and validate populational fluctuation models. This is usually only feasible under controlled experiments.

Conclusions

Night-counts can be precise and highly correlated with real population size. Linear models can be established between observers' night-counts and real population size. Night-counts are reliable in long-term studies even with different observers. The accuracy and precision of night-counts can be affected by the moonlight (the darker the better) as well as by animals' body size (the smaller the animal the more accurate the counting). However, weather conditions such as rain, wind, and ambient temperature can be surprisingly irrelevant. Future studies on the influence of aquatic vegetation on the efficiency of night counts are urged.

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