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Reproductive performance of the wild collared peccary (*Tayassu tajacu*) female in the Peruvian Amazon

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Abstract Based on the gross anatomic examination of 218 adult female reproductive tracts, we characterised the reproductive biology of the wild collared peccary in the Northeastern Peruvian Amazon. Collared peccary apparently breed year round in the Northeastern Peruvian Amazon and the number of pregnant females was 92 (42.2%). Estimations suggest 1.12 births/year and a yearly reproductive production of 1.98 piglets per pregnant female. Collared peccary females presented a mean ovulation rate of 2.25 ± 0.58 CLs, a litter size of 1.77 ± 0.48 embryos or foetuses and a reproductive wastage of 0.45 ± 0.65 (21.3%) oocytes or embryos per pregnant female. A phenomenon of embryo migration was observed in 31.8% of pregnant females. This study provides reproductive information that should be taken into account in management plans.

Keywords *Tayassu tajacu* · Collared peccary · Reproductive production · Amazon

Introduction

In the Amazon region, the collared peccary (*Tayassu tajacu*) is one of the most frequently hunted species and represents an important source of food and animal skins.

The reproductive biology determines the ability to support high hunting pressures and is fundamental to understand the dynamics of wild populations. Nevertheless, most information on the collared peccary reproduction in the Amazon region is based on outstanding long-term studies conducted in captivity in recent years (Mayor et al. 2005, 2006).

In the Amazon, the collared peccary female is considered to be aseasonally polyoestrous (Mayor et al. 2006), with an oestrous cycle length of 27.8 ± 1.5 days (Mauget et al. 1997), a mean gestation period of 138 days (Mayor et al. 2005) and a litter size of 1.7–1.9 foetuses or newborns (Gottdenker and Bodmer 1998). Reproductive production of the species in the wild was estimated at 1.4–1.8 (Gottdenker and Bodmer 1998).

Models used to determine the sustainability of bush meat hunting in the Amazon are paramount for conservation and community-based management (Bodmer and Robinson 2004). The commonly used production and unified harvest models rely on accurate estimations of reproductive productivity for specific sites. Conservation programmes aimed at sustainable use must therefore collect specific data on the reproduction of species, in this case the collared peccary. The objective of the present study was to examine the reproductive performance of the wild collared peccary in the Northeastern Peruvian Amazon.

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Materials and methods

Study area

This study was conducted in the Tamshiyacu–Tahuayo Communal Reserve, in the Northeastern Peruvian Amazon. The reserve spans 322,500 ha of continuous forest, predominantly non-flooded terra firme forest, with a harvest

per square kilometre and year between 1.1 and 2.7 mammals. The climate in that region is typically equatorial with an annual temperature of 22–36°C, a relative humidity of 80–100% and an annual rainfall of 1,500–3,000 mm. Seasons are defined as dry (January–February and July–September) and wet (March–June and October–December).

Animal collection and sample analysis

From 1996 to 2007, hunters in the study area, as part of an ongoing participatory conservation programme, collected genital organs of 218 adult collared peccary females. Genital organs were maintained in buffered 4% formaldehyde solution (v/v) until analysis. Ovaries were dehydrated, embedded in paraffin wax, cut into 3- μ m sections and stained with haematoxylin and eosin. Females with at least one embryo or foetus were considered to be pregnant. Non-pregnant adult animals with ovaries bearing large antral follicles and lacking corpora lutea (CL) were considered to be in the follicular phase of the oestrous cycle, while those with ovaries containing active luteal tissue were described to be in the luteal phase of the oestrous cycle. Corpora lutea were considered active in the presence of a pregnancy or as indicated by luteal cell morphology (Jori et al. 2002). Since Mayor et al. (2005) determined first anatomical signs of pregnancy around the 15th day of gestation in the collared peccary, we considered a possible underestimation of 10% of pregnancies with respect to non-pregnant females in the luteal phase.

Monthly conceptions were determined by back-dating embryos or foetuses from the estimated age on the date when collared peccary females were collected. Gestation length used to back-date foetuses was 138 days (Mayor et al. 2005). The determination of embryo/foetal age was based primarily on the description given by Mayor et al. (2005), who used developmental characteristics of the collared peccary in the Amazon. Litter size and foetal sex of each pregnancy were recorded.

Reproduction performance of the wild collared peccary was estimated as follows (Mayor et al. 2009):

Ovulation rate=number of CL/ovulating female

Fertilization rate=total embryos or foetuses/number of CL in pregnant females

Reproductive wastage=number of CL–number of embryos or foetuses in pregnant females

Pregnancy rate=number of pregnant females/total adult females

Pregnancy-days per year=365 days/year \times pregnancy rate

Number of births per female per year=yearly pregnancy-days/gestation length

Farrowing interval=gestation length/pregnancy rate

Parturition–conception interval=farrowing interval–gestation length

Yearly reproductive production=number of births per female per year \times litter size

Gross productivity=number of embryos or foetuses/number of adult females

Gross fecundity=number of female foetuses/number of adult females

Statistical analysis

To test the hypothesis of seasonal reproduction, we used the number of parturitions by season and applied the chi-square test. Comparison between weight of pregnant and non-pregnant females, and number of CL in right and left ovary was calculated using analysis of variance.

Hunting vulnerability of pregnant females according to its pregnancy stage or adult sex was analysed using chi-square test. Statistical analyses were performed using GraphPad Instat (GraphPad Software Inc., San Diego, CA, USA). Differences with a probability value of 0.05 or less were considered significant. All values are expressed as the mean \pm standard deviation (SD).

Results

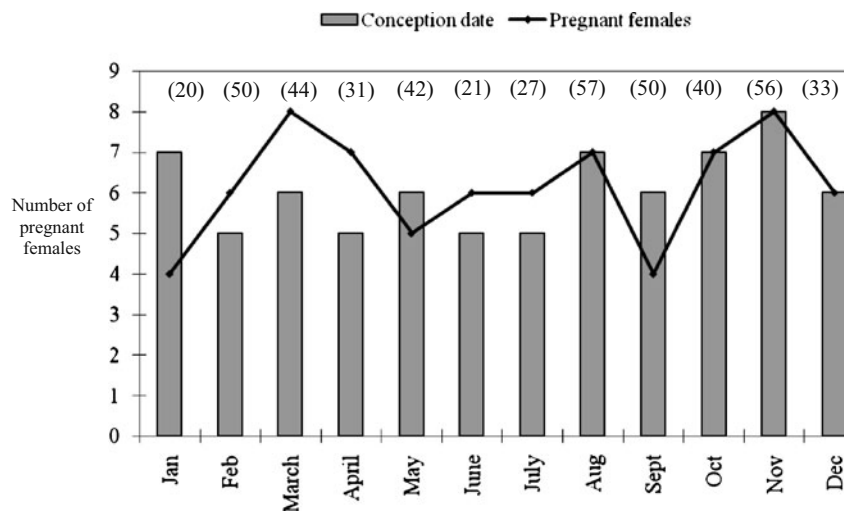
Among the 218 studied adult females, 92 (42.2%) were pregnant and 126 (57.8%) were non-pregnant females (Fig. 1). Table 1 shows the estimated reproductive performance of the collared peccary in the study area. Non-pregnant females included 20 (15.9%) females in the follicular phase and 106 (84.1%) females in the luteal phase. Considering a possible underestimation of 10% of pregnancies with respect to non-pregnant females in the luteal phase, ten females in the luteal phase could be considered as pregnant females in the earliest pregnancy stage. Therefore, the pregnancy rate could be as high as 46.8% (102 pregnant females). Pregnant females showed a higher weight of carcasses compared to non-pregnant females (21.8 \pm 3.3 and 19.8 \pm 4.3 kg, respectively; $P=0.01$).

Females conceived in every month of the year ($P=0.69$), and there was no significant difference between the number of estimated conceptions during the wet and the dry season (43 and 30, respectively; $P=0.86$). Number and percentages of pregnant females were similar in every month.

Ovulation rate did not show differences between pregnant and non-pregnant females in the luteal stage (2.25 \pm 0.58 vs. 2.03 \pm 0.72 follicles per ovulating female, respectively; $P=0.09$). There was no significant difference in the number of CL in the left and right ovaries (1.03 \pm 0.69 vs. 1.10 \pm 0.75, respectively; $P=0.44$).

The average litter size was 1.77 \pm 0.48 embryos or foetuses per pregnant female, with a foetal sex ratio of 52.2% females and 47.8% males, which did not differ from

Fig. 1 Monthly pregnancy rate and estimated number of collared peccary females ($n=73$) conceiving in each month in the Northeastern Peruvian Amazon. Percentage of pregnant females per month is shown in brackets



a 1:1 sex ratio ($P=0.35$). Among all pregnancies studied, 23 (25.0%) were single, 67 (72.8%) double and two (2.2%) triple. Collared peccary females presented a fertilisation rate of 79.7%, and a reproductive wastage of 0.45 ± 0.65 (21.3%) oocytes or embryos per pregnancy.

Right and left uterine horns presented a similar number of embryo or foetuses (49.6% and 51.4%, respectively). In 63 (68.5%) pregnancies, there was a correspondence between the occurrence of embryos or foetuses and CL in the ipsilateral ovary. On the contrary, in 29 (31.5%) females, the number of embryos or foetuses exceeded the number of CL in the ipsilateral ovary. Among females with embryo migration, four (13.8%) and 25 (86.2%) females presented a litter size of one and two foetuses, respectively.

Table 1 Reproductive performance of wild collared peccary females ($n=218$) in the Northeastern Peruvian Amazon from 1996 to 2007

Reproductive parameters	Value
Number of females	218
Number of non-pregnant females	126
Number of pregnant females	92
Number of foetuses	163
Pregnancy rate (%)	42.2
Pregnant days/year (days)	154
Non-pregnant days/year (days)	211
Parturitions/year/female	1.12
Farrowing interval (days)	327
Parturition–conception interval (days)	189
Litter size (piglets/parturition)	1.77
Foetal sexual ratio (F/M)	78:85
Yearly reproductive production (piglets/year/pregnant female)	1.98
Gross productivity (piglets/year/adult female)	0.61
Gross fecundity (female piglets/year/female)	0.306

There was no significant differences in hunted pregnant females according to the pregnancy stage ($P=0.12$) or adult sex ($P=0.20$).

Discussion

The presence of pregnant females in all months–year shows that pregnancies are evenly distributed year round. In agreement with the findings of Gottdenker and Bodmer (1998), this study suggests that the collared peccary breeds year round in the Northeastern Peruvian Amazon, probably due to the lack of huge seasonal differences in resources in the tropical environment and resulting in a sufficient food supply for peccaries to sustain a pregnancy regardless of the month of year.

Similarly to other studies conducted in the wild (Mayor et al. 2006), mean ovulation rate of the collared peccary in the wild was 2.25 follicles per female, with a low rate of reproductive wastage of 0.45 oocytes or embryo per pregnancy. In this study, the collared peccary female in the wild presented a pregnancy rate of 42.5% and presented an estimated yearly reproductive production of 1.98 piglets per pregnant female. This value was slightly higher than that reported by Gottdenker and Bodmer (1998). The increase in reproductive productivity reported in this study corresponds well with the likely Lotka–Volterra interactions between collared and white-lipped peccary. White-lipped peccary have gone through a natural decrease in the study site and collared peccary have increased accordingly, presumably because of decreased competition from the former species (Fang et al. 2008). The increase in the rate of population growth of the collared peccary at the site corresponds well with the observed increase in reproductive potential observed in this study. In turn, this increase makes for more sustainable hunting of collared peccary by local people.

A phenomenon of embryo migration was observed in 31.5% of pregnant females in the wild collared peccary. Moreover, 86.2% of females showing embryo migration were pregnant females with one embryo or foetus in each uterine horn and two CLs only in one ovary, suggesting the inability of each uterine horn to support the development of more than one foetus. This embryo migration has also been observed in its conspecific white-lipped peccary (Mayor et al. 2009).

In the Amazon region, the collared peccary is one of the most hunted species, making necessary a consideration directed to a management priority based primarily in the establishment of sustainable harvest rates. The present reproductive evaluation of the collared peccary in the Northeastern Peruvian Amazon provides important information that should be taken into account in management plans, and the results of this study are being used to determine the sustainability of hunting using the production model.

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