

Cranial measurements of jaguars (*Panthera onca*) from the State of Oaxaca, Mexico

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The jaguar is the largest felid in the Western Hemisphere, where its somatic measures vary widely throughout its distribution. On average the total length lies between 1.57-2.19 m, and females are 10-20% smaller than males; weight of males is between 56.3-158.0 kg. Concerning cranial measurements, the condyle-basal length ranges from 190-260 mm, but can exceed 275 mm; the width of the zygomatic arch is between 129-212 mm (mean= 165.2 mm); the rostral width between 55.4-89.8 mm (mean= 67.8mm); the interorbital width from 33.8-68.1 mm (mean= 46.1 mm) (Seymour 1989). The largest animals in size have been recorded in the Pantanal, Brazil, and the Llanos, Venezuela (Hoogesteijn & Mondolfi 1996), while the smallest individuals are located in the Yucatán peninsula, Mexico (Nelson & Goldman 1933).

Eight morphological subspecies were recognized (Seymour 1989), however morphometric studies does not support significant geographical differences (Larson 1997). Plus, a molecular study revealed that there is no important genetic separation in the species, recognizing only four phylogeographic groups (Eizirik et al. 2001). Because of the situation of the jaguar in Mexico, there are few studies that analyze morphometric aspects of the species due to the shortage of bone material in museums (Isidro & Cervantes, 2007).

In the state of Oaxaca there are 31 reliable records of jaguar (Briones-Salas et al. 2012). In the monograph "Mammals from the state of Oaxaca, in the American Museum of Natural History Mammals of Oaxaca", Goodwin (1969) published cranial measurements of three adult specimens collected in the state of Sonora, Mexico as a reference, but without providing precise information of jaguar specimens collected in Oaxaca. Therefore, the objective of this study is to provide, for the first time accurate information of cranial measurements of jaguar specimens in the state of Oaxaca.

From 1998 to 2009 we visited different regions of the state. During each visit we performed informal interviews with residents of communities in order to determine the presence of jaguars in the area and to detect the possession of the species' biological material (e.g. skulls or skins; Briones-Salas et al. 2012). Jaguar skulls were distinguished for presenting wide zygomatic arches, globose tympanic bullae, separated aliesfenoides bones, and the lack of a projection in the parietal bones (Hall 1981, Isidro & Cervantes 2007). Each cranial measurement was obtained in millimeters (mm) with a vernier following Hall (1981).

We recorded five jaguar skulls (Figure 1); four were placed in the physiographic subprovince of the Sierra Madre of Oaxaca, and one in the Pacific Coastal Plain (Ortíz-Pérez et al. 2004). Three individuals were hunted in cloud forest, one in pasture for livestock contiguous to oak forest, and the other in an area with a mixture of semi-deciduous tropical forest and coffee crops. Three skulls were recorded above 1000 masl, one was placed at 800 masl and the other at 300 masl. The individuals were killed due to jaguar-livestock conflicts.



Figure 1. One of the jaguar skulls recorded in the state of Oaxaca, Mexico.

The cranial measurements (range and mean) presented here correspond to a male adult specimen: maximum length, 242-288 mm, mean = 262 mm; condyle-basal length, 197-225 mm, mean = 214.25 mm; basal length, 180-211 mm, mean= 193.75 mm; width of the zygomatic arch, 150-196 mm, mean= 174.6 mm; rostral width, 61-70 mm, mean= 65.25 mm; length of maxillary row, 82-95 mm, mean = 87.75 mm; diameter of the canine, 18 to 24 mm, mean= 22.25 mm (Table 1).

Table 1. Cranial measurements of the jaguars recorded in the state of Oaxaca, Mexico. All the measurements are in millimeters

Locality	Maximum Length	Condyle-basal length	Basal length	Width of the zygomatic arch	Rostral width	Length of maxillary row	Diameter canine
Cascadas La Gloria, 8 km E of Sta, María Xadani, Municipality of San Miguel del Puerto, (800 masl).	250	---	---	150	---	85	---
Rancho La Bellísima, 3 km N of Santiago Camotlán, Municipality of Santiago Camotlán, (1200 masl).	264	225	200	184	67	89	24
Santiago Tlatepusco, 9.6 km S of Usila, municipality of San Felipe Usila, (368 masl).	266	210	180	180	70		18
Rancho La Bellísima, 3 km N of Santiago Camotlán, Municipality of Santiago Camotlán, (1200 masl).	288	225	211	196	63	95	24
Rancho Yajoni, 5.2 km NW of Santiago Camotlán, Municipality of Santiago Camotlán, (1134 masl).	242	197	184	163	61	82	23
Mean	262	214.25	193.75	174.6	65.25	87.75	22.25

The recorded measurements of the five jaguar skulls from Oaxaca are in the range reported for the species in its distribution (Seymour 1989, Hoogesteijn & Mondolfi 1996), however, are larger than the average reported by Hoogesteijn & Mondolfi (1996) for seven male specimens from Mexico and Central America (maximum length, 243.6 mm; condyle-basal length, 223.14 mm, width of the zygomatic arch, 166.4 mm). They are also larger than those recorded by Rabinowitz & Nottingham (1986) for 16 males of the Cockscomb basin, Belize (maximum length: 232 mm; condyle-basal length: 198 mm; width of the zygomatic arch: 163 mm) and for an adult male from Sonora, Mexico reported by Goodwin (1969) (maximum length, 241 mm; condyle-basal length 213 mm; width of the zygomatic arch, 159 mm). Although it is likely that the measures reported by Hoogesteijn & Mondolfi (1996) do not reflect the whole size range of jaguars of Mexico, since they only analyzed skulls from the Yucatan Peninsula and Central America and do not include specimens from other locations in Mexico. For example Nelson & Goldman (1933) reported a skull of San Andrés Tuxtla, Veracruz, on the Gulf of Mexico slope, with a maximum length of 279 mm, a condylobasal length of 247.4 mm and a zygomatic arch width of 180 mm.

In modern jaguars, body and skull size have a stronger relation with the biomass of prey rather than the latitudinal location (Hoogesteijn & Mondolfi, 1996). Nevertheless, there are no studies about diet of jaguar in Oaxaca, but the natural prey available in the subprovinces where the skulls were located are collared peccary (*Tayassu pecari*), Nine-Banded Armadillo (*Dasyus novemcinctus*), Paca (*Cuniculus paca*), Agouti (*Dasyprocta mexicana*), Red Brocket Deer (*Mazama temama*), White-Tailed Deer (*Odocoileus virginianus*) and White-Nosed Coati (*Nasua narica*) (Lavariega et al. 2012), with an average weight of 19.64 kg, and there is evidence of the presence of Tapir (*Tapirus bairdii*, 150-300 kg; Lira et al. 2006, Lavariega et al. 2013). On the other hand, in the area it is common the extensive breeding of cows (*Bos* spp.) and sheep (*Capra hircus*), which according to Hoogesteijn & Mondolfi (1996), may be related to the proportionately larger size of the specimens of Oaxaca, however, this idea must be assessed.

Due to reduction in populations size through habitat loss and fragmentation and hunting, the jaguar is categorized as Near Threatened on the IUCN (IUCN, 2016), while the Mexican Government included this species in the Mexican Official Norm 059 as Endangered (SEMARNAT, 2010), so new material for morphological studies is not justified. In this context, the cranial measurements presented here are relevant because they represent the first reports of jaguar morphological information for this region of Mexico and they will help to improve the knowledge of this species in the region.

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