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

**Mario C. Lavariega**
Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional, Unidad Oaxaca, Instituto Politécnico Nacional, Oaxaca, México. mariolavnl@yahoo.com.mx

**Miguel Briones-Salas**
Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional, Unidad Oaxaca, Instituto Politécnico Nacional, Oaxaca, México.

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 Oaxacan*, 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 alisfenoides 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 recorder 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 (Dasypus 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.

Acknowledgment

P. Vásquez and E. Durán contributed with the Santiago Tlatepusco specimen information. A. Ramírez for their helpful on the English version.

References

BRIONES-SALAS, M., et al. 2012. Distribución actual y potencial del jaguar (Panthera onca) en Oaxaca, México. Revista Mexicana de Biodiversidad 83: 246-257.
EIZIKI, E., et al. 2001. Phylogeography, population history and conservation genetics of jaguars (Panthera onca, Mammalia, Felidae). Molecular Ecology 10: 65-79.
GOODWIN, G. G. 1969. Mammals from the state of Oaxaca, Mexico, in the American Museum of Natural History. Bulletin of the American Museum of Natural History 141: 1-318.
HALL, R. E. 1981. Mammals of North America. John Wiley & Sons, New York, EE.UU.
HOOGSTEIJN, R. & E. MONDOLFI. 1996. Body mass and skull measurements in four jaguar populations and observations on their prey base. Bulletin of the Florida Museum of Natural History 39: 195-219.
ISIDRO, X. & F. A. CERVANTES. 2007. Estudio morfológico del cráneo de jaguar (Panthera onca) de México. Mesoamericana 11: 99.
IUCN. 2016. The IUCN Red List of Threatened Species. Version 2015-4. www.iucnredlist.org. Downloaded on 15 April 2016.
LARSON, S. E. 1997. Taxonomic re-evaluation of the jaguar. Zoo Biology 16: 107-120.
LAVARIEGA, M. C., et al. 2012. Mastodontes mediano y grande de la Sierra de Villa Alta, Oaxaca, México. Mastozoología Neotropical 19: 225-241.
LAVARIEGA, M. C., et al. 2013. Registro de tapir centromeridiano (Tapirus bairdii) con cámaras-trampa en la sierra Madre de Oaxaca, México. Revista Mexicana de Biodiversidad 84: 1007-1011.
LIRA, I. et al. 2006. Status and conservation of Baird’s Tapir in Oaxaca, Mexico. The Newsletter of the IUCN/SSC Tapir Specialist Group 15: 21-28.
NELSON, E. W. & E. A. GOLDMAN. 1933. Revision of the jaguars. Journal of Mammalogy 14: 221-240.
ORTIZ-PÉREZ, M. A., et al. 2004. Reconocimiento fisiográfico y geomorfológico. Pp. 43-54 in Biodiversidad de Oaxaca (García, A. J., et al., eds), Instituto de Biología, Universidad Nacional Autónoma de México-Fondo Oaxaqueño para la Conservación de la Naturaleza-World Wildlife Fund, México, Distrito Federal, México.
RABINOWITZ, A. R., & B. G. NOTTINGHAM, JR. 1986. Ecology and behavior of the jaguar (Panthera onca) in Belize, Central America. Journal of Zoology of London 210: 149-159.
SEMARNAT. 2010. Norma Oficial Mexicana NOM-059-SEMARNAT-2010, Protección ambiental-especies nativas de México de flora y fauna silvestres-categorías de riesgo y especificaciones para su inclusión, exclusión o cambio-lista de especies en riesgo. Diario Oficial de la Federación 2454: 1-77.
SEYMOUR, K. L. 1989. Panthera onca. Mammalian Species 340: 1-9.