Jaguar fangs and other animal parts confiscated by Bolivian authorities and examined at the Museo Noel Kempff Mercado

Colmillos de jaguar y otras partes de animales confiscados por autoridades de Bolivia y examinados en el Museo Noel Kempff Mercado

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***Palabras clave*:** morfología de dientes, *Leopardus pardalis, Panthera onca, Puma concolor,* pieles, marfil

INTRODUCTION

Trade of wildlife products in Bolivia is legal only for the few species that have specific management plans, while trafficking most wild animals or their parts is punishable by law (MMAyA 2019). Bolivia is a signatory to CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora), accordingly applies its regulations on international trade of wildlife species and has made efforts to assess the conservation status of animal species listed in national Red Data Books (MMAyA 2009). Despite CITES, starting in 2014, trade observations started to accumulate involving international travelers and post office packages carrying jaguar fangs and other animal parts, mainly to China (Nuñez & Aliaga 2017, CITES 2021).

Following an investigation launched by the Santa Cruz Department of Natural Resources (DIRENA) and in joint operation with the police, in 2018, two recent immigrant individuals of Chinese origin were captured in possession of a large assortment of teeth and other animal parts. The Noel Kempff Mercado Natural History (NKM) Museum offered to identify the seized parts and was asked by the prosecution to present the analyses in court as proof of the crime. This case compelled us to focus on the morphological identification of animal parts and to study them in comparison to those of museum specimens and other sources. Subsequent requests from authorities to support additional cases increased the variety of species trafficked, requiring additional learning and analytical processes on the part of NKM Museum staff.

Trade in the parts of wild felids, especially the jaguar (*Panthera onca*) is of broad regional concern, with varying levels detected throughout the species' range from Mexico to Argentina, especially in South America (CITES 2021, Polisar *et al*. 2023a). To facilitate the forensic task of assessing confiscated animal parts, in this note we describe features useful to identify canine teeth of jaguar (*Panthera onca*), puma (*Puma concolor*) and ocelot (*Leopardus pardalis*), and estimate the minimum number of dead

individuals they represent. Additionally, we provide a list of other species parts traded by wildlife dealers in the country and discuss current tools and limitations to identify them.

METHODS

The animal parts seized in the 2018 case had been listed in the news as 185 'fangs', 8 molars, 2 claws and 3 skins of jaguar; 1 giant armadillo claw, 3 pairs of deer antlers and 2 rattlesnake tails, plus 2 fur coats and 11 white figurines of uncertain nature. Upon reception at the NKM Museum, all parts were registered, numbered with an adhesive label and photographed. Canine teeth (181 in total, 4 other teeth removed) varied in size and shape (Fig. 1), were weighed in grams on a digital scale and measured in millimeters with a caliper in total length, crown height (from the dentin edge to the tip), and in two diameters at the enamel-dentin edge. Published descriptions of felid teeth (Sims 2005, 2012, Christiansen 2007) were used to rule out the possible presence of teeth from exotic large cats and helped, with additional sources, to confirm traits of jaguars and pumas (Morales Mejía *et al.* 2010, De La Torre & Rivero 2017).

Figure 1. One of the three boxes of mixed canine teeth seized in 2018.

We visually compared the unidentified canines to the ones on skulls from the NKM Museum collection (4 skulls of jaguar, 4 of puma and 5 of ocelot; catalog numbers in results), identified the position of each canine as upper / lower and right / left by its shape, and assigned each to a 'most likely' species (see Supplementary Figures S1-S6). A comparison was made between the measurements of 39 known teeth from the collection and those of the seized teeth, with the former divided according to species. Additionally, an examination was conducted of the skins, claws, and antlers in relation to the museum specimens and published sources. The uncertain white figurines were assessed following the CITES guide to recognize ivory pieces (Espinoza & Mann 1999).

Animal parts seized in Santa Cruz in 2022 and attributed to other Chinese immigrants were also assigned to the NKM Museum for identification. These included felid canines,

felid claws, leather belts and hats made of skin of native reptiles. Two other requests of assessment from police authorities (POFOMA- IITCUP) in La Paz during 2023 included 48 seized items consisting of dry stuffed toads and caimans, rattlesnake tails, and hats, wallets, and purses made of skins of a wide variety of vertebrates (S14-S17). The diversity in these seizures required consultations with herpetologists and local leather craftsmen in addition to the Museum reference collections.

RESULTS

Fangs

The 185 teeth seized in 2018 were too heterogeneous to be all 'jaguar fangs' (Fig. 1). In fact, they included canines of three felid species, plus one of a peccary and three incisors of jaguar. From the actual felid canines, 67 clearly resembled those on jaguar skulls (*Panthera onca*, museum specimens # 3549, # 3550, PIRsn no# a and b), other 91 resembled puma (*Puma concolor*, skulls # 34, # 3561, # 4637, PIR13), 15 were indeferentiable from either jaguar or puma. Eight small canines resembled those of ocelot (*Leopardus pardalis*, skulls # 28, # 32, # 911, # 2415, # 3054) (S3). In addition to 'fangs', there were seven molariform teeth and one large incisor, all appearing to belong to one jaguar (S2a). All canines of felids (181) were clearly different from those of Andean bear (*Tremarctos ornatus* # 1230, Fig. S2d), foxes (*Cerdocyon thous, Lycalopex gymnocercus*), dogs and caimans (*Caiman yacare*).

Canine teeth of the three cat species shared features (based on their shape and the presence of ridges on external and internal surfaces) that permitted their assignment as upper / lower and right / left. This is shown in a set of puma canines attached to their skulls (Fig. 2) and that can be recognized in single fangs seized by authorities, as described below (S5).

Figure 2. Puma skull, **left**: maxilla showing upper canines, internal face of left one and external of right one; **right**: mandible showing internal faces of lower canines.

When jaguar or puma canines are detached from the skull, roots look as long as crowns, or longer (Figs. 3 & 4). Upper canines (at the sides of these figures) are straight or slightly curved, while lower canines (at center) are more curved and usually shorter than the upper canines. In the upper and lower canine crowns of both species, the external face is convex and smooth (Figs 3 & 4, upper half), while the internal face is flatter, but has two longitudinal ridges that extend from the tip down to the gum line (Figs 3 & 4, lower half). The enamel border at the gum line is nearly straight in all canines, except on the inner face of the lower ones where it has a V-shaped notch (Fig. 3 lower half center, and S1, S5).

Figure 3. The four canines of a young jaguar (thin walls and hollow, fractured after drying), upper canines at the sides and lower ones at center; **above:** external faces, convex and smooth; **below:** internal faces with ridges.

Figure 4: The four canines of an adult puma (solid crowns and roots), upper canines at the sides and lower ones at center; **above:** external faces, convex and smooth, but lower canines worn by rubbing against the upper ones; **below**: internal faces with ridges.

The weight, total length and crown height of the canines from the museum (n=39) were similar to those of the confiscated canines for each of the three felids (Table 1) although, as expected, there was some overlap on the measurements of the two species.

Table 1. Descriptive statistics (**n:** sample size; $\overline{X}$: mean and **sd**: standard deviation) of weight, total length, crown height and diameter (d1: anterioposterior and d2: transverse) of upper and lower canines from the NKM and those seized by authorities, for the three felid species (J: jaguar, P: puma, O: ocelot).

sp.	Upper/Lower and source	Weight g			Total length mm			Crown ht mm			Diameter $\overline{X}$ mm		
		n	$\overline{X}$	sd	n	$\overline{X}$	sd	n	$\overline{X}$	sd	n	d1	d2
J	Upp-museum	2	16.50	--	2	8.35	--	2	4.30	--	2	19.00	15.50
J	Upp-seized	18	19.39	8.85	18	7.48	0.98	18	3.43	0.53	18	17.70	14.00
J	Low-museum	2	15.00	--	2	7.45	--	2	3.55	--	2	20.50	16.50
J	Low-seized	49	17.65	6.63	49	7.04	0.64	49	3.37	0.32	49	18.10	14.00
P	Upp-museum	1	5.00	--	3	4.87	0.29	9	2.11	0.50	9	12.00	9.76
P	Upp-seized	38	5.84	1.78	38	5.26	0.46	38	2.37	0.28	38	12.20	9.90
P	Low-museum	1	3.00	--	3	4.23	0.06	5	1.82	0.11	5	10.40	7.60
P	Low-seized	53	6.11	1.41	53	5.07	0.34	53	2.30	0.23	53	12.90	10.00
O	Upp-museum	--	--	--	1	3.10	--	9	1.72	0.11	9	8.55	6.22
O	Upp-seized	6	2.33	0.52	6	4.08	0.21	6	1.92	0.13	6	9.30	7.00
O	Low-museum	--	--	--	--	--	--	8	1.61	0.08	8	8.12	5.87
O	Low-seized	2	1.50	0.71	2	3.40	0.14	2	1.65	0.07	2	8.50	6.50

Size was clearly the main difference among the three felid species (Table 1), but the crown and root shapes were also distinctive (Fig. 3 & 4, S6). Crowns are curved with a smooth surface and two subtle ridges in jaguar and puma. Grooves (1 or 2) are infrequent and shallow in jaguar, and generally absent in puma (Christiansen 2007, Sims 2012). Ocelot upper canine have straight and pointed crowns, with sharp protruding ridges, while lower crowns were notably curved (S6). All ocelot canines had 1-3 grooves. Roots are relatively bulkier in jaguars than in pumas, with a round end when totally ossified. However, some jaguar roots were hollow and had thin walls with remains of pulp tissue inside, while others had thick walls and a small hole. Pumas had narrower roots, largely ossified, tapering to a thinner ending. The few ocelot canines were mostly solid. The upper canines of both jaguars and pumas were larger than lower ones in every right/left individual pair of our museum skulls (Table 1).

Selected jaguar and puma canines were perforated, wrapped with a string or fixed with a gold setting to wear them hanging as pendants. Some pieces also had dentist resin concealing cracks, and a few showed cracks being carved with a drill to repair them but were left unfinished (S7).

Claws, cat skins, antlers and ivory figurines

Two large cat claws (3.5 cm long), cream in color, looked like the ones of jaguar skins in the collection, but could also be puma's. One was repaired with resin (S8a).

There was also a large claw (13 cm long) of a giant armadillo (*Priodontes maximus*) fitted with a chain as in a key ring (S8b).

The three large cat skins were of jaguar (*Panthera onca*). One had recently been chrome-tanned like local tanneries do, showing a deep green color on the inside (S9). A fur coat

referred as of "African leopard" in the news, was made from eight skins of the native ocelot cat (*Leopardus pardalis*). The cat species was identified by its size and coalescent rosettes that formed longitudinal stripes (S10).

Dried tails of adult rattlesnakes (*Crotalus durissus*) were found in two cases (2 + 6 'rattles', S11) which represented at least eight killed snakes.

Three large skulls with antlers belonged to marsh deer (*Blastocerus dichotomus*). One skull still had skin and flesh attached, smelled strongly of formalin, and it was thickly wrapped in newspaper (S12).

The eleven figurines of human forms, white in color, 10-15 cm tall and representing icons of Asian mythology, were not made of plastic nor bone. The structure of the material visible at their base corresponded to elephant ivory (Espinoza & Mann 1999), with evident Schreger lines forming an obtuse angle (S13). It was not possible to confirm if they belonged to African (*Loxodonta africana*) or Asian (*Elephas maximus*) elephant. Further studies are necessary to clarify this issue in the future.

Native species and parts identified in the assessments

In the four assessments of seized objects done at the NKM, at least 16 species of vertebrates were found (Table 2) including amphibians (1 sp.), reptiles (6), birds (2) and mammals (7).

Table 2. Species (16) identified as part of four cases of wildlife trafficking assessed at the NKM Museum (pictures in S7-S18).

Common names and species	Part used, examples
Cururú toad, rococo (*Rhinella* sp.)	stuffed individuals, skin in wallets (S14)
Rattlesnake, cascabel (*Crotalus durissus*)	tail with rattle (S11)
Common boa, boyé *(Boa constrictor*)	skin in wallets, purses (S17)
Anaconda, sicurí (*Eunectes murinus,* or *E. beniensis?*)	skin in belts, wallets, purses (S15)
Yacare caiman, lagarto (*Caiman yacare*)	Small animals stuffed, skin in belts, purses, wallets (S15, 16)
Black caiman, caimán negro (*Melanosuchus niger*)	Highly valued skin, natural color or tinted, in belts, wallets, purses, hats (S15, 17)
Black and white tegu, peni (*Salvator merianae*)	Skin in belts, wallets, purses (S16, 17)
Great rhea, piyo (*Rhea americana*)	Body and throat skin, in wallets (S17, 18)
Jabiru, bato, tuyuyú (*Jabiru mycteria*)	Black throat skin, in wallets, purses
Jaguar, tigre (*Panthera onca*)	Canine teeth, claws, skin in many objects (all cat parts Fig. 1-5, S1-S10, S15-S16)
Cougar, puma, león (*Puma concolor*)	Canine teeth, ¿claws?
Ocelot, tigrillo, onza (*Leopardus pardalis*)	Canine teeth, skin in some objects (S 15)
Margay, gato Brasil (*Leopardus wiedii*)	Skin in some objects
Giant armadillo, pejichi (*Priodontes maximus*)	Large claw (S8b)
Collared peccary, taitetú (*Pecari tajacu*)	Valued skin in wallets, canine teeth (S2b)
Marsh deer, ciervo (*Blastocerus dichotomus*)	Skull, antlers (S12)

DISCUSSION

Fang identification

The canine teeth that we examined ranged broadly in size. The largest ones were smaller than those of Asian tiger (*Panthera tigris*) or African lion (*P. leo*), and different in shape from teeth of other large exotic cats as leopards (Sims 2005, 2012, Christiansen 2007). Conversely, they matched the size and shape descriptions for jaguar and puma (Morales Mejía *et al.* 2010, De La Torre & Rivero 2017), as well as in the comparison with museum specimens. The ocelot canines were notable for their sharpness and smaller size, but even then, they overlapped in length with those of small pumas (S3). Large puma canines overlap in size with small jaguar canines. However, as expected, no overlap was observed between ocelot and jaguar. Despite potential overlap in size, canines of these three species can be identified by a combination of shape and size (Table 1, Fig. 5, and Rumiz *et al*. 2020) although this conclusion must be tempered by the comparatively small sample. With more museum specimens, bibliographic data and morphometric or multivariate analyses of teeth (and also claws) we expect to better discriminate these parts by species.

Estimating number of individuals and impact

Loose canines from different felid species could be recognized as upper or lower, and right or left by identifying the internal / external faces, ridges in the inner face, and the shape of the enamel line (Morales Mejía *et al*. 2010, Rumiz *et al.* 2020). This is important to rule out teeth from caiman, peccary, dog, etc., but also to estimate the minimum number of dead cats represented in the assortment. For example, if four canine teeth are left and upper, they must belong to four individuals, and it would be wrong to assume that every four canines in the sample is the equivalent of one dead animal. Although the initial news stories for the seizure claimed '185 fangs seized = 46 jaguars killed', our more detailed analyses revealed that more likely the seizure included no less than 26 jaguars, 33 pumas, 4 ocelots and 1 peccary.

Figure 5. Upper canine teeth representative of jaguar, puma and ocelot.

In the 2018 case, the evidence that we examined was used to prove damage to Bolivian natural assets (as stated in the law which protects Bolivian components of Mother Earth,

MMAyA 2019). Resulting from of our analyses we are certain that all parts (except for the ivory figurines) belonged to native species. Further, jaguar teeth and skins, deer antlers, and claws came from species listed as threatened under Bolivian legislation as recognized in the Bolivian Red Data Book (MMAyA 2009) and listed in CITES Appendix I (CITES 2017). Teeth that retained pulp in the root, a freshly tanned jaguar skin, and a deer skull soaked in formalin indicated that these pieces were not antiquities, but instead had been recently acquired, most likely in country. The intent of trafficking was supported by the fact that some canines had been fixed with gold or strings to be worn as jewelry, while others were being repaired with dentist resin to conceal cracks and add value to the pieces (S7). The ivory figurines further suggested trafficking, due to inferred links with Asian illegal markets.

The cases from 2022 and 2023 prompted us to examine the diagnostic traits of new wildlife skins, and added several native species to the list of traded animal parts. This experience highlighted the importance of museum collections and the exchange of images with international experts in sustaining the identification of animal parts. It also showed the need to have illustrated guides that synthetize the diagnostic features of the species for control officers and training. The preparation of a morphological guide to the parts of Bolivian felids (Rumiz *et al.* 2020) was useful to identify pictures of objects advertised on-line (Polisar *et al.* 2023b) and to develop cat guides by Panthera adapted for Suriname, Peru, Brazil, Colombia and Mesoamerica (ej. Rumiz *et al.* 2022). However, there is the pressing need of compiling and sharing photographic catalogs of trafficked parts including teeth, claws, bones and skins, and to develop comparative hair morphology guidelines and accessible molecular methods that can be incorporated as forensic tools against the increasing threat of illegal traffic of wildlife in Latin America.

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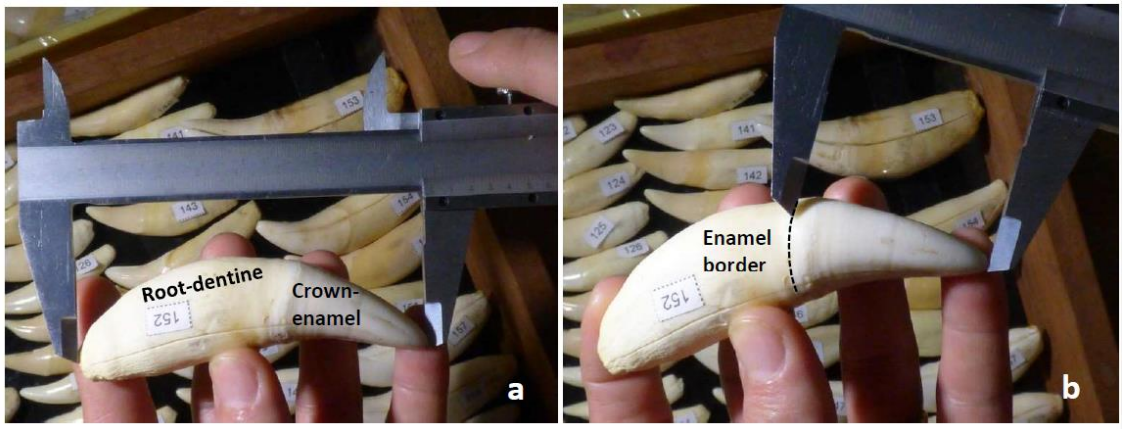
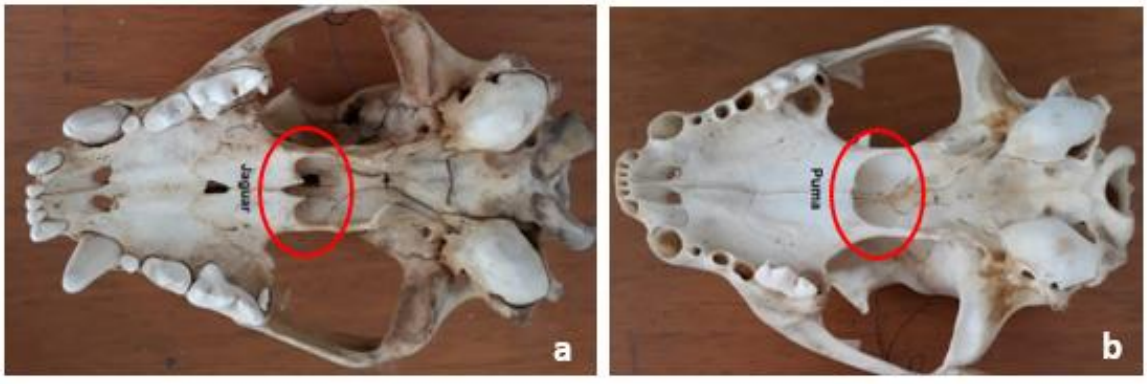
Supplementary pictures (by Damián I. Rumiz - Museo NKM)



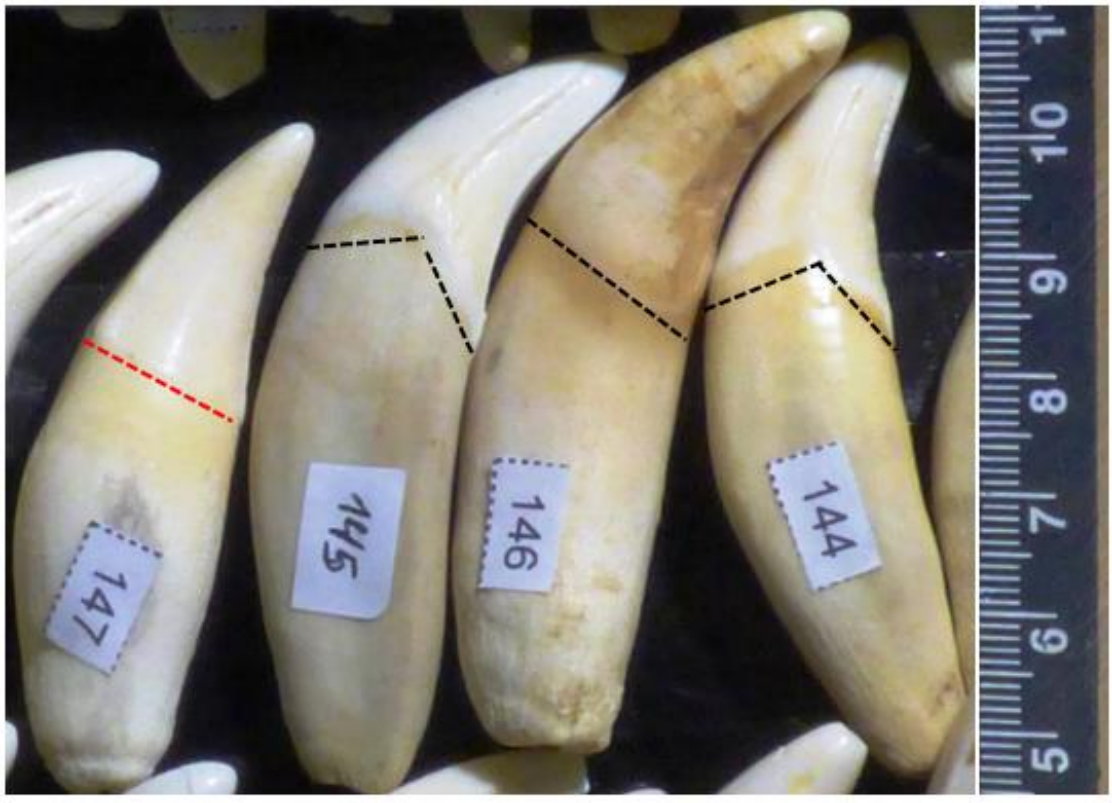
S.1. Measuring a large upper jaguar canine: a) total length 88 mm, b) crown height 41 mm.

S 2. a) Seized jaguar molars (1), premolars (2) and one upper incisor (3), b) seized collared peccary canine, and museum specimens of c) yacare caiman tooth, d) Andean bear canines.

S 3. Front teeth and skulls (in right lateral view) of jaguar (above), puma (center) and ocelot (below); at the same scale within each column.



S 4. Difference between jaguar and puma skulls, a) jaguar, rear edge of palatine bone with a notch, b) puma, rear edge of palatine round and entire.

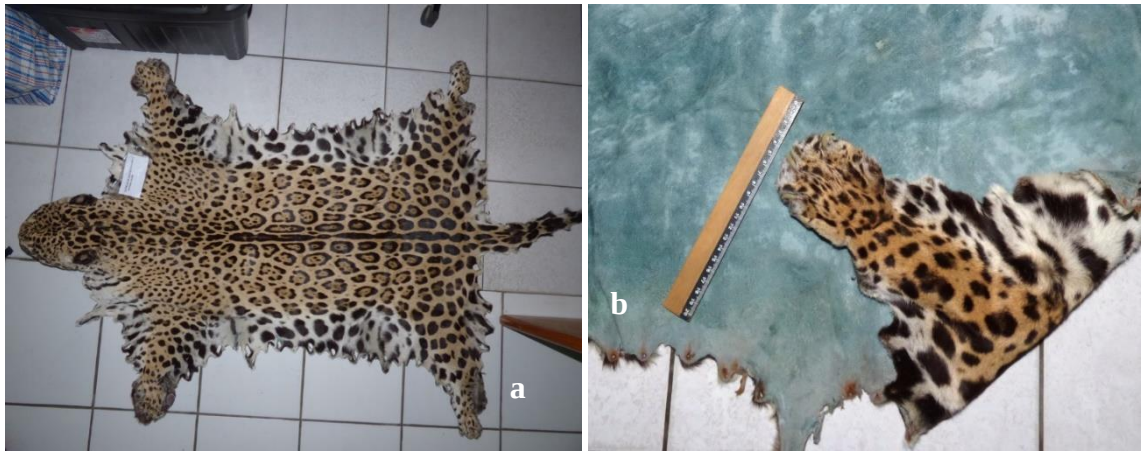


S 5. Shape differences among jaguar canines according to their position: 147 upper left, 145 lower right, 146 lower left, 144 lower right.

S 6. Size and shape differences of canines of native felids: jaguar's large roots above, puma's mid-size canines (#136, 133, 131, 129, 128, 127), ocelot's small canines (#134, 132, 130), one jaguar upper lateral incisor (#135).

S 7. Jaguar and puma canines prepared for sale: a) perforated or fixed with gold to wear as a pendant, b) cracks repaired with dental resin, and c) drilled to be repaired but unfinished.

S 8. a) Two undetermined (jaguar or puma) claws, the left one fixed with resin, b) a key chain made of a giant armadillo claw, compared to a museum specimen.



S 9. a) One of the two seized jaguar skins; b) it had been recently chrome-tanned since it showed a deep green color, which fades away in old skins.

S 10. a) A fur coat made of an estimate of eight ocelot skins, as b) this specimen from the museum.

S 11. Two of the eight chopped off rattlesnake tails.

S 12. Two of the three marsh deer skulls with antlers recovered, the last one kept flesh and skin on the bones, preserved in formalin.

S 13. The 11 figurines of mythological icons were not made of plastic nor bone, but of elephant ivory according to the obtuse angle of Schreger lines (Espinoza & Mann 1999) seen at the base of pieces.

S 14. Large Cururú toads sold: a) as stuffed animals, and b) its skin used to make wallets.

S 15. a) Skin belts made of tinted black caiman (1), yacare caiman (2), ocelot (3) and jaguar (4), b) small caiman head used as belt buckle, c) wallet made of anaconda skin (1) and black caiman (2).

S 16. a) Hat with jaguar skin, b) wallet made of tegu lizard (2) and young yacare caiman (1).

S 17. Wallets made of skins of: a) Collared peccary (1), tegu lizard (2) and black caiman (3), and b) Greater rhea throat skin (1), yacare belly (2), great rhea body (3) and constrictor boa (4).

S 18. a) Wallet made of greater rhea body skin, b) cap made of black caiman.