

2 **First description of milk teeth of fossil South American procyonid**
3 **from the lower Chapadmalalan (Late Miocene–Early Pliocene)**
4 **of “Farola Monte Hermoso,” Argentina: paleoecological**
5 **considerations**

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9 **Abstract** The first record of milk teeth of South American fossil procyonids comes from the Late Miocene–Early Pliocene at “Farola Monte Hermoso,” Buenos Aires Province, Argentina. Five extant genera of Procyonidae inhabit South America (*Bassaricyon* Allen, *Nasuella* Hollister, *Potos* Geoffroy Saint-Hilaire and Cuvier, *Procyon* Storr, and *Nasua* Storr). Of these only *Procyon* and *Nasua* are present in the fossil record (Late Pleistocene–Holocene), in several localities in Brazil, Uruguay, and Bolivia. In addition, six other fossil genera were named, but only two are considered valid: *Cyonasua* and *Chapadmalania*. Thus, *Cyonasua* encompasses ten formally named species and *Chapadmalania* two. The new specimen, MLP 09-X-5-1, is assigned to cf. *Cyonasua*. In addition, anatomical evidence implies a much more carnivorous diet in Late Miocene–Early Pleistocene procyonids than that of extant South American taxa. Finally, I examine and discuss the “competitive displacement” hypothesis regarding the extinction of native marsupial carnivores after the arrival of immigrant placental carnivores in South America.

31 **Keywords** Procyonidae · Fossil · Milk teeth · *Cyonasua* · South America

34 **Kurzfassung** Ich beschreibe hier zum ersten Mal Milchzähne von südamerikanischen fossilen Procyonidae. Diese acht Zähne (MLP 09-X-5-1) kommen aus dem späten

Miozän–frühen Pliozän von “Farola Monte Hermoso”, Provinz Buenos Aires, Argentinien. Fünf resente Gattungen von Procyonidae leben in Südamerika (*Bassaricyon* Allen, *Nasuella* Hollister, *Potos* Geoffroy Saint-Hilaire & Cuvier, *Procyon* Storr und *Nasua* Storr). Von diesen Gattungen sind nur *Procyon* und *Nasua* im Fossilbericht (spätes Pleistozän–Holozän) aus verschiedenen Lokalitäten in Brasilien, Uruguay und Bolivien bekannt. Außerdem wurden sechs fossile Gattungen benannt, aber nur zwei werden noch heute als gültig anerkannt: *Cyonasua* und *Chapadmalania*. *Cyonasua* umfasst damit zehn formell benannte Arten und *Chapadmalania* zwei. Nach der Beschreibung und dem Vergleich von MLP 09-X-5-1 ordne ich die Zähne cf. *Cyonasua* zu. Außerdem zeige ich anatomische Hinweise, die eine stärker räuberische Lebensweise und carnivore Ernährung der Procyonidae aus dem späten Miozän als die der heutigen Taxa in Südamerika anzeigen.

Schlüsselwörter Procyonidae · *Cyonasua* · Südamerika · Fossilien · Milchzähne

Introduction

Five extant genera of Procyonidae inhabit South America (*Bassaricyon* Allen, *Nasuella* Hollister, *Potos* Geoffroy Saint-Hilaire and Cuvier, *Procyon* Storr, and *Nasua* Storr). Of these only *Procyon* and *Nasua* are present in the fossil record (Late Pleistocene–Holocene), in several localities in Argentina, Brazil, Uruguay and Bolivia (Soibelzon et al. 2009a). In addition, six fossil genera have been named (*Cyonasua* Ameghino, *Oligobunis* Burmeister, *Pachynasua* Rovereto, *Brachynasua* Ameghino and Kraglievich, and *Chapadmalania* Ameghino) of which only two are considered valid today (*Cyonasua* and *Chapadmalania*, Patterson

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69 and Pascual 1972; Berman 1994; Soibelzon 2007). A thorough taxonomic study is in progress by the author. Thus, 70 *Cyonasua* encompasses ten species: *C. argentina* Ameghino, 71 *C. brevirostris* (Moreno and Mercerat), *C. longirostris* 72 (Rovereto), *C. pascuali* Linares, *C. groeberi* Kraglievich 73 and Reig, *C. lutaria* (Cabrera), *C. clausa* (Ameghino), 74 *C. robusta*, *C. argentinus* (Burmeister), and *C. meranii* 75 Ameghino and Kraglievich, whereas *Chapadmalania* 76 includes two species: *Ch. ortognatha* Ameghino and 77 *Ch. altaefrontis* Kraglievich and Ameghino. *Cyonasua* and 78 *Chapadmalania* are mainly recorded during the late Tertiary 79 (Late Miocene to Pliocene); nevertheless, there are scarce 80 records of *Cyonasua* (*C. meranii*) in the Quaternary of 81 Argentina (Ensenadan, Early to Middle Pleistocene). 82 Despite the great number of species of *Cyonasua* described, 83 it is relatively scarce, and most specimens remain 84 unpublished. 85

86 Procyonids were the first placental carnivores that 87 arrived in South America after the marine barrier separating 88 North and South America disappeared ca. 4–2.5 Ma 89 (see Woodburne et al. 2006; Soibelzon and Prevosti 2007). 90 It is important to note that recent South American procyonids 91 represent a second invasion from North or Central 92 America during the Latest Pleistocene–Holocene and are 93 not directly related to *Cyonasua* or *Chapadmalania* (Prevosti 94 and Soibelzon in press). Therefore procyonids are 95 recorded in South America from Late Miocene to Recent 96 times but with a record gap of ~900 Ky between the Early 97 and the Latest Pleistocene.

98 Milk teeth of this genus (dI3, dC1, dP1–4; belonging to 99 one specimen) are described for the first time herein. These 100 specimens from the Late Miocene–Early Pliocene at Farola 101 Monte Hermoso (Buenos Aires, Argentina) are assigned to 102 cf. *Cyonasua*. Also some paleoecological issues in relation 103 to the Mio-Pleistocene South American carnivore guild 104 (integrated by placental and marsupial carnivores) are 105 discussed.

106 Locality and age

107 Eight milk teeth (MLP 09-X-5-1) were exhumed from the 108 marine cliff at the Farola Monte Hermoso locality (see 109 Fig. 1a), Buenos Aires, Argentina. Farola Monte Hermoso 110 is of historical interest because it was one of the paleontological 111 localities visited by Charles Darwin during 1832; 112 he was the first to study the geology and paleontology of 113 this site. Farola Monte Hermoso is particularly attractive 114 because of abundant and diverse Mio-Pliocene fossils; 115 additionally this is the type locality of the Monte Hermoso 116 Formation. Interestingly, Farola Monte Hermoso was the

117 first Argentinean lighthouse; it was inaugurated in 118 November 1881.

119 The bearing level of MLP 09-X-5-1 is known as 120 “Miembro de las Limolitas claras” (Bonaparte 1960) and 121 corresponds to the *Neocavia depressidens* Biozone (Cione 122 and Tonni 1996) included in the Monte Hermoso Formation, 123 which is Chapadmalalan in age [Late Miocene–Early 124 Pliocene, Cione and Tonni (1996)]. MLP 09-X-5-1 was 125 found in association with fragmentary remains of the no- 126 toungeulate *Paedotherium* and the rodents *Actenomys* and 127 *Neocavia* (Sergio Bogan, pers. comm. 2008).

128 Materials and methods

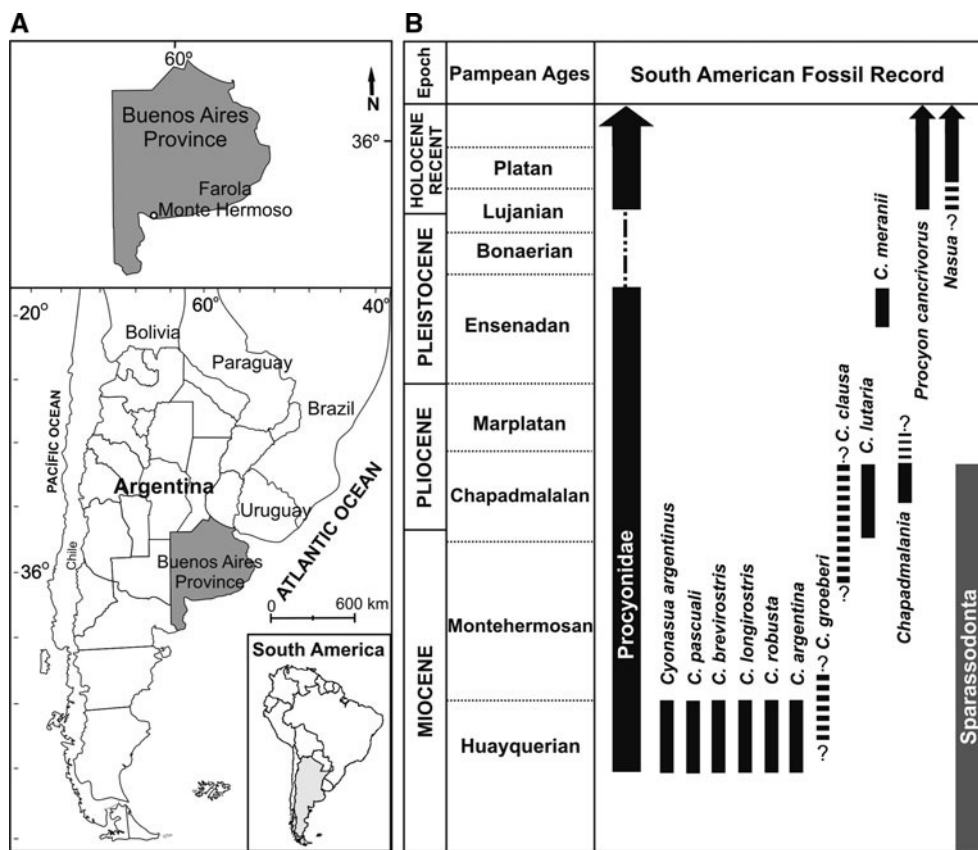
129 Material used for comparisons. Juveniles: MACN 34-47 130 (*Procyon cancrivorus*), ETMNH 301 (*P. lotor*). Adults: 131 MLP 34-VI-20-6 holotype of *Pachynasua lutaria* (= *Cy-* 132 *onasua lutaria*); MLP 29-IV-15-1 holotype of *Amphinasua* 133 *brevirostris* (= *Cyonasua brevirostris*); MACN 8209 holo- 134 type of *Amphinasua longirostris* (= *Cyonasua longirostris*); 135 AMNH 45985 holotype of *Cyonasua pascuali*; MACN 136 6687, MACN 6689, MACN 6688, MMMP 362, MMMP 137 1004, MMMP 971, MMMP 1120 (*Cyonasua* sp.); MLP- 138 zool. 1-I-03-25 (*Procyon cancrivorus*), AMNH 30748 139 (*Bassaricyon gabii*), MLP-zool 6026 (*Nasua nasua*), ET- 140 MNH 516 (*Potos flavus*), ETMNH 516 (*Bassaricyon* 141 *astutus*).

142 Morphological terms and definitions of measurements 143 follow Soibelzon and Carlini (2004) and papers cited 144 therein. We numbered the deciduous premolars mesiodis- 145 tally as Terzea (1969) and all recent authors (i.e., the last 146 deciduous premolar is dP3/dP4) to facilitate comparisons. 147 The chronostratigraphic/geochronologic units used herein 148 follow the usage by Woodburne et al. (2006). Measure- 149 ments were taken with a Vernier caliper.

150 Abbreviations

151 AMNH American Museum Natural History, USA; ETMNH 152 East Tennessee Museum of Natural History, USA; 153 GHUNLPam Geología Histórica, Universidad Nacional de 154 La Pampa, Argentina; MACN-zool: Mastozoology collec- 155 tion, Museo Argentino de Ciencias Naturales “Bernardino 156 Rivadavia”, Argentina; MACN: Vertebrate paleontology 157 collection, Museo Argentino de Ciencias Naturales “Ber- 158 nardino Rivadavia”, Argentina; MLP: Vertebrate paleon- 159 tology collection, Museo de La Plata, Argentina; MLP-zool: 160 Mastozoology collection, Museo de La Plata, Argentina; 161 MMMP Museo Municipal de Mar del Plata, Argentina. Ky. 162 Kilo Years (1,000 years). Ma. Million Years.

Fig. 1 **a** Map showing the locality Farola Monte Hermoso where cf. *Cyonasua* was recovered. **b** Chronological chart of the late Cenozoic in South America, showing the biochrons of all procyonids with fossil record and the biochron of Sparassodonta (chronostratigraphic units according to Woodburne et al. 2006)



163 **Results**

164 Systematic paleontology

165 Class Mammalia Linnaeus, 1758

166 Order Carnivora Bowdich, 1821

167 Family Procyonidae Gray, 1825

168 cf. *Cyonasua* Ameghino, 1885

169 Figure 2a–n, Table 1

170 Type species: *Cyonasua argentina* Ameghino 1885.

171 Temporal range: Late Miocene to Middle Pleistocene (Huayquerian to Ensenadan) (Fig. 1b). Geographic distribution: Argentina (Catamarca, Córdoba, Entre Ríos, Buenos Aires, Jujuy, Mendoza, and La Pampa Provinces) and Peru (?). Referred specimen: MLP 09-X-5-1: left dC1, right dI3, right dP1-4, and left dP3-4 (Fig. 2a–e) collected by Sergio Bogan.

178 Comments

179 Because the milk teeth described herein were not in association with definitive molars it is impossible to make a secure taxonomic assignment of MLP 09-X-5-1 to *Cyonasua*. However, this identification seems likely because: (1) this is the only genus presently recognized for Late Miocene to Early Pleistocene procyonids in South

185 America (*Procyon* was reported in the earliest Pleistocene of 186 Argentina by Soibelzon et al. 2009a), (2) at a nearby 187 locality the type specimen of *Pachynasua clausa* 188 (Ameghino) (= *Cyonasua clausa*) was found, and (3) the 189 general morphology of dP3–4 is more similar to that of 190 *Cyonasua* than to any other South American Procyonidae. 191 I propose to classify it as cf. *Cyonasua*. Notably, MLP 09- 192 X-5-1 is smaller than all known fossil specimen except the 193 holotype of *Cyonasua pascuali* (a mandible, AMNH 194 45985) that is the smallest species of *Cyonasua*.

195 This fossil record is 6° south of the southern limit of 196 recent procyonid distribution (*P. cancrivorus*, Entre Ríos 197 Province), and today the habitat and climatic conditions at 198 Farola Monte Hermoso are far from optimal for procyonids, 199 but wet and warm climatic conditions were inferred at 200 this locality by the Late Miocene-Early Pliocene based on 201 the fossil record (see Tonni et al. 1992 and articles cited 202 therein).

203 Description: The morphology of the third upper deciduous 204 incisor (dI3, Fig. 2a, b) is quite different from that of 205 the corresponding permanent tooth. In addition, dI3 is 206 straighter, more slender, and smaller than I3. Unfortunately, 207 the apex of the crown is broken. In labial view, the 208 upper margin of the crown is rounded, and the mesial and 209 distal margins join towards the base of the crown. In 210 occlusal view, the tooth is elliptical in section. An enamel

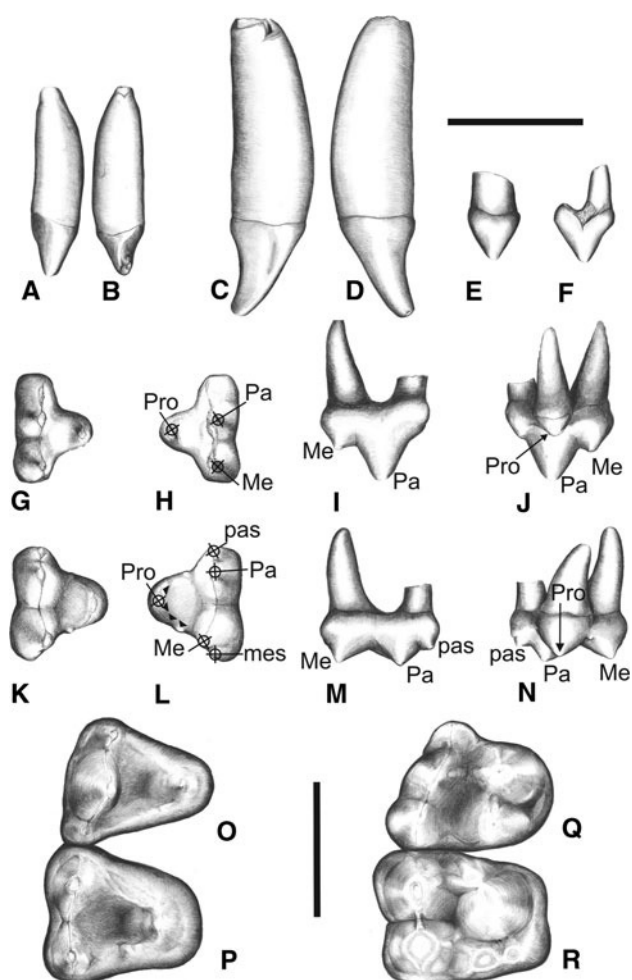


Fig. 2 MLP 09-X-5-1. Right dI3 in **a** distal view and **b** mesial view. Left dC1 in **c** mesial view and **d** distal view. Right dP1 **e**. Right dP2 **f**. Occlusal views of **g** right and **h** left dP3; Right dP3 in labial **i** and **j** lingual views. Occlusal views of right **k** and left **l** dP4. Right dP4 in labial **m** and lingual **n** views. *Cyonasua* (MLP 29-IV-15-1) right P4 **o** and M1 **p**. *Procyon cancrivorus* (MLP 1-I-03-25) right P4 **q** and M1 **r**. *Me* metacone. *mes* metastyle. *Pa* paracone. *pas* parastyle. *Pro* protocone. *Black triangle* denotes the position of a cusplet. *Scale bar* = 1 cm

Table 1 Measurements (mm) of MLP 09-X-5-1

Teeth	MDL	LLW
dI3	2.7	3.3
dC1	5.6	4.2
dP1	3.1	2.6
dP2	3.7	2.3
dP3 left	7.05	5.05
dP3 right	7.1	5.1
dP4 left	8.1	7.2
dP4 right	8.2	7.4

MDL mesiodistal length; LLW labiolingual width

crest crosses the lingual margin mesiodistally, and in the middle of this crest a low cusp is developed. The crown would have been implanted obliquely and slightly rotated mesially. The root is mesiodistally compressed and elliptical in section, as is the crown.

The left upper deciduous canine crown (dC1, Fig. 2c, d) is distally curved, and the apex is distolabially directed. Both the crown and the root are labiolingually compressed. The lingual side has a thin enamel edge running from the neck to the crown apex. The distal side is convex, and the mesial side is almost flat. The crown basal margin is at the same height around the tooth. The crown occupies a quarter of the tooth length; in definitive canines of *Cyonasua* it occupies half of the length.

The first upper deciduous premolar (dP1, Fig. 2e) has only one root (as in P1) and its crown is very simple and composed by one low and distally curved cusp. The labial side of this cusp is convex, but the lingual side is almost flat. The general morphology of dP1 is very similar to that of P1, except for the absence of a thin cingulum that runs from the mesial to the distal angle along the lingual-side crown base in definitive P1. It is important to note that P1 is often absent in *Cyonasua*.

The second upper deciduous premolar (dP2, Fig. 2f) has two roots, as does P2. The crown is simple and has one laterally compressed and slightly distally inclined cusp. This tooth is broken near the base of the mesial root, affecting not only the root but also the distal crown base. As in dP1 the labial side of the crown is convex but the lingual side is nearly flat. An enamel ridge ascends on the way to the apex of the crown and descends toward the distal angle running across the mesiodistal axis.

The crown of the third upper deciduous premolar (dP3, Fig. 2g–j) is laterally compressed. Two conspicuous labial cusps are aligned, the mesial cusp (paracone) being much higher and having a wider base than the distal cusp (metacone) (Fig. 2i); a mesiodistally oriented enamel ridge connects both cusps. The labial sides of both cusps are convex, and the lingual is almost flat (Fig. 2g, h). On the lingual side of the crown there is a small cusp (protocone) that lies at the same plane as the paracone apex (Fig. 2g, h, j). The dP3 has three roots (Fig. 2j). MLP 09-X-5-1 dP3 is morphologically simpler in comparison with the same tooth of *Procyon lotor* and *P. cancrivorus*. In these two species the protocone is high, the parastyle is well differentiated, there is a strong cingulum on the lingual border just behind the protocone, the enamel ridge that connects paracone and metacone is very sharp, descending the mesiolingual side of paracone towards the protocone, and at this level there are two small cusplets.

The fourth upper deciduous premolar crown (dP4, Fig. 2k–n) is triangular in occlusal view. The labial margin

263 is slightly curved and longer than the lingual margin, which
 264 is strongly convex. The mesial and distal margins are almost
 265 straight and converge towards the lingual side. The two
 266 labial cusps are elongated mesiodistally, and both are much
 267 larger than the lingual cusps (Fig. 2k, l, n). The mesial cusp
 268 (paracone) is larger and slightly more compressed than the
 269 distal cusp (metacone). The paracone is vertical, while
 270 the metacone is distally inclined (Fig. 2k, l). A large cusp,
 271 the parastyle, arises in front of the paracone; also in the right
 272 dP4 a small metastyle is situated behind the metacone, but it
 273 is not present on the left dP4 (Fig. 2l–n). A deep furrow runs
 274 mesiodistally between the labial and lingual cusps. On the
 275 lingual margin of the crown there is a large cusp (protocone)
 276 with several relatively low cuspules arranged in a mesio-
 277 distal series over its apex. These cuspules are more evident
 278 on the left than on the right tooth (Fig. 2l). An enamel crest
 279 descends on the lingual side of the metacone toward the
 280 center of the crown; over this crest and at the valley that
 281 divides the lingual and labial cusps there is a cuspule
 282 (Fig. 2k, l). No cingulum is observed, apart from a slight
 283 widening of the enamel running along the labial side of the
 284 metacone (Fig. 2k, l). Contrary to the case of dP3, dP4 of cf.
 285 *Cyonasua* is very similar to dP4 of *Procyon* species, the
 286 main difference being that dP4 of *Procyon* has two cusps on
 287 the lingual side, the largest corresponding to the protocone
 288 and the other to the hypocone.

289 Comparisons

290 The adult dentition of procyonids is I3/3, C1/1, P4/4, M2/2,
 291 total 40. First premolars may be absent, and extra teeth
 292 have been reported in several species (Goldman 1913;
 293 Guilday and Parmalee 1966; Lotze and Anderson 1979);
 294 this is also the dental formula of *Cyonasua* and, as in
 295 Recent taxa, the absence of first lower and upper premolars
 296 is very frequent. Procyonids' deciduous dental formula is
 297 dI2/2, dC1/1, dP4/4 (Gompper 1995). In most mammals
 298 the milk dentition is replaced once, a condition called
 299 diphodonty (hemiphyodontism by Mones 1982), the first
 300 set is called primary and the next set secondary (Jernvall
 301 1995); then deciduous teeth and molars are both primary
 302 teeth. As Jernvall (1995) pointed out, the last deciduous
 303 premolars (dP4/p4 in procyonids) always resemble the first
 304 permanent molars. Because we do not have other milk
 305 teeth of *Cyonasua* and because dP4 and M1 are both pri-
 306 mary teeth we will make comparisons between these two
 307 teeth.

308 The dP4 is triangular in occlusal view, but M1 of *Cy-*
 309 *onasua* is always wider than long (Fig. 2p). The cuspule
 310 that lies over the enamel crest and between the metacone
 311 and protocone in dP4 is always present in M1 of *Cyonasua*
 312 (Fig. 2p); in some specimens it presents two apices. There

is no cingulum on dp4, but the M1 of *Cyonasua* always has
 a lingual cingulum more or less developed (Fig. 2p). Also
 dP4 has a well-differentiated parastyle that is reduced or
 absent in the M1 of *Cyonasua* (Fig. 2p).

Paleobiology and paleoecology

Interestingly, dP3 of cf. *Cyonasua* (Fig. 2g–j) and *Procyon*
 are much more sectorial (i.e., laterally compressed trigonid,
 high and sharp lingual cusps) than P4 (Fig. 2o, q); in fact
 they are more similar to the P4 of much more carnivorous
 procyonids, such as *Bassariscus* Coues. In turn, it is
 remarkable that the absence of a hypoconid in the dp4 of
 cf. *Cyonasua* (Fig. 2k–n) corresponds to the absence of this
 cusp in the M1 of *Cyonasua* (Fig. 2p). On the other hand,
 its presence in *Procyon*'s dP4 is congruent with its pres-
 ence in their M1 (Fig. 2r).

The reduction of cingula and the absence of the hypo-
 cone in the P4 and M1 of *Cyonasua*, in contrast to the
 condition observed in Recent South American procyonids
 (i.e., *Bassaricyon*, *Nasuella*, *Potos*, *Procyon*, and *Nasua*),
 suggest an omnivorous but mostly carnivorous diet for the
 former taxon. In turn, *Procyon*, *Nasua*, *Nasuella*, *Potos*,
 and *Bassaricyon* are mainly frugivores and/or insectivores
 and only opportunistic predators (Kays 2009), with clearly
 bunodont molars (e.g., square-shaped P4 and M1 with
 well-developed hypocone, Fig. 2q–r) in contrast to the
 much more secodont molars (e.g., P4 and M1 triangular-
 shaped without hypocone, Fig. 2o–p) observed in *Cyona-*
sua species.

This dietary shift (and consequently ecological niche
 change) between the first immigrant procyonids and the
 Recent taxa could have been the result of the peculiar
 evolution of the carnivore guild in South America, because
 here the only placental carnivores until the Late Pliocene
 were procyonids (Forasiepi et al. 2007; Soibelzon et al.
 2009b). The other mammalian predators were the Spar-
 assodonta (Metatheria) that become extinct by the Late
 Chapadmalalan (Forasiepi et al. 2007 and articles cited
 therein; Fig. 1b).

There is considerable debate as to whether placental
 carnivores arriving from North America caused the
 extinction of South American marsupial carnivores by
 competitive displacement (e.g., Simpson 1950 and sub-
 sequent papers, Patterson and Pascual 1972; Werdelin
 1987, 2009) or not (e.g., Forasiepi et al. 2007; Prevosti
 et al. 2009). The fossil record indicates that Sparassodonta
 taxa only coexisted with procyonids (Fig. 1b), as they
 become extinct before the first record of *C*ae in the
 Marplatense age and when procyonids were appear spar-
 assodonts were already in decline (Marshall 1977; Forasi-
 epi et al. 2007).

363 On the other hand, most sparassodontids were hyper-
 364 carnivores, thus they occupied a different ecological niche
 365 from that occupied by procyonids. Some sparassodonts
 366 (e.g., *Stylocinus* Mercerat, “Prothylacininae”) show more
 367 omnivore molar morphologies (Forasiepi et al. 2007) and
 368 could have entered in ecological competition with
 369 *Cyonasua*. Although the fossil record indicates that these
 370 taxa become extinct shortly after a relatively short coex-
 371 istence with procyonids (during the Huayquerian, Late
 372 Miocene; see Forasiepi et al. 2007), they were larger than
 373 *Cyonasua* and presumably occupied a different ecological
 374 niche. Noticeably, it was during this time span that
 375 *Cyonasua* experienced its greatest diversity (seven species,
 376 out of ten described, were present). During a relatively
 377 short time span (Middle to Late Pliocene), large procyonids
 378 (body mass ~25 kg in contrast to the ~6–7 kg of
 379 *Cyonasua*) belonging to the genus *Chapadmalania*
 380 Ameghino (closely related to *Cyonasua*; Kraglievich and
 381 Olazabal 1959) were recorded in South America, but they
 382 quickly become extinct and their fossil record is very poor
 383 (Fig. 1b). Noticeably, *Chapadmalania* extinction appears
 384 to have been approximately synchronous with the last
 385 record of Sparassodonta (family Thylacosmilidae; Fig. 1b).

386 It was not until the Late Pliocene (Marplatan) that other
 387 placental carnivores (e.g., Canidae, Mustelidae) migrated
 388 to South America (Prevosti and Pardiñas 2009; for a dif-
 389 ferent view, see Verzi and Montalvo 2008) in the context
 390 of the Great American Biotic Interchange (see Woodburne
 391 et al. 2006; Soibelzon and Prevosti 2007). By the Early
 392 Pleistocene (Ensenadan), the placental carnivores were
 393 represented in South America (as today) by six families
 394 (i.e., Felidae, Ursidae, Canidae, Mustelidae, Mephitidae,
 395 and Procyonidae). Noticeably Procyonidae, with the lon-
 396 gest presence in South America, was represented in
 397 Ensenadan times by only one species (*Cyonasua meranii*
 398 Ameghino and Kraglievich), and according to the fossil
 399 record, procyonids disappeared from South America by the
 400 Early-Middle Pleistocene boundary (the boundary between
 401 Ensenadan and Bonaerian; Fig. 1b).

402 Therefore, while procyonids were the only placental
 403 carnivores in South America, they were diverse and,
 404 according to their molar morphology, seemed to have
 405 occupied a much more predator niche than today. Never-
 406 theless, when the other placental carnivores arrived they
 407 promptly become extinct.

408 The fossil record indicates that, after the extinction of
 409 *Cyonasua meranii*, procyonids were absent from South
 410 American ecosystems during nearly 900 Ky, as the next
 411 record of a procyonid in South America is from the Latest
 412 Pleistocene (Lujanian) when *Procyon* ~~syn~~ *syn* *syn*
 413 (G. Cuvier) is recorded for first time (Soibelzon et al.
 414 2009a). Remarkably, when Recent taxa (i.e., *Bassaricyon*,
 415 *Nasuella*, *Potos*, *Procyon*, and *Nasua*) joined the South

American carnivore guild, they occupied a quite different
 niche from that occupied by fossil procyonids for almost
 6 Ma.

Further studies are needed to understand the role of
Cyonasua and *Chapadmalania* in the South American Mio-
 Pleistocene ecosystems and the possible causes of their
 extinction; hence, this contribution could be a starting point
 for future research projects.

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