

Appendix S4 - Local South American Native Ungulates (SANU), rodents, marsupials, and other vertebrates from Quebrada Fiera (Mendoza Province, Argentina).

Since the first detailed studies by Cerdeño *et al.* (2010) and Cerdeño & Vera (2010) to the recent works by Schmidt *et al.* (2019) and Martínez *et al.* (2020), almost all the Quebrada Fiera meridiungulate (= SANU) findings have been analysed from anatomical, systematic, and evolutionary perspectives. The SANU are the most abundant mammals in the late Oligocene assemblage of Quebrada Fiera, with different proportions of their clades (Fig. 17B–C), some being absent (e.g., Astrapotheria, and Xenungulata, the latter did not reach the Oligocene).

SANU are represented in Quebrada Fiera by three orders (Fig. 17B–C): i) notoungulates (Fig. S1), ii) pyrotheres, and iii) litopterns (Table 1). The notoungulates (Notoungulata) are present in South America throughout the Palaeogene and Neogene periods, and Pleistocene epoch, with a peak of species diversity during the late Eocene and Oligocene epochs (see Croft *et al.* 2020 for further details). During the Desadan, they are represented by 33 genera (Croft *et al.* 2020), thus constituting by far most of the small- medium- and large-sized representatives of the mammalian fauna. Eight of the thirteen commonly recognized clades, traditionally considered as families, are present in Quebrada Fiera: four Typotheria - Hegetotheriidae, “Archaeohyracidae,” Interatheriidae, and Mesotheriidae – and four Toxodontia - Notohippidae, Leontiniidae, Toxodontidae, and Homalodotheriidae (Table 1, Fig. 17B–C; e.g., Cerdeño & Vera, 2010, 2014, 2015, 2017; Seoane & Cerdeño 2014; Cerdeño & Reguero 2015; Hernández Del Pino *et al.* 2017). Sixteen notoungulate species, representing these eight clades, constitute 84% of the SANU species and 42% of all mammalian species in Quebrada Fiera, with a clear predominance of hegetotheriids (Fig. 17B–C). Notoungulata represent 70% of SANU species during the

Deseadan (Croft *et al.* 2020), which is slightly lower than the percentage in the sole Quebrada Fiera locality.

Some Hegetotheriidae are among the smallest Typotheria and convergently resemble lagomorphs. In Quebrada Fiera, the hegetotheriids are the most diversified notoungulates (i.e., five species; Table 1, Fig. 17B), as in the Bolivian locality of Salla (Billet *et al.* 2009). Cerdeño & Reguero (2015) recognized the hegetotheriines “*Prohegetotherium*” *malalhuense*, “*Prohegetotherium*” *schiaffinoi*, “*P.*” cf. *sculptum*, and “*Prohegetotherium*” sp. (identified as *Hegetotheriopsis sulcatus* by Kramarz & Bond 2016), and the highly hypselodont pachyrukhine *Propachyrucos* cf. *smithwoodwardii* (later recognized as *Prosotherium garzoni* by Seoane *et al.* 2019) in the Mendozan Deseadan locality. *Hegetotheriopsis sulcatus* is the most basal recognized hegetotheriine (Kramarz & Bond 2016). “*Prohegetotherium*” *malalhuense* (Fig. S1A–B) is endemic to Quebrada Fiera and differs from other “*Prohegetotherium*” species by several dental characters (see Cerdeño & Reguero 2015). The other Quebrada Fiera hegetotheriines are common in other Deseadan localities from Patagonia, and the widespread species “*P.*” *schiaffinoi* is also present in Bolivia and Uruguay. Small hegetotheriids clearly suggest the presence of open habitat (Cassini 2013). The presence of *Prosotherium* is the northernmost geographic record of Pachyrukhinae (Seoane *et al.* 2019). The members of “Archaeohyracidae” resemble hyracoids (hence the name) in general aspect and ecology and are relatively abundant in terms of quantity of specimens in Quebrada Fiera (as in Salla, Billet *et al.* 2009; Fig. 17C), in contrast to Patagonian localities, but *Archaeohyrax suniensis* is the only species recognized (Cerdeño *et al.* 2010) and one of the last representant of this genus. Interatheriidae are highly diversified and extremely widespread in South America at this time. Vera *et al.* (2017) recognized three interatheriids in Quebrada Fiera: *Argyrohyrax proavus*,

Progaleopithecus sp., and an unidentified taxon represented by a single specimen. The first two genera are also represented in localities from high (Patagonia), approximately middle (Fray Bentos in Uruguay and Argentina), and lower (Salla in Bolivia) latitudes. Furthermore, their presence in Quebrada Fiera extends the geographic distribution for both taxa into the middle latitudes of west central Argentina (Vera *et al.* 2017). Mesotheriidae, which appeared during the late Oligocene in South America and survive until the Pleistocene (Billet 2011), were medium-sized notoungulates with a peculiar dentition reminiscent of that of Glires and may have had fossorial capabilities. Cerdeño (2014) recognized in Quebrada Fiera a single species, *Trachytherus* cf. *spgazzinianus*, based on a skull fragment. *T. spgazzinianus* is recognized in localities from higher (Patagonia) and lower latitudes, such as Salla and Lacayani in Bolivia (Billet *et al.* 2008).

Notohippidae (Toxodonta) exhibit numerous convergences mainly with equoids. They are represented in Quebrada Fiera by *Mendozahippus fierensis* (Cerdeño & Vera 2010, 2014; Fig. S1B–C) that is also likely present in Fray Bentos Fm. in Corrientes Province (Argentina, Cerdeño *et al.* 2020) and an undetermined taxon (Cerdeño & Vera 2014; Table 1). The basal notohippid *Mendozahippus fierensis* presents an elongation of the limbs (similar to *Rynchippus* and more gracile than *Eurygenium*) in relation to a more open habitat. Leontiniidae include large and powerful notoungulates that possibly occupied the ecological niche of modern pachyderms (i.e., open habitat). They were highly diversified during the late Oligocene in Argentina, Bolivia, and Brazil (Cerdeño & Vera 2015), but limited in faunistic assemblages to never more than two coeval species in the same locality (Ribeiro *et al.* 2010). Cerdeño & Vera (2015) described the endemic species *Gualta cuyana* (Fig. S1D–E), the only leontiniid recognized in Quebrada Fiera and represented by craniodental and postcranial remains (Hernández Del Pino *et al.* 2017;

Martínez *et al.* 2020). Hernández Del Pino *et al.* (2017) also recognized two Toxodontidae in this locality, *Proadinotherrium* sp. and an undetermined taxon, based on fragmentary dental and postcranial material. Toxodontids were large to very large mammals, with probably pachyderm lifestyle, like leontiniids. The Deseadan genus *Proadinotherrium* is relatively well distributed in both higher (Bolivia) and lower (Patagonia) latitudes (Hernández Del Pino *et al.* 2017). The last family of toxodontians present in Quebrada Fiera is the peculiar Homalodotheriidae, represented by *Asmodeus petrasnerus* (Seoane & Cerdeño 2014), a species different from the Patagonian *A. osborni*. Homalodotheriidae is constituted by large Oligo-Miocene taxa characterized by the presence of claws in the forelimb; they are considered mainly browsers, possibly inhabitants of wooded environments. *A. petrasnerus* is represented by isolated postcranial remains (Fig. S1F–G) and constitutes the first mention of the genus outside Patagonia.

The pyrotheres (Pyrotheria) are massive tapir-like SANU restricted to the Eocene and Oligocene of Argentina, Bolivia, Brazil, Colombia, Peru, and Venezuela. They are poorly diversified and possessed incisor tusks, bilophodont teeth, and, possibly, a proboscis (Croft *et al.* 2020). They are represented by one (Pyrotheriidae) or two (if considering the Late Eocene Colombitheriidae) clades (see Billet *et al.* 2010 and Croft *et al.* 2020 for further information). The pyrotheriid *Pyrotherium* is one of the most typical elements of the Deseadan SALMA. In a recent detailed study, Houssaye *et al.* (2016) suggested that *Pyrotherium* presented graviportal hyperspecializations rather than semi-aquatic habits, as it was commonly accepted in the literature. *Pyrotherium romeroi*, recognized by Cerdeño & Vera (2017) in Quebrada Fiera, is typical of late Oligocene Patagonian localities and is also known from Salla (Shockey & Anaya 2008), several Amazonian localities of Peru (Antoine *et al.* 2016), and the Taubaté Formation (Brazil; Couto-Ribeiro 2010). In Quebrada Fiera, the pyrotheres represent only 5% of the SANU

species (Fig. 17B), which is comparable with other contemporaneous localities (i.e., 2% according with Croft *et al.* 2020).

The litopterns (Litopterna) are equoid-like SANU in relation to their similar aspect to Equidae, as reflected by their limb, and particularly ankle, morphology (e.g., Cifelli 1983). They are represented by nine clades (e.g., Croft *et al.* 2020), including Proterotheriidae and Macrauchiidae, the only litoptern families identified in Quebrada Fiera, each scarcely represented by a single species (Schmidt *et al.* 2019), and comprise ~10% of the SANU species (Table 1; Fig. 17B), less than half of that in other Deseadan localities (i.e., 19% according with Croft *et al.* 2020). Litopterns were diversified in South America especially during the Miocene and represented by small and large forms, such as proterotheriids and macrauchiids, respectively (see Croft *et al.* 2020 for further details). The only two litopterns present in Quebrada Fiera are the stem macrauchiid *Coniopternium andinum* and the proterotheriid cf. *Lambdaconus suinus* (Schmidt *et al.* 2019; Fig. 17C). *C. andinum* is present in lower (Bolivia and Peru) and higher (Argentine Patagonia) latitude localities and its presence in Mendoza Province extends its geographical distribution; moreover, the probable presence of *Lambdaconus suinus* in Quebrada Fiera corresponds to the first mention of this genus outside Patagonia (Schmidt *et al.* 2019). The Litopterna (as well as the Astrapotheria) are generally considered mainly browsers occupying closed habitats (Soria 2001; Cassini 2013).

The absence of the astrapotheres (Astrapotheria), mammals characterized by enlarged canines and the probable presence of a proboscis (e.g., Kramarz & Bond 2009; Goillot *et al.* 2011), is notable and somewhat surprising. Their absence from Quebrada Fiera could reflect the beginning of their decline, at least on the western part of Argentina. Riggs (1935) suggested that some astrapotheres might have lived in semiaquatic habitats. Environmental conditions, such as

the absence of significant expanses of water might also explain their absence in several late Oligocene faunas. Alternatively, bias in the fossil record cannot be completely dismissed.

In summary, three of the SANU clades commonly recognized at the end of the Oligocene in South America are present in the locality of Quebrada Fiera (i.e., 84% of notoungulates, 11% of litopterns, and 5% of pyrotheres in terms of species; Fig. 17B) with a clearly large predominance of notoungulates as in the rest of the continent and the notable absence of astrapotheres. Of the 19 SANU species listed in Table 1 (which represent precisely half of the species of the mammalian Quebrada Fiera fauna), three species (= 16%) are only present in Quebrada Fiera locality up to now: i) the hegetotheriid “*Prohegetotherium*” *malalhuense* (Fig. S1A), ii) the leontiniid *Gualta cuyana* (Fig. S1D–E), and iii) the homalodotheriid *Asmodeus petrasnerus* (Fig. S1F–G). Several authors (e.g., Cerdeño & Vera 2017; Hernández Del Pino *et al.* 2017; Vera *et al.* 2017) suggested that the Quebrada Fiera SANU fauna presents affinities with contemporaneous faunas from lower (i.e. Bolivia and Uruguay) and mainly higher (Patagonia) latitudes. Indeed, several taxa are present in Patagonia and also in Bolivia and/or Uruguay: “*Prohegetotherium*” *schiaffinoi*, *Archaeohyrax suniensis* (abundant in Bolivia), *Argyrohyrax proavus* and *Progaleopithecus* sp. (present in Fray Bentos Fm. but not in Bolivia), *Trachytherus spegazzinianus*, *Proadinotherrum*, *Pyrotherium romeroi*, and *Coniopternum andinum*. Other taxa from Quebrada Fiera with only higher latitude record are: “*Prohegetotherium*” *sculptum*, *Hegetotheriopsis sulcatus*, *Prosotherium garzoni*, *Asmodeus* (with a different species), and *Lambdaconus suinus*. The SANU in the Quebrada Fiera fauna record the last presence of *Archaeohyrax*, *Trachytherus*, *Argyrohyrax*, *Progaleopithecus*, and *Pyrotherium*, which did not survive the Oligo-Miocene turnover and support a late Oligocene age (i.e., Deseadan SALMA) for this fauna, as it had already been established (e.g., Cerdeño &

Vera 2017). The SANU fauna from Quebrada Fiera is constituted by: i) small- (Hegetotheriidae, Interatheriidae, and “Archaeohyracidae”) and medium- (i.e., Mesotheriidae) sized animals with ecological similarities to lagomorphs, ii) medium and large-sized animals (i.e., Toxodonta, Homalodotheriidae, and Pyrotheria), most of which presenting ecological similarities to pachyderms, and iii) equid-or camelid-like ungulates (i.e., Litopterna). The SANU fauna as a whole is represented by characteristic animals of an open habitat (e.g., Cassini 2013, for the study of comparable faunal assemblage from the Santacrucian SALMA, and Ercoli *et al.* 2019 and SANU at a more general level), with isolated forests, and the presence of water bodies, a mammalian fauna and environment comparable to modern southern Africa.

Ultimately, caviomorph rodents, of African origin, are present at least since the late middle Eocene in South America and have been recovered from several Amazonian localities of Peru (~41 Ma; Antoine *et al.* 2012, 2016). Rodents are generally abundant in Palaeogene South American fossiliferous localities; however, they are extremely scarce in late Oligocene Quebrada Fiera locality, which is surprising. Considering the abundance, diversity, and exceptional preservation of the majority of the vertebrate remains recovered from Quebrada Fiera, peculiar taphonomic conditions might explain their rarity; the same observation can be made for other small vertebrates, which are extremely rare or entirely missing, such as marsupials, primates, bats, or lizards.

Late Oligocene caviomorphs represent one of the most significant early adaptive radiations of this group of rodents. Through the Deseadan SALMA, Caviomorpha exhibits a high taxonomic diversity, are represented by approximately 30 genera, and have an extensive geographic distribution, with those from Salla (Bolivia) and Patagonia (Argentina) being particularly diverse (Pérez *et al.* 2018).

The handful of rodent fossils discovered at Quebrada Fiera (Fig. 17C) indicates the presence of three taxa (Fig. 17B): a new cavioid of the genus *Asteromys* and the chinchilloids *Incamys bolivianus* and *Cephalomys* sp. The new species of *Asteromys* (Candela *et al.*, unpublished data) presents closer affinities with the Bolivian *A. bolivianus* from Salla than with *A. punctus*, which is exclusively present in the Patagonian localities of Cabeza Blanca, Punta Nava, and Laguna de Los Machos (Pérez *et al.* 2018). Among Chinchillioidea from Quebrada Fiera, *Incamys bolivianus* is represented by isolated cheek teeth (e.g., Fig. S2A–B), with an occlusal pattern identical to that of *Incamys bolivianus* from the Deseadan SALMA of Salla (Hoffstetter & Lavocat 1970) and Cabeza Blanca (Vucetich *et al.* 2015; Busker & Dozo 2017). Therefore, the record of *Incamys* and *Asteromys* in Quebrada Fiera, together with other mammals reported from this locality and especially SANU (e.g., Cerdeño 2011, 2014; Cerdeño & Reguero 2015; Vera *et al.* 2017), complete their patterns of distribution (Pérez *et al.* 2018). The third rodent, *Cephalomys* sp., is identified based on isolated cheek teeth (e.g., Fig. S2C–D) that have a molar morphology very similar to those of *C. arcidens* (Wood & Patterson 1959; Busker 2013, 2019; Vucetich *et al.* 2015). The genus *Cephalomys* showed up to now an exclusive Patagonian distribution, with records in La Flecha, Punta Nava, Cabeza Blanca, and Pico Truncado (Vucetich *et al.* 2015; Busker 2019). The caviomorphs from Quebrada Fiera reveal a complex biogeographic history, as it contains one that is endemic, a species of *Asteromys*, a second with Patagonian affinities, *Cephalomys* sp., and a third, *Incamys bolivianus*, with a wide distribution in South America.

Metatherians (marsupials and stem relatives) recognized in Quebrada Fiera include the sparassodonts *Proborhyaena gigantea* (Bond & Pascual 1983) and a taxon preliminarily identified

as *Pharsophorus* sp., and the stem paucituberculatan *Fieratherium sorex* (Forasiepi *et al.* 2014). The first metatherian species known from Quebrada Fiera was *P. gigantea*, a partial left maxilla and left dentary described by Bond & Pascual (1983; Fig. S2G–H). *P. gigantea* was a hypercarnivore with the capacity to break hard elements, such as bones, similar to the living hyenas (i.e., *Crocota*; Zimicz 2012). The calculated body mass (>200 kg; e.g., Prevosti & Forasiepi 2018; Zimicz 2012) suggests that this is the largest sparassodont hitherto known. Remains of *P. gigantea*, or specimens tentatively assigned to this species, were also recovered from other Deseadan localities of Uruguay (i.e., Paso del Cuello, Mones & Ubilla 1978) and Argentina (e.g., Patagonia; Patterson & Marshall, 1978; Forasiepi 2009). The second sparassodont corresponds to an undetermined Borhyaenoidea, much smaller than *P. gigantea*. The size range and preliminary observations on its dental features are reminiscent of *Pharsophorus* (see Forasiepi *et al.* 2014), a genus from the late Oligocene (Deseadan) of Argentina and Bolivia (see Marshall 1978; Prevosti & Forasiepi 2018).

The most peculiar metatherian taxon from Quebrada Fiera is *Fieratherium sorex*, a stem Paucituberculata with unique dental features among South American metatherians, largely convergent with eulipotyphlans (Forasiepi *et al.* 2014). The specimen consists of partial dentaries and maxilla with dentition of a juvenile specimen (Fig. S2E–F). The presence of this unique form in the Deseadan beds of Quebrada Fiera, but absent from the richest outcrops of Patagonia, suggests that *F. sorex* may represent a lineage that had its origin in more Neotropical regions (see also Goin & Candela 2004), a likely view but currently unsupported by the fossil record.

In sum, Quebrada Fiera metatherians are known by two large sparassodont predators, *Proborhyaena gigantea* and a borhyaenoid indet comparable with *Pharsophorus* spp., recognized in higher (Argentine Patagonia both taxa) and lower (Uruguay the former and Bolivia

the latter) latitudes of South America, and a very small stem paucituberculatan with peculiar “insectivoran” features, *Fieratherium sorex*, to date only reported for the locality of Mendoza.

Extinct birds are present in Quebrada Fiera. Gorroño *et al.* (1979), in their preliminary faunal list, noted the presence of the “terror bird” phorusrhacid cf. *Andrewsornis*. This genus of giant flightless predatory birds is present exclusively during the late Oligocene in several localities of Patagonia, Argentina (Alvarenga & Höfling 2003). Several indeterminate fossils belonging to small undetermined birds are also signaled in this locality (e.g., Cerdeño 2011; Table 1). Finally, an iguanid reptile of uncertain affinities (Cerdeño 2011) completes the vertebrate faunal list of the late Oligocene locality of Quebrada Fiera.

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