

# Cave Paleontology in the Lagoa Santa Karst

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## Abstract

In Brazil, the majority of fossils of Quaternary tetrapods were found in caves. Among the fossil sites, the Lagoa Santa Karst stands out, especially regarding mammal paleontology. This chapter aims to present a review of the paleontological research in the area, which started in the beginning of the nineteenth century with Danish naturalist Peter Wilhelm Lund. Besides having discovered 22 extinct mammal species, Lund also described eight living species. Lund also performed studies about other vertebrates such as birds. He was also the first to discover remains of humans associated with the extinct megafauna. It took nearly one hundred years before systematic paleontological research in Lagoa Santa was resumed, through the work of members of the Academia Mineira de Ciências (Minas Gerais Academy of Sciences) and National Museum at Rio de Janeiro. Among the scientists, the names of Aníbal Mattos, H.V. Walter, Fausto Souza Cunha, and Carlos de Paula Couto stand out. Up to now, the life and works of Peter Lund are still being researched. In the 2000s, more sophisticated techniques were applied to Lagoa Santa fossil sites, including radiometric dating and a taphonomical approach, allowing the confirmation of the contemporaneity between humans and the extinct fauna. Efforts were also made toward understanding the mechanisms associated with the formation of the fossiliferous cave deposits in the area.

## Keywords

Quaternary mammals • Lagoa Santa Karst • Peter Wilhelm Lund • Cave paleontology • Minas Gerais

## 1 Lund's Discoveries in Lagoa Santa

Peter Wilhelm Lund (Fig. 1) was born in Copenhagen, Denmark in 1801 and died in Lagoa Santa (state of Minas Gerais, Brazil) in 1880. He went to medical school at the University of Copenhagen for 6 years. At that time, Natural Sciences were studied as a complementary program for students in the Medical and the Theology programs. After graduating, he exchanged the hospital for the Botanical Garden and The Natural History Museum of Denmark. Subsequently, he received a grant to gather zoological and botanical collections for the aforementioned institutions and decided to travel to Brazil where he arrived in 1825. His work was mainly in the vicinity of Rio de Janeiro, Niterói, and Nova Friburgo, in the state of Rio de Janeiro. He collected botanical material, fish, skulls, and skeletons of mammals, insects, and shells, for the future king Prince Christian's (1786–1848) collection.

He returned to Europe 4 years later. After defending his doctoral dissertation at the University of Kiel (Germany) in November 1829, he traveled to several European countries: Italy, Austria, Germany, and Switzerland, contacting renowned scientists of the time. After that, he arrived in Paris in 1830, remaining there for 9 months. There he contacted several famous naturalists such as von Humboldt (1769–1850), Milne-Edwards (1800–1855), and Audouin (1793–1841). The latest introduced Lund to Cuvier (1769–1832); he then attended the famous scientist's History of Science Course as a listener at the Collège de France. Cuvier influenced Lund's way of interpreting the history of living beings (Hoch 1982).

As a student Lund read Cuvier's first book of Zoology: *Tableau élémentaire d'histoire naturelle des animaux*, published in 1798 and translated into Danish in 1801. In 1824, Lund wrote a thorough essay on physiology based on experimentation, as opposed to writing from philosophical speculations, which was common at the time. The essay was published in German the following year and was used as

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**Fig. 1** Peter W. Lund (1801–1880). Photo by E. Warming around 1865. Collection of the Natural History Museum of Copenhagen

textbook in several European universities (*Physiologische Resultate der Vivisectionen neuerer Zeit*). In the Preface, Lund mentions Cuvier as a renowned person in the field of zoology.

During his stay in Paris, in addition to Cuvier's course, he attended courses in astronomy, physics, and chemistry with Professors Biot (1774–1862), Ampère (1775–1836), and Thénard (1776–1857), respectively. In 1831, the *Annales des Sciences Naturelles* published a paper by Lund: "Lettre sur les Habitudes de Quelques Fourmis du Brésil, adressée to M. Audouin." Lund brought from Brazil a collection of ants with 30 different species, only three had been previously described.

The death of his mother, the monotony of the European fauna and flora, and the climate, made Lund decline the invitation of several universities and return to Brazil, where he arrived in 1833, a year after Charles Darwin (1809–1882) was in Rio de Janeiro, and stood there until his death.

He immediately resumed his studies in Rio de Janeiro, where he was in touch with members of the Langsdorff Expedition, in special the naturalist Olfers (1793–1872) and the botanist Riedel (1790–1861), both Germans. Olfers narrated the findings of two giant sloths in Rio Grande do Sul which were sent to Germany, while Riedel, who in 1829 finished his work on the expedition mentioned, would

become the Director of the Botanical Garden of Rio de Janeiro. Riedel and Lund decided to carry out an expedition for collecting samples of the Brazilian Cerrado flora. The project included traveling through the States of Rio de Janeiro, São Paulo, and Minas Gerais, ending in the capital of the state of Goiás. The expedition departed in October 1833.

The obvious difficulties of the trip along with a disease that struck Riedel were responsible for aborting the expedition when they reached the area currently named Uberaba, a city in the Center-West of Minas Gerais. On the way back, they crossed the São Francisco River in Paracatu (Minas Gerais). They went to Ouro Preto where they took the road Estrada Real, leading to Rio de Janeiro.

In Santo Antônio de Curvelo, a city in the center of Minas Gerais, they spent the night on a ranch. And by chance the Danish naturalist–botanist had his life changed. The fortuitous meeting with an also Danish guest at the ranch, Peter Claussen (1801–1872), resulted in a radical change in the scientific life of P. W. Lund.

Like Riedel, Claussen during the Langsdorff Expedition worked with the German paleontologist Sellow gathering fossils in the state of Rio Grande do Sul and in Uruguay. Sellow drowned in the Doce River, in Minas Gerais, and Claussen eventually acquired a small farm near Santo Antônio de Curvelo, where there were numerous caves in which he obtained saltpeter and mammal fossils he traded with European museums. Most certainly his encounter with Claussen made him relive his contact with Cuvier and with paleontology, the new science. This new science became very important in the early nineteenth century, mostly due to the work of two exceptional scientists, the French Georges Cuvier and the English Richard Owen (1804–1892).

The trip continued to Ouro Preto, which was at that time the capital of the "Province" Minas Gerais. Recovered from his illness, Riedel continued his trip to Rio de Janeiro but Lund returned to the vicinities of Santo Antônio de Curvelo. On his way back, he went through the small town of Lagoa Santa, which had approximately five thousand inhabitants. There were hundreds of cave openings in the vicinity where he chose to live.

The decision was made: his interest in botany shifted to paleontology. His first excavation took place in the Maquiné Cave in 1835, which had been discovered shortly before. Impressed by the odd beauty of the cave, he described it in his First Memoir (Lund 1837). In addition to the narration of his first paleontological findings, he published the wonderful cave map (Fig. 2) made by his recently hired secretary and draftsman Peter Andreas Brandt (1792–1862), Norwegian, who worked with him until his death.

Lund's numerous publications proved his magnificent intellectual readiness of a genius. In addition, they showed a progressive evolution in the accuracy of his taxonomic



**Fig. 2** Map of Maquiné Cave (Lapa Nova de Maquiné). Survey and drawing by P. A. Brandt. From Lund (1837)

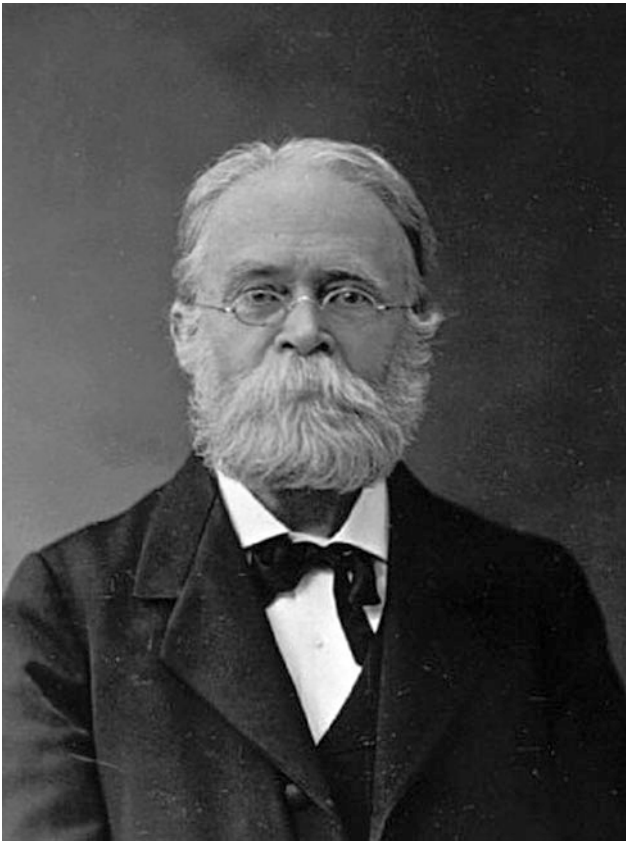
determinations. Lund pioneered the survey of the Quaternary faunal composition of a region, identifying numerous species of mammals. Showing an encyclopedic knowledge in his isolation in Lagoa Santa, over the years he modified his taxonomic determinations being able to identify among the recovered fossils the extinct species and the living ones. Throughout his memoirs, he offered ever more accurate lists of the extinct and the living species whose fossils he encountered during expeditions to the enormous number of eight hundred caves. He has thus reached an unprecedented achievement: a broad and comprehensive survey of the species of a region in two distant historical moments separated by ten thousand years. The exactness of his taxonomic determinations shows his vast knowledge. The mistakes made by him can be considered to be almost “logical.”

The repetition of his findings and the high costs incurred in the excavations were decisive for Lund’s termination of the project, donating the collection consisting of over 12,000 fossil pieces—most of the items being mammals—to King Christian VIII in Denmark, in 1845. In his letter to the King that same year, Lund explained: “This collection must be used by science as soon and as completely as possible due to interest and the scientific value of it” (Lund and Paula Couto

1950: 10). The material was sent along with a manuscript Catalog with numerical record, morphological and specific identifications, as well as the location of each finding. In addition, he has also sent a collection of breccias from several caves, as well as a huge collection of micro mammal fossils collected from a chamber in Escrivania Cave. These small bones were the result of regurgitations of successive generations of owls on the site, which left such record at the end of the Pleistocene—there will be further development on this finding.

The collection sent to Denmark became a reference in Europe and placed Lagoa Santa in the world scientific circuit. The discoveries were, in addition to being original, broad, and diverse, and they became the subject for several researchers’ studies.

The monumental piece of work entitled *E Museo Lundii* deserves special emphasis. It started in 1888 and ended in 1915, consisting of five volumes with high-quality printing and images. 1,368 pages were published, 1,188 of which were written by Herluf Winge (Fig. 3). These works were enriched by 81 slides containing 564 images. Recently, an *Addendum to E Museo Lundii* was published with 103 pages and 41 images (Hansen 2012). Winge’s studies cover practically all the



**Fig. 3** Herluf Winge (1857–1923). Winge published several works based on Lund’s collection, mainly related by mammals. Collection of the Natural History Museum of Copenhagen

species discovered by Lund. He is rightly considered one of the leading mastozoologists of the twentieth century, being compared to P. W. Lund. His works dedicated to the study of the material collected by Lund in Lagoa Santa took place in Winge (1887, 1892, 1893, 1895a, b, 1906, 1915).

## 2 The Mammal Fossils Found by Lund

When beginning his paleontological work in Lagoa Santa, Lund worked with two premises guiding his research: the composition of the fauna he discovered should be like a replica of the old-world fauna, including Africa; and Cuvier’s theory of catastrophes should ground the interpretation of the findings through the new scientific path undertaken by Lund.

Thus, during his first excavation, which was in the Maquiné Cave, about 50 km from Lagoa Santa, the neophyte paleontologist identified a typical South American deer, *Mazama*, as an antelope, a species from the Old Continent that had never occurred in America. In addition, in 1842 Lund would first identify the feline *Smilodon*

*populator* (Lund 1842), the famous saber-toothed tiger, as a hyena. He initially based the theory on the similarities occurring in the incisor teeth; both animals had soft tubers on the lingual faces of their teeth. Shortly afterward, Lund abandoned this interpretation, the first premise included.

As for the theory of catastrophes, at that time shared by many, he claimed its reasons. The sediments introduced into the caves showed what Buckland (1784–1856), a geologist and paleontologist admired by Lund, coined *diluvium*. The ones covering the fossils of living species consisted of terrigenous sediments, while the fossils of extinct species were rescued under the stalagmitic floor, *antediluvian*. This paradigm repeated in several initial excavations, reinforcing the catastrophism paradigm. One argument was able to reinforce this point: A human fossil had not been found. Therefore, he interpreted cave paintings and utensils as belonging to recent and still-living Native Americans.

And then a sharp drought, in 1843, made the Sumidouro Lake near Lagoa Santa disappear, and penetrating the tunnel which, at the base of a wall, was the lagoon’s drain became possible. The findings were surprising, and Lund, at the time with many questions about the effectiveness of the theory of catastrophes, realized it was in fact unacceptable. The finding was so conclusive and surprising that Lund reformulated and revised several times the processes associated with the findings in the Sumidouro Lake, until no more questions were left. In the same sediment, an “impossible” association according to the Cuvierian theory occurred: human fossils along with remains from extinct and still-living species. Lund carried out a detailed and accurate description of the findings, justifying his conclusions (Piló et al. 2004, 2005). The theory of catastrophes was finally refuted and Lund’s second premise guiding his research could not be maintained.

Following the publication of these discoveries, Lund considered his paleontological research almost done. The scientific isolation and the high costs of the excavations were confluent causes for this decision. From then on, he dedicated himself mainly to what he identified as the “sweet idleness of the countryside.” The discoveries in the Sumidouro Lake were the last straw, making him realize that his mentor’s theory was incorrect. In addition to the above-mentioned reasons, the fear of criticism which could arise in Europe contributed to his behavior. He justified himself by stating that the findings had become repetitive. In that particular aspect, he was quite right. After Lund’s findings, so far, only one extinct mammal species has been discovered in Lagoa Santa.

In his works, Lund continuously published lists containing extinct species and living species whose fossils he recovered, along with numerous references to the fauna of mammals existing in the region. According to Lund and



Paula Couto (1950), Lund recorded 149 species of mammals. Thirty-one were first described by Lund, 22 of which were extinct species and nine living species (Cartelle 2012). It was a unique, absolutely original wide survey in such a geographically restricted area, including species which were distant in time.

The discoveries which prove Lund's exceptional knowledge are now highlighted. Over time, some species have been synonymized while others have been modified. But comprehensiveness and identifications attest to the genius of the most Brazilian Danish person.

The first list was elaborated by Lund and Paula Couto (1950); then, it was updated by Cartelle (2012). And this is the list we use hereafter—with only minor modifications. The rapid dynamics of Systematics allows the interpretation or correction of the nomenclature previously used. In bold, we indicate the extinct species and in italics the still-living species, both as Lund has established.

Among the Primates, he discovered the extinct species *Protopithecus brasiliensis* (Lund 1839). All extinct species of Carnivorous in Lagoa Santa were determined by Lund: the Canidae *Protocyon troglodytes* (Lund 1838), *Speothos pacivorus* (Lund 1839) (Fig. 4), the Felidae *S. populator*, and the Ursidae *Arctotherium brasiliense* (Lund 1839).

Among the Xenarthrans, besides fossils of extant species of anteaters and armadillos, he determined a group of extinct species. In Pilosa, with material from his first excavation, he coined the Nothrotheriidae *Nothrotherium maquinense* (Lund 1839), and later the Megatheriidae *Eremotherium laurillardii* (Lund 1842), the Mylodontidae *Ocnotherium giganteum* (Lund 1839), *Catonyx cuvieri* (Lund 1839), and *Valgipes bucklandi* (Lund 1844). Among the Cingulata are the Dasipodidae *Cabassous squamicaudis* (Lund 1844), *Propraopus punctatus* (Lund 1839), and *Propraopus sulcatus* (Lund 1842), and also, the Pampatheriidae *Pampatherium humboldti* (Lund 1839) and finally, the Glyptodontidae *Hoplophorus euphractus* (Lund 1839).

Among the Perissodactyl, he identified *Equus neogaeus* (Lund 1840), and *Hippidion principale* (Lund 1845). Among the Artiodactyla, Lund identified the extinct *Brasiliochoerus stenocephallus* (Lund in Gervais 1867–69) and the Laminae *Palaeolama major* (Lund in Liais 1872).

As for the Rodents, Lund identified the hedgehog *Coendou magnus* (Lund 1839), the giant capybara *Neochoerus sulcidens* (Lund 1839), and the giant *Cuniculus major* (Lund 1839) which, according to Mayer et al. (2016), should be referred to as *Cuniculus rugiceps* (Lund 1837).

Among the still-living species, Lund identified the Didelphomorpha *Didelphis albiventris* (Lund 1840) and *Marmosops incanus* (Lund 1840); as for Carnivora, the *Lycalopex vetulus* (Lund 1842) and the *Speothos venaticus*

(Lund 1842); and Rodents: *Rhipidomys mastacalis* (Lund 1840), *Carterodon sulcidens* (Lund 1839), *Phyllomys brasiliensis* (Lund 1840), and *Tricomys apereoides* (Lund 1839).

Winge, in the material sent by Lund, identified two other extinct species: the Perissodactyls *Tapirus cristatellus* (Winge 1906) and the Rodent *Juscelinomys vulpinus* (Winge 1887). Among the fossils recovered by Lund, Winge (1906), holding a few cranial remains, identified the Gomphothere *Mastodon andium* (Cuvier 1824) (= *Stegomastodon waringi* (Holland 1920)). With seven cranial fragments, he also identified the Toxodontinae *Toxodon platensis* (Owen 1837). However, due to the existence in sympatry in the Brazilian intertropical territory of this species and the Toxodontinae *Piauhytherium capivarae* (Guérin and Faure 2013), Guérin and Faure (2013) such identification is uncertain. The material recovered by Lund could belong to this species. Even less numerous was the material Winge attributed to Litopterna *Macrauchenia patachonica* (Owen 1838): vertebral fragments and a metapodial distal epiphysis. It is possible that such material belongs to the species *Xenorhinotherium bahiense* (Cartelle and Lessa 1988), since there are no records in intertropical territories of *M. patachonica*.

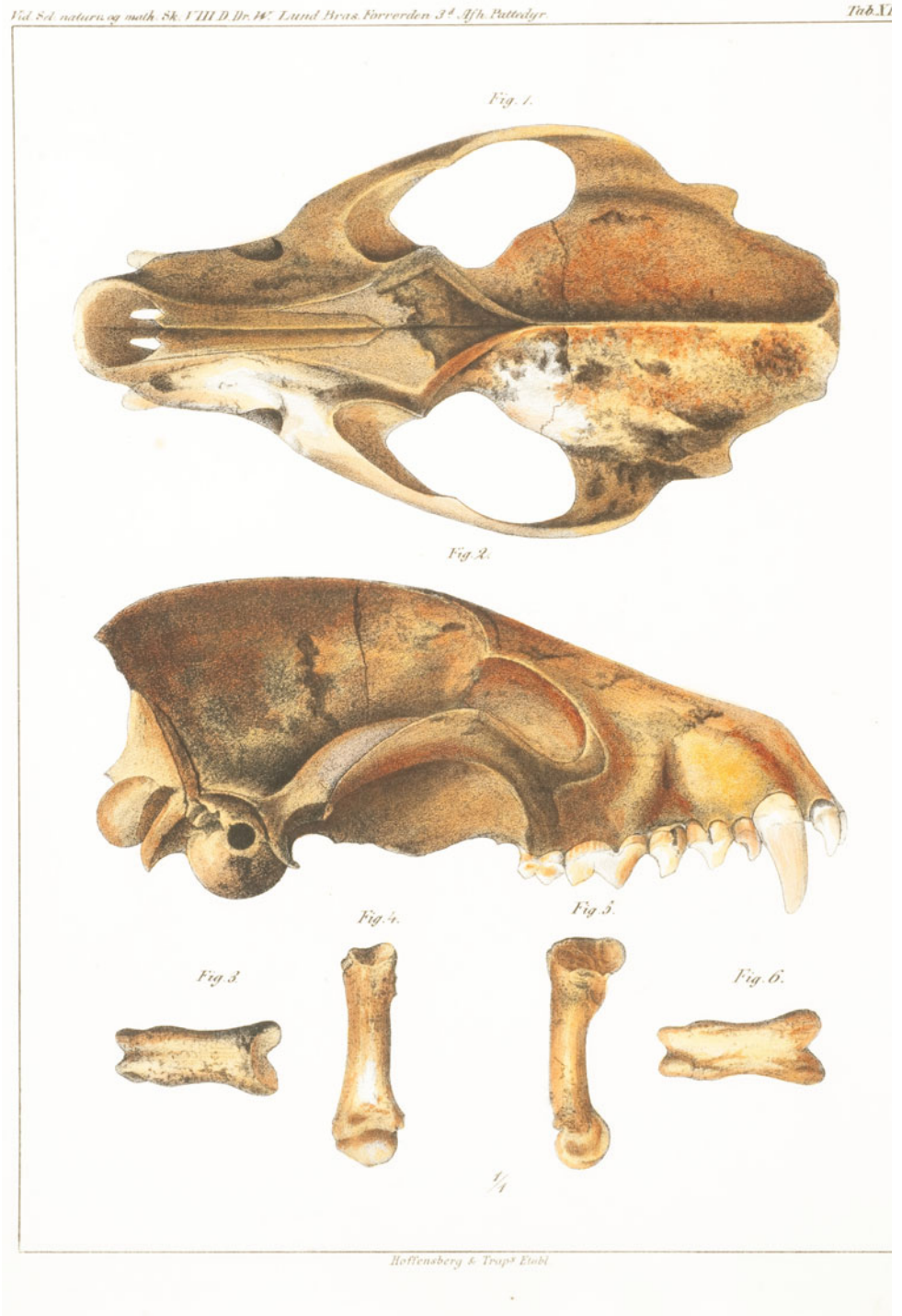
Lund named 22 of the 27 extinct species he identified. Lund determined eight of the 123 living species he collected. Few naturalists were able to make that many discoveries and taxonomic determinations. Some of the species, mentioned above, are worth being further discussed because of their exceptional importance.

### 3 Some of Lund's Emblematic Findings

Lund began his publications, as we have already pointed out, in 1825. He then wrote a few articles on invertebrates, the stomach of a bird, and botany. His first publication concerning his discoveries in Lagoa Santa was in 1837, and the last ones in 1846. Lund's complete bibliography about his findings in Lagoa Santa was published by Mones (1986). This bibliographic survey—the most exhaustive so far—includes original works, abstracts, and some translations of his works. In this list, Mones has entered 60 publications, 38 of which are in Danish, nine are in German, 7 are in French, 5 are in the Portuguese, and 2 are in English.

We have already pointed out that the first excavation carried out by Lund was in the Maquiné Cave, on the outskirts of Lagoa Santa. There was little material found, and it does not differ from the findings made later in Lagoa Santa Caves. *N. maquinense* was his first discovery and the first species identified by him as extinct. Later, he would find further subjects of that species in caves in the area of Lagoa

**Fig. 4** Skull and foot bones of the canid *Speothos pacivorus*. Hand-colored illustration in Lund (1840)



Santa. In his first report, he tells about the finding that which today we understand is the symbol species of the Brazilian paleontology.

Initially, he identified the species he had found in the Maquiné Cave as a *Megatherium* of the size of a tapir. This interpretation was heavily influenced by events that had happened earlier. The discovery, in 1788, of *Megatherium*

*americanum* (Cuvier 1796) was emblematic for the South American paleontology. A very complete skeleton found by a priest in the area where Luján (Argentina) is settled was sent to Spain and kept in the Madrid's Royal Natural History Cabinet. The Institution's researchers identified it as a South American elephant and set it up with palmar and plantar supports—currently, it is still exhibited this way. Being an

exceptional and historical finding, it was kept as original, even if erroneous and with the reconstruction of some missing pieces. During his first stay in Brazil, Lund became acquainted with the findings of Megatherians through Olfers, but he most likely extended his knowledge when in contact with Cuvier. He obtained drawings of the Madrid skeleton and concluded that the South American “elephant” was, in fact, a giant extinct ground sloth. And the *Megatherium* became a consumer’s dream for more than a few European museums. *N. maquinense* was much smaller than *Megatherium* and would eventually be identified as a different family.

The Xenarthra had Lund’s special attention. In addition to the work by Cuvier, he learned about the sloths discovered in North America, later expanding his knowledge with some of Owen’s works, among others. He gradually changed concepts in such a way that in his final works the identifications were very consistent. He rightly attributed ossicles shaped like small nodules to osteoderms, bones located in the dermis of some extinct sloths. From the skeletal remains, he inferred the habits and behaviors of these animals.

Lund found two molariforms belonging to young sloths in two separate caves. Even with so little material, the determination at the time was accurate: *Megatherium laurillardi* (Lund 1842). With such limited material, he was able to identify a large sloth. Only in the second half of the twentieth century did the exact name of the species come to be known as *E. laurillardi*. At the end of this chapter, we will mention this species again.

Also noteworthy is the determination of several extinct Cingulata, the Xenarthra with exoskeleton. Aware of Sellow’s research, probably through Claussen, who had described a Glyptodont, Lund identified a species of these Cingulata, the *H. euphractus*, which was large and had rigid carapace and tail. He also identified *P. humboldti*, a pampathere, as well as three extinct armadillos *D. punctatus*, *P. sulcatus*, and *C. squamicaudis*. His confidence in identifying those species is admirable, which shows the deep knowledge of the current fauna of the region he acquired in a short period.

Unfortunately, none of Lund’s possessions in Lagoa Santa was preserved. His house was put down to build a school on the site; his furniture and especially his library also disappeared. Rumor says his books were destroyed with the pages being used to make fireworks. But it is obvious that during the early years of his research Lund had access to North American publications about Xenarthra Pilosa more than to the ones published in Europe. His findings of medium-sized sloths must then be interpreted with the generic name *Megalonyx* following the identifications in North America. He subsequently abandoned such identifications, renaming the specimens he found as *Scelidotherium*, probably because of the works received from Europe,

notably those by Owen. That denomination identified medium-sized sloths species in South America.

One of the greatest discoveries made in Lagoa Santa occurred in 1837. Lund realized the importance of it and did not take long to write the memoir with an account of that discovery (Lund 1839). For the first time in history, Primate fossils were found and identified as *Protopithecus brasiliensis* (which translates as “first monkey from Brazil”). This determination, once again, shows Lund’s confidence and great knowledge. The material recovered in two caves was minimal: a pair of phalanges, a metatarsal, a cervical and a caudal vertebra, proximal half of a femur and distal half of a humerus. It was enough for him not only to define the species but also to consider it extinct.

The human findings lingered and happened only in 1840, 5 years after Lund’s arrival in Lagoa Santa. Lund realized that cranial morphological features did not match the modern Native Americans. He ended up comparing them to the skulls of Egyptian civilization. At present, archaeologist Walter Neves beckons the possibility of those being cranial features of former ancient dwellers of Lagoa Santa with Negroid skulls. Lund got it almost right.

In Carnivores, he was precise when separating, with great skill, the fossils belonging to extinct and still-living species. The extinct *S. populator*, as has already been mentioned, initially considered being a hyena was recognized as Felidae. Prior to this species, Lund had identified species *A. brasiliense* (Ursidae) and *P. troglodytes* (Canidae).

But there are two species of Canidae that deserve attention. Once again it shows Lund’s confidence in his knowledge. In 1839, he determined, by means of a very well-preserved skull found in the Cerca Grande complex, the extinct species *S. pacivorus*. When finding numerous remains of paca in that place, he reached the conclusion that the carnivore—“a devourer of pacas”—was responsible for the accumulation of fossils of that species, which translated into the specific denomination.

At that time, Lund had heard frequently about a small, wild carnivore occurring in the area. The descriptions provided by a few who saw the animal waded the possibility of it being a species still unknown. After offering a reward, hunters located two subjects in the woods: one was killed, and the other one was captured. Lund kept it alive in his yard for over a year, watching his behavior. The skeleton of the dead animal was prepared. He had previously encountered a fossilized skull of the same species, concluding that the unknown animal, the bushdog, belonged to the same genus as the extinct *S. pacivorus*. It was coined *S. venaticus*. For the first time, an extinct fossil species was recognized earlier than a current species belonging to the same genus.

Another finding that showed Lund’s consistency was the discovery of Equids. In a cave of uncertain location named Horse Cave, Lund identified a metacarpal. The anatomy of

horses, zebras, and donkeys is very similar. Lund initially raised the hypothesis that he might have had in hands a horse-type metacarpus originally introduced by the Portuguese settlers. After numerous comparisons, he came to the conclusion that the piece belonged to an extinct horse: “*It is noticeably wider and flatter than those of all the living Horses with which I have been able to compare it*” (Lund and Paula Couto 1950: 315).

In 1833, Darwin found on the surroundings of the Paraná basin two upper molars of Equidae together with the remains of extinct animals. Owen described the finding. As a result, the South American horses were extinguished before the arrival of the colonizers. Owen (1840: 109) realized the importance of the discovery: “*...is not one of the least interesting fruits of Mr. Darwin’s paleontological discoveries.*”

Lund in turn wrote an article in Lagoa Santa in April 1840. That same year it was published in France (Lund 1840). In the isolation of Lagoa Santa, Lund, surprisingly, had already learned of Darwin’s discovery: “*How he found in the temperate parts of America (in the United States and in the Republic of Uruguay) fossilized horse bones*” and concluded that having disappeared completely it would only reappear in America introduced by the colonizers (Lund and Paula Couto 1950: 315–316). Later findings by Lund confirmed the correctness of the identification. In Lagoa Santa, there occurred two species of extinct Equidae *E. neogeus* and *H. principale*.

In the Artiodactyla Tayassuidae, in addition to the fossil remains of the two extant species, the “cateto” and the “queixada,” Lund identified a rare species *Brasiliochoerus stenocephalus* of which only two skulls are known, one found by Lund and the other by researchers to be further mentioned. Both findings occurred in the region of Lagoa Santa. Still among the Artiodactyls, we highlight the findings of *P. major*; many bones of that species were recovered by Lund. He correctly identified the specimens as belonging to Camelids. But in his publications he did not determine the species and only published the image of a molar of a young animal. In the absence of comparative material, he preferred omission to the possibility of error.

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## 4 An Unusual Find

In one of the caves of the Escrivania complex, the “wise man of Lagoa Santa” discovered what today we consider to be of great importance; nevertheless, it has not received due attention. The following account presents data acquired from one of Lund’s memoirs (Lund 1846).

During three and a half months, the work of removing fragments was carried out, mostly of micromammals coming from the regurgitations of owls probably during a great

sequence of years. 6,552 barrels of sediment were withdrawn from inside a cave. Using teeth and long bones, predominantly from rodents and marsupials, Lund estimated there had been 6,881,500 individuals there.

In his house, Lund had a pair of cave owls, *Tyto furcata* (Temminck 1827), which allowed him to observe its habits. On average, they ate four small animals per meal. From this assumption, the deposition in the passage of the cave where he had made the finding would have occurred during five thousand years, the time spent by couples of owls in the cave to accumulate so many bones.

We do not know of any study with this material. Lund and Reinhardt made intensive collections of small mammals of the Lagoa Santa region in the middle of the nineteenth century, which, like the previous findings, are also deposited in the Museum of Zoology in Copenhagen. By combining data obtained from these two moments with data from the present situation, it would be possible to compare three scenarios, one possibly from the late Pleistocene (Escrivania), data from 150 years ago and the current material. The confluence of these circumstances, hardly replicated elsewhere, can provide data and information on possible environmental changes over a long period of time.

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## 5 The Paleontological Findings After Lund

After Lund, paleontological research in the Lagoa Santa region was not immediately carried on. Virtually, a century passed by before some research took place.

Between 1935 and 1960, members of the now-disbanded Minas Gerais Academy of Sciences resumed researches in the field of paleontology and archeology. Among others, Harold V. Walter (1889–1969), English consul in Belo Horizonte, and Aníbal Mattos (1897–1976), professor and artist, excavated in several municipalities around Lagoa Santa, such as Confins and Pedro Leopoldo. Their main interest was archeology, but over the years they carried out paleontological collections today housed in the Museum of Natural History of the Federal University of Minas Gerais. They published their works with a general scope, with emphasis on archaeological findings (Mattos 1934, 1938, 1939; Walter 1940, 1943, 1949).

Some of these paleontological findings were later used for studies by several paleontologists, among which Carlos de Paula Couto (Fig. 5) stands out. He warned about the importance of Harold Walter’s private collection, mentioning he was willing to sell it. It was bought by the Federal University of Minas Gerais in the 1960s.

Based on the material found by H. Walter, Paula Couto (1947) described an incomplete skull, molariforms, the posterior half of a carapace, some limb bones, and the caudal tube as belonging to the Glyptodont *H. euphractus*.





**Fig. 5** Carlos de Paula Couto (1910–1982) was an important Brazilian paleontologist who translated into Portuguese Lund’s paleontological works. Collection of the Fundação Zoo-botânica do Rio Grande do Sul

The fossils were found in Borges Cave (Pedro Leopoldo). Paula Couto confirmed Lund was right in identifying only few carapace fragments as *H. euphractus* (1839). Paula Couto (1957a) resumed studying this species considering the previous article as a preliminary note. In addition to the description and figuration, he reconstructed the species defined by Lund. After Lund, only one extinct species was described in Lagoa Santa with material he had not found: *Tetrastylus walteri* (Paula Couto 1951), a Cavoidea rodent. Species of that genus were only known from the Pliocene of Argentina. The finding consisted of incomplete right teeth with Incisive, PM4 and M1 to M3. The piece was part of the Walter Collection but, at present, it is deposited in the collection of the National Department of Mineral Production in Rio de Janeiro (Paula Couto 1951).

Later, the illustrious paleontologist (Paula Couto 1960) studied the South American Tremarctine species, dedicated

to the “*Pararctotherium brasiliensis*” (= *A. brasiliense*). He increased the restricted knowledge about the species by studying a very complete skull with dentition and left ulna found in Lagoa Funda Cave, in the municipality of Pedro Leopoldo, also included in Walter’s collection.

Fonseca (1979) in an unpublished Master’s degree thesis studied the material of Tayassuidae belonging to the Museum of Natural History of the Federal University of Minas Gerais. The pieces studied also belonged to Walter’s collection. In this work, he came to the conclusion that a rare extinct species, *B. stenocephalus*, of which two skulls are known, one discovered and studied by Lund, and the other discovered by H. Walter and studied by Fonseca, is valid. Paula Couto (1981) ratified Fonseca’s conclusion.

In 1956, a joint expedition of the National Museum of Rio de Janeiro and of the University of South Dakota occurred in Cerca Grande (Paula Couto 1958). The main purpose of the expedition was the search for archaeological elements and to prove the coexistence of human beings and the extinct fauna. Paula Couto (1958, 1970) did not believe this was possible. Excavations were made in Caetano Cave and in the cliff of Cerca Grande, both located in the municipality of Matozinhos. Subsequently, with the new data, Paula Couto changed his mind. The expedition collected a few pieces of Tayassuidae and fragments of the carapace of the extinct armadillo “*Propraopus punctatus*” (= *Dasybus punctatus* (Lund 1839)), which is currently in the collection of the Museum of Natural Sciences of the Zoo-botanical Foundation of Rio Grande do Sul (Paula Couto 1980).

Souza Cunha (1960, 1964) described the teeth of *H. principale* collected in the Mortuária de Confins Cave (Confins municipality), deposited in the National Museum of Rio de Janeiro and collected by Padberg-Drenkpohl in 1926, an employee at the Museum, according to unpublished reports.

In the 1970s, archaeologists Annette Laming-Emperaire and André Prous performed an excavation at Lapa Vermelha IV Cave, located in the region of Lagoa Santa, in the municipality of Pedro Leopoldo, which culminated in the finding of skull of “Luzia, the oldest Brazilian.” Based on material collected in this excavation, Souza Cunha and Guimarães (1978) cite the findings of a *Glossotherium* nail phalange (such identification is questionable), as well as a list of small mammals at a generic level that Souza Cunha and Guimarães (1978), Magalhães and Locks (1983), and Locks and Montenegro (1985) also pointed out.

André Prous, an archaeologist at the Museum of Natural History at the Federal University, found in the 1980s a very complete post-cranial skeleton of *C. cuvieri* in the Cuvieri

Cave (Matozinhos). This specimen is deposited in that institution and about this nothing has been published.

Souza Cunha and Magalhães (1986) pointed out new Cervidae material which Magalhães (1987), in a Master's degree thesis, later defined more accurately. In his work, he reviewed the Cervidae fossil/subfossil found in several Brazilian regions, emphasizing the findings in Lagoa Santa: *Mazama gouazoubira* (Fisher 1814), *Mazama sp.*, *Ozotoceros bezoarticus* (Linnaeus 1758), *Blastocerus dichotomus* (Illiger 1815), *Antifer sp.*, and, doubtfully, *Morenelaphus sp.* He also pointed out an indeterminate Odocoileini from Lapa Vermelha.

C. Cartelle in sporadic excavations in caves in the Jaguará Farm (Matozinhos), Baú Cave (Pedro Leopoldo), Cerca Grande (Matozinhos), and Escrivânia (Prudente de Morais) in the 1980s collected several pieces of Carnivores, Xenarthra, Rodents, and Tayassuids of known species. This unpublished material is deposited in the Museum of Natural Sciences of the Catholic University of Minas Gerais.

The Archaeological Project *Origins and Microevolution of Men in America* started in the beginning of the year 2000 and is still ongoing. Directed by archaeologist Walter Neves, from the University of São Paulo, it reached spectacular results in the archeology field (see Da-Glória et al. 2017). At the same time, his team developed a paleontological excavation in the Cuvieri Cave where, years before, the archaeologist André Prous found the skeleton mentioned before. This excavation was an attempt to find extinct fauna and men in association. No human record took place in this cave. Mammalian findings repeated some of those identified by Lund. The material is deposited in the Human Evolutionary Studies Laboratory of the University of São Paulo.

According to Hubbe (2008), Mayer (2011), and Mayer et al. (2016), the mammal remains recovered from Cuvieri cave were *Tapirus terrestris* (Linnaeus 1758), *Mazama sp.*, *C. cuvieri*, *V. bucklandi*, *Panthera onca* (Linnaeus 1758), *S. populator*, *Cuniculus paca* (Linnaeus 1766), *Cuniculus rugiceps*, (Lund 1837) *Dasyprocta sp.*, *Euphractus sexcinctus* (Linnaeus 1758), *Sylvilagus brasiliensis* (Linnaeus 1758), *Didelphis sp.*, *Tayassu pecari* (Link 1795), *Tayassu tajacu* (Linnaeus 1758), *Cavia sp.*, *Akodon sp.*, *Necromys sp.*, *Oxymycterus sp.*, and *Oryzomys sp.*

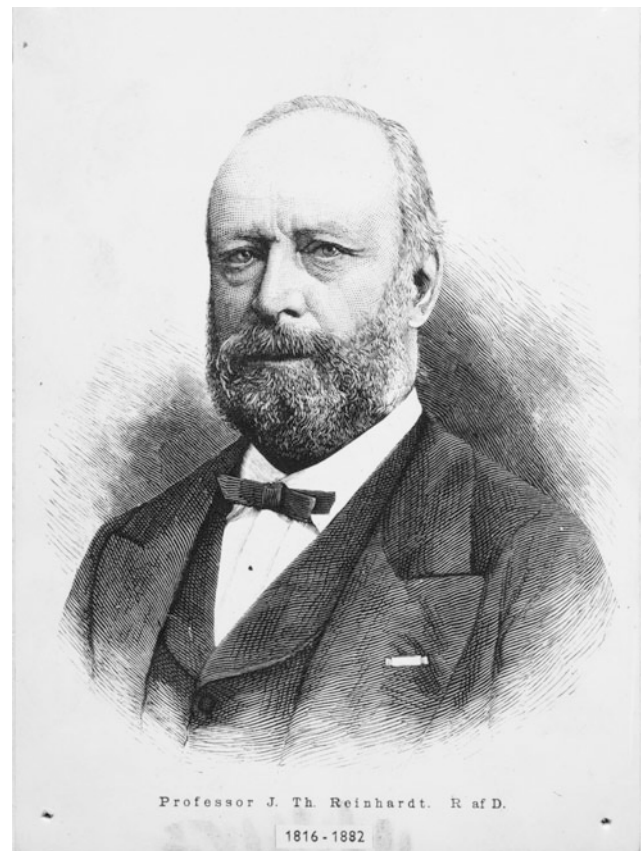
Perônico and Araújo (2002) report a excavation in Bauzinho dos Ossos Cave (Pedro Leopoldo municipality) and findings of mammal at the Order level (Pilosa and Artiodactyla). Vasconcelos et al. (2015) carried out taphonomic and taxonomic analysis of his findings in a small cave located in the municipality of Prudente de Morais. Common specimens of *T. pecari*, *Dasypus novemcinctus* (Linnaeus 1758), *Speothos sp.*, *Eira barbara* Linnaeus 1758, *Sylvilagus sp.*, *V. bucklandi*, and a rare occurrence: the rather complete jaw of a *C. rugiceps* were found.

## 6 Publications of Mammal Fossil Related to Lagoa Santa

After Lund's publications, many authors turned their attention to Lagoa Santa. The main ones are here summarized. The related work mentioned before which had direct or more explicit links with the Lund's findings will not be listed hereafter, such as the work by Winge in *E Museo Lundii* as previously noted or the aforementioned works by Paula Couto.

The German Burmeister (1871, 1885), who came to visit Lund in Lagoa Santa around 1852, wrote articles about the species *H. euphractus* and the "*Coelodon maquinense*" (= *N. maquinense*). Boas (1881) once again addressed the subject of Equines discovered by Lund claiming the possibility that *H. principale* could be a zebra.

By 1845, Lund had already sent thirty boxes of fossils to Denmark. That year the Galathea corvette, the Danish version of Darwin's Beagle voyage, departed from Copenhagen. Lund invited Reinhardt (Fig. 6), one of his mentor's



**Fig. 6** Johannes T. Reinhardt (1816–1882). Reinhardt worked as Lund's assistant in Lagoa Santa and he would become the first Curator of Lund's paleontology collection. Collection of the Natural History Museum of Copenhagen

son, to be the first curator of the collection. The Danish government ordered the young man to interrupt his voyage in the Galatea to visit Lund in Lagoa Santa. Reinhardt would return two more times to the small town (1852–54 and 1856–58).

On his second stay in Lagoa Santa, Reinhardt received the book with Brandt's drawings as a gift. On the previous voyage, he had received Lund's notes and the Manuscript Catalog with the record of the specimens collected as well as the journal with a detailed record of each excavation. Therefore, we know the dates and the excavated caves. In a cross-checking of data, it is possible to infer when and where Lund collected each one of his pieces. In addition to the records of the excavations carried out by Lund (Reinhardt 1888), he wrote some articles (Reinhardt 1868, 1870, 1875, 1877, 1878, 1880) dealing with birds, armadillos, glyptodonts, tayassuids, *N. maquinense*, and Lund's general findings.

Works by Paula Couto have already been mentioned in this chapter; they were prepared with material from the Walter collection composed of findings which succeeded Lund's and extended the knowledge about several species. But there are other works by this author which are essential to the knowledge of the discoveries which took place in Lagoa Santa. The update of Winge's nomenclature is a highlight (Paula Couto 1946), as well as an article on *S. populator* in which he reviewed the material from Minas Gerais deposited in several Museums (Copenhagen, Paris, and London). In the Walter collection, there are no remains of this species (Paula Couto 1955).

The publication of Lund's works in Portuguese is particularly noteworthy: Memories on Brazilian Paleontology (Lund and Paula Couto 1950). In addition to an introduction and the translation of Lund's scientific works, on a large number of notes Paula Couto updates the nomenclature and observations with the most exact concepts at the time. Images from Lund's works and an index make this all-important 592-page publication, containing 55 images a complete edition.

Four of the five Memoirs published by Lund in Danish were translated into French by Henri Gorceix (1842–1919), a French geologist, physicist, and mathematician who was hired by Emperor Dom Pedro II to found the Ouro Preto Mining School (MG). The Emperor, who admired Lund's work, paid for the costs.

In 1979, the magnificent Treaty of Paleomastozoology in which Paula Couto (1979) indicates all the species discovered by Lund was published. Previously, in several articles (1957a, b, 1970, 1971), he had already written about all the mammal fossils Lagoa Santa.

Hoffstetter (1908–1999), a renowned French paleontologist, in several works, and notably in his Ph.D. thesis (Hoffstetter 1952) made frequent allusions and comparisons

with species of Megatheriidae, Pamphateridae, Equidae, Scelidotheriinae, and Lamini, which Lund and Winge defined for Lagoa Santa. Subsequently (Hoffstetter 1954) with the material deposited in Denmark, from Lagoa Santa, came to a series of conclusions about some Xenarthra that were accepted for a long time, influencing the erroneous analysis of Brazilian species by several authors. To a large extent, such conclusions were refuted by Cartelle et al. (2009).

As previously mentioned, in 1837, Lund made a very important discovery. He hastened to send a work to Europe (Lund 1839) in which he reported the discovery of *P. brasiliensis*. For the first time, a fossil of monkey was recorded. Lund's discovery was almost forgotten after the publication of Winge (1895a), who illustrated the remains Lund discovered. The revival of the importance of this finding is due to Hartwig (1995a). The title of the article is a summary of the content: "*Protopithecus: rediscovering the first fossil primate.*" Later, Hartwig (1995b, 2002) described the remains stored in the Museum of Zoology, in Copenhagen.

Cartelle and Fonseca (1983) improved the somewhat restricted knowledge about the *N. maquinense* sloth, a symbol of Lund's paleontological discoveries. Czaplewski and Cartelle (1998) did a survey on the Chiroptera fossil found in several regions of Brazil, including Lagoa Santa. Earlier, Winge (1892) identified 27 bat species in the material Lund had collected. Czaplewski and Cartelle (1998) reached almost the same conclusion: they identified 26 species in Lagoa Santa. Berta (1984) improved the knowledge of the Carnivora *S. pacivorus*. In the same sense, Cartelle and Langguth (1999) extended the knowledge about another species of Carnivora determined by Lund: *P. troglodytes*.

Alberdi et al. (2003) reviewed the Equidae Lund had discovered. Cartelle and Bohórquez (1982) revalidated the giant sloth species *E. laurillardi*. Cartelle and De Iuliis (1995) reinforced this revalidation in an important article. Also, Cartelle et al. (2009) revalidated the species *V. bucklandi*. These denominations are now in disuse.

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## 7 Other Views

Besides the already mentioned work, there were other approaches that moved away from those reported, with an emphasis on taphonomy. We relate Perônico and Araújo (2002), Auler et al. (2006), Hubbe (2008), Hubbe et al. (2011), Mayer et al. (2009a, b), Mayer (2011), and Vasconcelos et al. (2015).

Another approach was that of the publications that carried out a survey focusing on the fossil fauna of Lagoa Santa (Cartelle 1994). Cartelle et al. (1998), in a comprehensive



report justifying the creation of the Environmental Protection Area of Carste in Lagoa Santa (and which until today has not been fully implemented), plotted and listed caves and the findings therein. Most of them, with rare exceptions, are those explored by Lund.

The analysis of the extinct Caatinga and Cerrado fauna by Cartelle (1999), including Lagoa Santa, can be referred to in this item. In such work, the author defended the hypothesis that the main cause of the extinction of the Late Quaternary was climatic, reaching especially the megafauna of herbivorous mammals from open field. Examples of the fauna discovered by Lund were the basis for this hypothesis.

Cartelle (2012) broadened and deepened the work produced in 1994. He placed special emphasis on the area of Lagoa Santa, on Lund, and obviously on the fauna he discovered. Special attention was given to the illustrations and the original descriptions made by P. W. Lund. A list of species of late Quaternary mammals of Minas Gerais was included in this publication.

We have finally and rightly to point out some publications which refer to the life of P. W. Lund or to aspects of it or to its discoveries. Reinhardt (1880) summed up Lund's scientific life in the year of his death. Shortly thereafter, a niece (Lund 1885) wrote a biography that was used by Nereo dos Santos, Lund's adopted son, as a basis to write a short booklet about his father's life (Santos 1923). Degerböl (1945) provided the essential data for organizing a biography used by Paula Couto as an introduction to the publication of the Memoirs of Brazilian Paleontology (Lund and Paula Couto 1950: 5–26). Schøllhammer (2002) briefly pointed out several facets of Lund's life in Brazil.

It is worth highlighting Marchesotti's (2005) Master's degree dissertation, and the Luna (2007) Ph.D. thesis, both carried out in-depth analyzes with solid foundations. Recently, two excellent books were translated from Danish to Portuguese. In the first one, Holten and Sterll (2011), supported by numerous documents, carried out in-depth research work portraying Lund's life and its discoveries. In the second one, Holten et al. (2012) depicted the life and work of Lund's main assistant, his secretary, and artist Peter Andreas Brandt. Both Luna (2007) and Holten and Sterll (2011) used primary information contained in the extensive correspondence (family and scientific) Lund kept throughout the years he was in Lagoa Santa, and which is preserved in the Royal Library of Copenhagen.

## 8 Chronological Data Related to the Lagoa Santa Fauna

At the end of the nineteenth century and in the beginning of the twentieth century, issues pertaining to humans' coexistence with the extinct fauna identified by Lund as a result of

his discoveries in Sumidouro Cave were the subject of several controversies. Piló et al. (2004, 2005), after detailed topographic, sedimentological, and taphonomic studies, provided data that, I believe, undoubtedly clarified the question: human beings and the extinct fauna were contemporaneous in the Lagoa Santa region. Lund was right. By means of dating, they obtained the minimum ages of human bones and of eight-thousand-year extinct fauna. The contemporaneity is also supported by absolute dates.

Previously, Neves and Piló (2003) recorded new dates with material collected by Lund and deposited in the Museum of Copenhagen and the Museum of Natural History of UFMG. Collagen from bones belonging to extinct species was used—*E. (A.) neogaeus*, *C. cuvieri*, *S. populator*, and *Homo sapiens* (Linnaeus 1758). In addition, they used tooth collagen of *E. (A.) neogaeus* and charcoal. They were aged between  $9,260 \pm 150$  (*S. populator*) and  $16,900 \pm 70$  years (*E. neogaeus*). The date for *H. sapiens* was  $9,780 \pm 70$  BP (Calibrated: 10,790–11,270) which overlaps the confidence interval of the calibrated age of the *S. populator* mentioned above (calibrated 9920–11,060) and also of a *C. cuvieri* from Cuvieri cave which was dated at  $9,990 \pm 150$  (calibrated 10,900–12,020), and was also reported in Neves and Piló (2003). Hubbe et al. (2009) offered new dates with material collected in the previously cited Cuvieri cave. For *S. populator*, they indicate conventional,  $10,790 \pm 60$  (calibrated 12,560–12,750), for *V. bucklandi*: conventional,  $11,020 \pm 40$  (calibrated 12,730–12,980), and for *Tayassuidae*: conventional  $10,470 \pm 40$  (calibrated: 12,050–12,540). Additional ages are provided by Auler et al. (2006) and Hubbe et al. (2011).

## 9 Epilogue

This chapter ends with a final observation emphasizing Peter Lund's scientific figure. We consider that he finished his publications on the extinct fauna of Lagoa Santa in 1846. Now, 170 years later, 22 species determined by Lund (Table 1) are still valid, as previously indicated. During this long period, from the Brazilian intertropical Pleistocene, 17 extinct species were either established or identified (Table 2). Two were designated with material collected by Lund in Lagoa Santa (*J. vulpinus* and *T. cristatellus*). A species of Chiroptera, *Desmodus draculae* (Morgan, Linares and Ray 1988), discovered in Venezuela and also identified in Bahia and São Paulo (Czaplewski and Cartelle 1998) can be added to the list.

Mammals were Lund's main interest. But he also found fossils of other vertebrates and some of them were recorded in his "Katalog," a manuscript he sent to Denmark along with his collection. At the end of his brief but astonishing paleontological career, he recorded 12,622 specimens. For



**Table 1** List of extinct mammals of Lagoa Santa named by Lund (22 species)

<b>Pilosa</b>
<i>Nothrotherium maquinense</i> (Lund 1839)
<i>Eremotherium laurillardii</i> (Lund 1842)
<i>Catonyx cuvieri</i> (Lund 1839)
<i>Ocnotherium giganteum</i> (Lund 1839)
<i>Valgipes bucklandi</i> (Lund 1839)
<b>Cingulata</b>
<i>Cabassous squamicaudis</i> (Lund 1844)
<i>Propraopus punctatus</i> (Lund 1839)
<i>Propraopus sulcatus</i> (Lund 1842)
<i>Pampatherium humboldti</i> (Lund 1839)
<i>Hoplophorus euphractus</i> Lund 1839
<b>Primate</b>
<i>Protopithecus brasiliensis</i> Lund 1839
<b>Carnivore</b>
<i>Protocyon troglodytes</i> (Lund 1840)
<i>Speothos pacivorus</i> (Lund 1839)
<i>Arctotherium brasilienses</i> (Lund 1839)
<i>Smilodon populator</i> Lund 1842
<b>Perissodactyla</b>
<i>Equus neogeus</i> (Lund 1840)
<i>Hippidion principale</i> (Lund 1845)
<b>Artiodactyla</b>
<i>Brasiliochoerus stenocephalus</i> (Lund in Gervais 1867–69)
<i>Palaeolama maior</i> (Lund in Liais 1872)
<b>Rodent</b>
<i>Coendou magnus</i> (Lund 1839)
<i>Neochoerus sulcidens</i> (Lund 1839)
<i>Cuniculus rugiceps</i> (= <i>major</i> ) (Lund 1839)

each one of them, he indicated number, morphological identification, specific identification, and location of the finding.

Lund's work in Brazil was broader than previously reported. In addition to the paleontological works and their implications, the zoological collections and the innumerable botany findings must be highlighted. This is due to him advising students from Denmark who lived with him: Reinhardt, who would become the first Curator of Lund's paleontology collection, and E. Warming who with his studies on interrelations in the Cerrado should be considered the founder of Ecology. Lund's material concerning botany is deposited at the Botanical Museum in Copenhagen. In addition to photographs taken by Warming during his stay in Lagoa Santa (1863–1866) and his notes, the correspondence

**Table 2** List of extinct mammals of intertropical Brazil named after Lund's works (17 species). The ones that occurred in the region of Lagoa Santa are written in bold

<b>Perissodactyla</b>
<i>Tapirus cristatellus</i> (Winge 1906)
<b>Rodent</b>
<i>Juscelinomys vulpinus</i> (Winge 1887)
<i>Tetrastylus walteri</i> , Paula Couto 1951
<b>Proboscidea</b>
<i>Stegomastodon waringi</i> (Holland 1920)
<b>Cingulata</b>
<i>Panochthus greslebini</i> (Castellanos 1941)
<i>Panochthus jaguaribensis</i> (Moreira 1965)
<i>Pampatherium paulacoutoi</i> , Cartelle and Bohórquez 1983
<i>Pachyarmatherium brasiliense</i> , Porpino, Fernicola and Bergqvist 2009
<b>Glossotherium phoenesis</b> Cartelle, De Iuliis, Boscccini and Pujos, 2019
<b>Pilosa</b>
<i>Myloodonopsis ibseni</i> Cartelle, 1991
<i>Aytherium aureum</i> Cartelle, De Iuliis & Pujos, 2008
<i>Australonyx aquaee</i> De Iuliis, Pujos and Cartelle, 2009
<b>Litopterna</b>
<i>Xenorhinotherium bahiense</i> , Cartelle and Lessa 1988
<b>Toxodontia</b>
<i>Piauthorium. capivarae</i> , Guérin and Faure 2013
<b>Primate</b>
<i>Caipora bambuorum</i> Cartelle and Hartwig, 1996
<i>Alouatta mauroi</i> Tejedor, Rosenberg and Cartelle, 2008
<i>Cartelles coimbrasilhoi</i> Halenar and Rosenberg, 2013

between him and Lund has been preserved. In the herbarium of the Botanical Museum, sixteen thousand exsiccatae (Holten and Sterll 2011) collected by Lund and Warming are deposited. We further summarize other findings of vertebrate fossils also collected by Lund. He did, in some of his works, restricted allusions to these specimens.

Reinhardt, directed by Lund, carried on an important collection of fish in the Velhas River, which he sent to Denmark. This collection was studied by Lütken (1875, 2001) (Fig. 7), which identified 55 species. It seems that 14 of these are not found in the ichthyofauna in its currently polluted waters (Alves and Pompeu 2010). Lund found, mainly in the Sumidouro Cave, fossils belonging to eight fish species (Hansen 2012) no longer found in the lake: *Oseudoplatystoma corruscans* (Spix and Agassiz 1829), *Pimelodus maculatus* (Lacépède 1803), *Bergiaria westermanni* (Lütken 1874), *Pseudopimelodus charus* (Valenciennes 1840), *Rhynel*



**Fig. 7** Christian F. Lütken (1827–1901) studied the collection of fish of the Velhas River, which Reinhardt sent to Denmark. Collection of the Natural History Museum of Copenhagen

*quelen* (Quoy and Gaimard 1824), *Hoplias malabaricus* (Bloch 1974), *Prochilodus costatus* (Valenciennes 1860), and *Astyanax lacustris* (Lütken 1875).

In several caves, Lund also collected parts of the amphibian *Ceratophrys aurita* (Raddi 1823), the toad-totán or ox-toad. Non-avian reptile findings were broader (Hansen 2012). They took place in 13 caves: two species of turtles—*Phrynops hilarii* (Duméril and Bibron 1835)—and *Platemys platycephala* (Schneider 1792), a Crocodylia—*Caiman latirostris* (Daudin 1802)—an Amphisbaena—*Amphisbaena alba* Linnaeus 1758—four Lacertidae: *Ptychocheilus acutirostris* Spix 1825, *Tropidurus torquatus* (Wied 1820), *Ameiva ameiva* (Linnaeus 1758), and *Tupinambis teguixin* (Linnaeus 1758), and finally, four snakes: *Boa constrictor* (Linnaeus 1758), *Mastigodryas bifossatus* (Raddi 1820), *Crotalus durissus* (Linnaeus 1758), and *Lachesis muta* (Linnaeus 1766).

Lund collected more than just a few fossils of different bird specimens. And it is worth noticing that, in addition to the fossils, excellent collections of the current vertebrate fauna (fish, amphibians, reptiles, birds, and mammals) were also sent to Denmark, as we have already mentioned. But it

was mainly Reinhardt, during his visits to Lagoa Santa, who carried out the surveys of the regional bird fauna, entering 393 species to his list. Among them, 198 species of non-Passeriformes (Reinhardt 1878) were described in a remarkable and long publication (Krabbe 2007).

Winge (1887), on the other hand, indicated that Lund found in 19 caves fossil remains belonging to 126 species of non-passerines and a large quantity of remains of these birds. Twenty-two species identified by Winge are not found among the species recorded by Reinhardt and most of the species found as fossils in the caves still survive in the region. The greatest number of findings occurred in the cave Escrivania 5 (Prudente de Moraes). Winge (1887) identified, in the material collected by Lund, the new species *Chenelopex pugil* (Winge 1887) as previously related.

There were no explicit references to fossil findings of fish, amphibians nor non-avian reptiles in the Lagoa Santa area after the records previously mentioned. In the material recovered in the Cuvieri Cave, a new extinct bird species was identified: *Pleistovultur nevesi* (Alvarenga et al. 2008). With remains from Lapa Vermelha IV, the cave where “Luzia” was found, Alvarenga (2007) identified the presence of *Vultur gryphus* (Linnaeus 1758) and of *Anodorhynchus glaucus* (Vieillot 1816) or *Anodorhynchus leari* (Bonaparte 1856). These two species are almost identical in their osteology so it was not possible to define the exact identity of the Psittacidae.

Concerning the birds, it is important to point out what has already been said about mammalian micro-fossils: the possibility of comparative studies between three historical moments of which there are enough study elements belonging to the Late Quaternary, second half of the nineteenth century and contemporary collections. In the material found by Lund, there are elements that allow inferring that the ornithofauna in the region he has studied would indicate, in the Late Quaternary, a predominant environment of forest. Such a paleoenvironment could explain a strange fact observed in the fauna composition of extinct megamammals in Lagoa Santa. In most of the Pleistocene deposits of the Brazilian intertropical region, numerous findings consist of specimens of *S. waringi* and, notably, *E. laurillardi*. Possibly the remains of this species are found in greater numbers and sites in this area. But, in Lagoa Santa, Lund’s findings of these two species were very scarce. For the species *E. laurillardi*, only two molariforms were recovered. This fact, at the least, is exceptional since the collections were extensive and intensive. It is perhaps associated with a type of regional environment that is not in agreement with the most common in other intertropical areas. A plausible explanation for this finding could be the environment translated by the fossils of the birds identified previously indicated. Large animals, such as those mentioned,

would hardly inhabit a distinctly predominantly forested environment in which large areas of pasture, necessary to such massive species, would be nearly absent.

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