

Chapter 2

Peter Wilhelm Lund: Life and Work

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Abstract Peter Wilhelm Lund (1801–1880) was a most remarkable nineteenth century Danish naturalist. During 10 years of intense work in the Brazilian limestone caves in the 1830s and 1840s, he generated new explanations for the evolution of the Earth, its fauna and flora, and human beings. His scientific methods were characterized by his unprecedented focus on complete systematic registration. Lund discovered and described an enormous range of extinct animals. He demonstrated that the extinction of prehistoric animals had by no means been complete, that actual animals in fact had lived side by side with animals that are now extinct and even that human beings had been contemporaneous with the extinct megafauna. Lund's discoveries and analyses contributed toward the lasting and persistent reformulation of the history of the Earth and of humanity that eventually paved the way for a more general acceptance of Darwin's revolutionary ideas. In fact, he offered to Darwin a long-term view of animal evolution. In addition, Lund performed a pioneering attempt of determining an absolute dating of the contents of a cave. This chapter gives an introductory survey of Lund's work in the caves of the Lagoa Santa region, as well as a summary of his most important studies on cave fauna.

Peter Wilhelm Lund (1801–1880) was among the most remarkable Danish naturalists of the nineteenth century (Fig. 2.1). During 10 years of intense work in Brazilian limestone caves, he generated new explanations for the origin and evolution of the Earth, its fauna and flora, and human beings. His scientific methods were characterized by his unprecedented focus on complete systematic registration – whether it involved the contents of an individual cave, the taxonomy of the fauna of the Brazilian central plateau, or the vegetation around Lagoa Santa.

Lund's discoveries and analyses contributed toward the lasting and persistent reformulation of the history of the Earth and of humanity that eventually paved the way for a more general acceptance of Darwin's revolutionary ideas. The overriding aim of P.W. Lund's excavation work was not merely to collect as many bones as possible but, above all, to create a comprehensive view of the “Brazilian animal

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Fig. 2.1 Photographic portrait of Lund aged 64 taken by Eugen Warming (Natural History Museum, University of Copenhagen)



world.” He did that by making detailed descriptions of the species, whether extinct or not, and their kinship relations.

Peter Wilhelm Lund was born into a wealthy family of cloth merchants in the Danish capital, Copenhagen. His father had left him and his two brothers a considerable fortune at his death in 1820. That inheritance, competently administered by his brothers, made Lund economically independent for the rest of his days.

In 1818, Lund entered the University of Copenhagen as a medical student, as the natural sciences were not yet included in the curriculum. Even so, Lund spent most of his time at the Museum of Natural History, presided over by Professor J.C. Reinhardt,¹ and at the botanical gardens with Professor J.F. Schouw.² At the age of 23, Lund graduated with the presentation of two dissertations, both of which were awarded the university gold medal. One of them, a treatise on vivisection (Lund 1825) became widely disseminated as a textbook at the universities of Europe. The subject of the other treatise was crustaceans, one of Lund’s principal interests under his first stay in Rio (Lund 1826).

Lund set off for Brazil shortly after his graduation. Unlike most of his colleagues, he did not need a travel allowance from the state; he was instead endowed with a monetary grant for the express purpose of making a collection of zoological material for the Museum of Natural History.

We have no explicit indications of why Lund chose to go to Brazil. We know, however, that the country’s recent independence had opened a new and unexplored field for naturalists. The resulting ample possibilities for making important discoveries and the warm climate is a valid explanation for the choice made by an ambitious and independent – as well as adventurous – young man.

¹Johannes Christopher Hagemann Reinhardt (1776–1845), zoologist and Lund’s professor at the University of Copenhagen. Father of Johan Theodor Reinhardt (1816–1882), zoologist and curator of the Lund collection at the Museum of Natural History in Copenhagen.

²Joakim Frederik Schouw (1789–1852), professor of Botany and an important political figure in Denmark.

Lund spent most of his first journey in Rio de Janeiro, with some incursions in Niteroi and a more prolonged stay near Nova Friburgo. Apart from the material he collected for the museum, the journey rendered good results for Lund's scientific endeavor and yielded important studies on tanagers (which became the object of Lund's doctoral thesis; Lund 1829),³ mollusks (Lund 1834), vultures (Lund 1832), and ants. Lund returned to Europe in 1828 full of new experiences and with a profound and long-lasting love for the Brazilian Nature. This first trip was decisive for the course of his life.

Back in Denmark in 1829, Lund soon set off on his grand tour across Europe, visiting museums and making contacts with colleagues in the big cities. He passed through Berlin and Vienna, and on arrival in Italy, he took off to Sicily to study botany and marine zoology. While there, he received the news that his mother had passed away. Even devastated by the loss, he welcomed his freedom to travel and stay abroad. First, he decided to spend the winter of 1830–1831 in Paris where he attended George Cuvier's lectures on comparative anatomy and made acquaintance with leading figures in the field of natural history like Alexander von Humboldt, Henri Milne-Edwards, and Jean Victoire Audouin.⁴ In the spring of 1831, he informed his family of his wish to make another trip to Brazil to complete the material already collected (Holten and Sterll 2010:69–85).

At the end of 1832, Lund set off once more for Brazil, arriving in Rio de Janeiro in January 1833. After a stay in Rio, he arranged to make an expedition to the interior with the botanist Luiz Riedel, a veteran of the ill-fated Langsdorff expedition.⁵ They set off for São Paulo in 1833, spent the rainy season in Campinas, and then headed north, intending to pass through the province of Goiás. However, repeated bouts of fever delayed them so much that they opted for a shorter route across the northern part of Minas Gerais province (Holten and Sterll 2010:106–28). The immediate result of this expedition was an important botanical paper, which like Lund's other work was published in Copenhagen (Lund 1837a). Herein, Lund discusses the effects of fires on the *cerrado* (Brazilian savannah vegetation), stating his conviction that they occurred before the arrival of the Europeans in Brazil. This understanding would later serve his interpretation about the extinct megafauna way of life (Lund 1841b, 1846).

In the village of Curvelo, in the north of Minas Gerais province, Lund had an accidental and decisive encounter with his compatriot Peter Claussen.⁶ A common industry of this region was the extraction of saltpeter from caves for the manufacture

³Small passerine bird inhabiting forests in Brazil, Argentina, and Paraguay (Family: Thraupidae). Lund studied the *Euphonia* genus which today is attributed to the Fringillidae family, subfamily Euphoniinae.

⁴Georges Cuvier (1769–1832), French zoologist, instrumental in establishing the fields of comparative anatomy and paleontology. Alexander von Humboldt (1769–1859), German geographer, explorer and diplomat, known for his expeditions in Latin America. Henri Milne-Edwards (1800–1885), French zoologist, publisher of *Annales des sciences naturelles*. Jean Victoire Audouin (1797–1841) French entomologist and ornithologist.

⁵Luiz (Ludwig) Riedel (1790–1861), German botanist, became director for the department of botany and the botanical garden of the Natural History Museum of Rio de Janeiro.

⁶Peter Claussen (1804–1855), also known as Pedro Claudio Dinamarquez and Chevalier Claussen. Danish natural history collector, business man, and adventurer.

of gunpowder. Claussen was heavily involved in this industry, as he possessed several caves at his nearby farm. At the end of the extraction process, huge bones were frequently found, which the local people believed were the remains of “giants.” Claussen, however, was better informed. He had participated in the expeditions of Friedrich Sellow in the 1820s and had at that time established a lucrative trade, selling fossilized bones to European museums.⁷

Lund immediately realized the significance of Claussen’s findings and changed his travel plans. After accompanying Riedel to Ouro Preto, Lund returned to Curvelo to explore the caves with Claussen. Two important incidents marked Lund’s return to Curvelo. First, at Claussen’s home, he met the Norwegian Peter Andreas Brandt, who for almost 30 years went to work with him as his illustrator and assistant.⁸ Second, Lund realized that he could not stand Claussen’s company. Indeed, they crossed paths many times in the years that followed (for further details, see Holten and Sterll 2010:131–34, 164–172).

In October 1835, Lund and Brandt traveled from Curvelo to Lagoa Santa where they intended to spend the rainy season. Lund, however, was captivated by the little town by the lake, and after 2 year of residence, he purchased a house on a large plot of land that went right down to the lake’s edge. This house became his home for the next 43 years and the center of his scientific activity. The grounds were large enough for an ever-increasing number of sheds to store and study the findings from the caves. The garden was planted with specimens of the regional vegetation, including orchids, and gardening became Lund’s main leisure activity. It also housed several animals – armadillos (Fig. 2.2), bush dogs, sloths, monkeys – that the boys from the town used to bring to him. In addition to company, these animals were utilized as study objects and references for the past megafauna behavior.



Fig. 2.2 Armadillo. Drawing by Lund (Museum of Natural History, University of Copenhagen)

⁷Friedrich Sellow (1789–1831), German botanist and naturalist. One of the earliest scientific explorers of Brazil.

⁸Peter Andreas Brandt (1792–1862), Norwegian artist and publisher; Lund’s illustrator and assistant.

Excavations

During 10 years of work in the Lagoa Santo region, Lund excavated and researched innumerable caves. What follows is a summary of his enterprise.

In 1836, Lund undertook three journeys. Two of them were to the Fazenda do Mocambo and the Cerca Grande cave complex (Lund 1837c), and one was to the more distant Sete Lagoas region.

In 1837, Lund made two trips, the first returning to the Fazenda do Mocambo where Lund visited the Cerca Grande cave and the Lapa do Baú. On his second trip, Lund made a brief and unfruitful visit to the Sumidouro cave before returning to Cerca Grande and Baú.

In the years that followed, Lund cut down his trips to one every year, as he had already collected an enormous quantity of bones. In 1838, he visited the Lapa do Baú cave and made another try in the region of Sumidouro. In 1839, he began explorations at Sumidouro and visited the Escrivânia cave complex for the first time, before completing the excavations at Cerca Grande.

The decisive year of 1840 was marked by the first discovery of fossilized human remains. It was made at Lapa de Sumidouro, which is usually flooded. Lund wrote:

Sunday, (July) 26. Visit to two caves in the rock at the eastern extremity of the Sumidouro Lake one of which I had been inside the year before but I had not got very far because it had been full of water. In a corridor of that cave, which had been under water the year before and probably becomes submerged periodically during the rainy season, two extraordinarily old, completely petrified human skeletons were found, in addition to some animal remains.⁹

In 1841, Lund concentrated his efforts on the Baú and the Sumidouro caves, as both continued to yield good results. The following year, he visited Baú and Escrivânia until the work was interrupted by a local insurrection, which stopped any further travel.

The year of 1843 became Lund's most productive one – he undertook no fewer than six expeditions, simultaneously excavating various caves and continuing work until the height of the rainy season. The largest project was the emptying of the Sumidouro cave to such an extent that it became possible to obtain a complete view of its geology and evaluate the deposits of human bones found together with those of extinct animals. The project was destined to yield one of his most important papers (Holten and Sterll 1998; Lund 1845a, b).

The last year of excavations, 1844, was dedicated to the complete removal and registration of all the material from the Lapa da Escrivânia V (Lund 1846). This was a daring experiment attempting to obtain an absolute dating of the contents of the cave. The cave's entrance was a vertical shaft stretching downward from the rock surface. A scaffold was mounted over the entrance, and during three and a half months, a dozen men extracted 6552 barrels of earth from within. The mandibles of small mammals contained in one barrel - chosen at random - were counted. Then followed a series of complicated calculations that considered the reduced numbers

⁹Lund: Travel Diaries (manuscript); Royal Library, Copenhagen, Add. 1128 4°.

of animals in the deeper layers of sediment. From that inventory, Lund estimated that the cave had contained 7,590,650 animals, most of them mammals and representing a total of 56 species.

The next step was the result of many years of ornithological observations. Lund was quite familiar with the white owls (*Glaucidium perlatum*) living in the caves, one couple to each cave, and he knew that each couple captures and devours about four mice a day, afterward regurgitating their bones. If the cave had been occupied without interruptions, the owl's devouring of 7.5 million mice would have required no less than 5137 years.

This estimate was in concordance with the high age of the Brazilian central plateau that Lund had emphasized in his scientific memoir on the excavations at Sumidouro (Lund 1845c). Lund's investigation of the owl pellets is remarkable as one of the first qualified attempts ever made to obtain an age estimate of paleontological material based on empirical observations.

Working Methods

Work in the caves was often carried out in complete dark, only sparsely illuminated by torches or candles. To reach the bone breccia, the layers of stalagmite covering most of the sedimentary deposits had to be removed using hammer and chisel. When the breccias were brought to the surface, the next step in the process was to evaluate their contents, cutting free the more interesting parts for supplementary investigation. In addition to thousands of isolated bones, Lund's collection included a great number of bone breccia to help the interpretation of how the bones were deposited. Lund himself described the organization of this work in these words:

First the breccias are separated and divided into two classes: those that should be preserved just as they are, and those that should be sacrificed to extract the bones. The former, according to the circumstances, may undergo a finishing process, partly to eliminate any useless parts, and partly to obtain characteristic surfaces showing not only the bones but also the material surrounding them. The second class calls for more work and the use of different instruments, according to the hardness of the mass and the condition of the bones. For three months, two people have been busy at this work under my constant supervision. Similarly, the bones are separated into two groups: one comprising the complete bones and those with ancient fractures; the other comprising those with recent fractures and all the broken parts with the same characteristics. In spite of all the care taken, many bones are broken during the excavation or in the separation process and it is not always possible to localize and adjust the parts that should fit together. Piles of broken bones and bone fragments are always accumulating, and the cleaning up this veritable Augean stable calls for great patience and implies a great loss of time. It is like a puzzle, putting each of those pieces in its proper place and afterwards gluing and reconstructing the complete bones. Naturally, only I can carry out that work and it has taken me several months. Afterwards, each bone has to be examined, determined, numbered and introduced in the catalogue and, as you, Sir, are well aware, my own house does not have space enough for all those things, so I have packed up a large part of them and sent them to Rio. Only after all those preparations have



Fig. 2.3 Bone breccias (Museum of Natural History of the University of Copenhagen)

I been able to form an approximate vision of the contents and, even then, only in relation to the larger animals because, in regard to the smaller mammal species and the bird and reptile classes, that is absolutely unthinkable in view of the stunning quantity of pieces, which is so great that, even if I were to use thousands as my unit, there would be great difficulty to count them, much less to examine them appropriately.¹⁰

During 10 years of excavation, Lund collected more than 1000 bone breccias (Fig. 2.3), thousands of fossilized and recent bones of animals, many of which were type specimens, fossilized human bones, and a reference collection of contemporary animal skeletons. In addition, he used the animals in his garden for behavioral studies.

The results of this assiduous activity were published in Danish in the *Journal of the Danish Scientific Society* (1837–1846). Excerpts of these publications were translated and published in journals in England and in France. At the end of the nineteenth century, four scientific memoirs were translated into Portuguese via the French versions, and in 1950, these Portuguese translations were reedited and supplemented by Carlos Couto (1950). The memoirs reveal quite clearly how Lund's thinking was transformed during his work in the caves; they show his growing understanding of the geological evolution of the Brazilian highland and bring evidence of the evolution of his view regarding the taxonomy of species from the caves. We shall proceed with a brief introduction to Lund's more important writings.

¹⁰P.W. Lund to J.Ch. Reinhardt, Letter dated April 26, 1844, Royal Library, Copenhagen, NKS 2838 4°.

Lapa Nova de Maquiné (Lund 1837b)

Maquiné was the first cave Lund ever visited, and his ideas and even his destiny were strongly marked by the singular beauty and scientific potential he found in this cave. The memoir on Maquiné is imbued with an almost lyrical tone, and Peter Andreas Brandt provided a detailed mapping of the cave as well as his first scientific illustrations to Lund's work. The memoir supplies a precise geological description and a full report of the remains of animals found below the stalagmite (Fig. 2.4). Lund and Brandt visited the cave together with Claussen and spent a week in the excavation.

Lund based his analysis of the Maquiné cave on Cuvier's catastrophism, proposing that a flood had swept the animals into the cave. The British geologist William Buckland (1784–1856) had proposed in 1823 a radical catastrophism derived from the biblical diluvium (Buckland 1823). Lund, however, clearly dissociates his views from any biblical understanding, accepting the term “diluvian” proposed by Buckland “in spite of the hypothetical identification of that event with the Mosaic diluvium that the name could, and indeed, did lead to” (Lund 1837b:230).

Fig. 2.4 Articulated skeleton underneath stalagmite crust in the Lapa Nova de Maquiné cave. Pencil drawing by Brandt (Natural History Museum of the University of Copenhagen)



More interesting is that Lund, already in this first memoir, introduces one very important question, which was to occupy his thoughts for the following years: how the animals have entered – and remained – in the caves. Throughout his scientific memoirs, Lund discusses this question repeatedly, proposing a total of five different explanations. In this first attempt, he considers three of them (numbers 1, 2, and 5):

1. Sick or old animals may have sought shelter in the caves and died inside.
2. Animals may have been carried inside by predators.
3. Animals may have entered the caves to lick the salty earth, getting lost in the dark corridors.
4. Animals may have fallen into the caves through vertical fissures in the roof that would apply both to extinct animals like the giant sloths and to actual ones like cattle.
5. Animals may have been swept inside by currents of water.

At Cerca Grande, Lund witnessed a demonstration of his first two explanations, while his observations of cattle and other actual animals made him include explanations 3 and 4.

Cerca Grande (Lund 1837b)

The Cerca Grande cave is situated on the Mocambo farm near Lagoa Santa, and Lund visited the many caves on this farm several times (Fig. 2.5). In Cerca Grande, Lund found his first fossil carnivore: a large, robust canine species that Lund called cave wolf (*Canis troglodytes*). In view of the great quantity of bones found in the cave, both wolves and their prey, it was possible to establish that this was the first



Fig. 2.5 The Indians' Rock near to the Mocambo farm. Painting in Indian ink by Brandt (Royal Library, Copenhagen)

animal found that had indeed lived in the caves. Furthermore, the finds at Cerca Grande gave Lund his first clues for his description of the process of petrification.

The Cerca Grande canines lived in the caves and carried their prey, mostly pacas (*Coleogenys laticeps*), inside. Both the fossil canines and the fossil pacas were bigger than the contemporary ones. The establishment of this observation as a rule was a major inspiration for Darwin, giving him a concrete example of a very long-lasting evolution process and earning Lund and Claussen a reference in *On the Origin of Species*.

The petrification process had transformed many of the fossil bones into molds, where only the form remained while the bony tissue itself had been transformed into stone. Lund explained this process as being result of the continuous immersion of the bones in the calcareous waters of the cave.

As regards the internal constitution of those bones and their chemical composition, they exhibited yet another phenomenon; one which I had not previously had the opportunity of observing in bones from that period. With the loss of their animal constituents, which these bones generally have lost to a greater or lesser extent, they normally become brittle and present a weak, earthy fracture in which the organic structure is clearly recognizable. That was not the case here. Every trace of bony substance and organic structure had disappeared, being replaced with calcite. Consequently, those bones were very heavy and stronger than fresh bones, and dropped on the floor they made the same sound as pieces of stalactite. Only a few bones avoided this transformation but in some of them the process was more or less complete making it apparent that the transformation had begun on the surface and advanced towards the inside.

The Cave Fauna Memoirs (Lund 1841a, b, c, d, 1842a, b, c, 1845c, 1846)

“A view of the animal world in Brazil before the last cataclysm of the Earth” (Blik paa Brasiliens Dyreverden før den sidste Jordomvæltning) is the collective title of a series of six scientific memoirs with various addenda that Lund published in the Journal of the Danish Scientific Society from 1841 to 1846. The memoirs consist of approximately 450 written pages and 56 illustrations produced by Brandt.

The Earth’s geological evolution was the object of intense debate at the time. Had the Earth’s history proceeded as a smooth evolution or as a sequence of sudden catastrophes? Was the extinction of a species a conceivable idea? Could one species be transformed into another?

The title of the memoirs contains a clear reference to Cuvier’s catastrophism, according to which one or several “terrestrial convulsions” had wiped out the animals in a given area, later to be replaced by a new fauna. Cuvier did not speculate as to where that new fauna might come from, much less about the origins of human beings. The same is true of Lund, who always warned against any attempt to subordinate empirical observations to a system of thought. Lund, however, let himself become gradually convinced of the inadequacy of catastrophism and veer toward

the uniformitarianism proposed by Charles Lyell.¹¹ He bought Lyell's book in 1840 and in later years regretted the Cuvier-inspired title chosen for his major work.¹²

The first memoir was written the year after the first memoirs on the Maquiné and Cerca Grande caves. The investigation and excavation of an additional 59 caves led him to alter his explanation for the cave formation and development. When he wrote the memoir on Maquiné, he imagined that the cave had been formed by the infiltration of water from above. Later, he abandoned that idea, demonstrating that far more violent currents of water would have been necessary.

In these caves you feel as if wandering at a rocky coastline seeing how the naked rock walls are eroded and abraded by the waves. The origin is the same, and one is forced to change the period of creation of the caverns to those remote times when either great terrestrial lakes covered all of the now dry land, or the times when they still rested at the bottom of the sea. What is evident, is that infiltration of water from above through clefts in the limestone is in no way sufficient to explain those phenomena, especially in the case of deep, although blind, erosions of the ceilings. (Lund 1841a:32)

The first step in the process, the degradation of the rock by infiltrated water, is therefore attenuated and completed by a much more intense and more complicated process. First, it is necessary to bear in mind the slow rising up from the sea bed of the whole South America in the course of thousands of years. That was a subject of constant discussion among the geologists of the day, and Lund could read the regularly published notes by Charles Darwin, among others, about the measurement of the rising of the landmass on the coast of Chile, in the journal *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie*.

Following the introductory notes on the region's geology, the formation of caves, and the contemporary animal species, the main contents of the memoirs consist in a progressive presentation of extinct animal species from the caves. It starts from the description of individual bones, and, as knowledge cumulated and new bone deposits were discovered, the complete image of the animal and its taxonomic relations is gradually delineated.

Lund's most valuable tool for his work with the extinct animals was the discipline of comparative anatomy, which is Cuvier's most lasting contribution to natural history. Lund had studied his methodology in depth and had become highly skilled at extrapolating conclusions from the detail to the whole, from the tiny bone to the complete animal. This method was especially useful, as many of the fossil bones were separated from their connections and often more or less broken.

Lund's basic premise for his work was that "... the set of animals which, prior to the Earth's last modification, populated the Brazilian tropical central plateau, was, in terms of basic types, the same as that which inhabits it now" (Lund 1841b:114) – on the other hand, however, "the last set of mammals to disappear from the South American continent, in terms of species, was completely different from those which

¹¹ Charles Lyell (1797–1875), British geologist. His book *Principles of Geology* proposed the principle of uniformitarianism, that the Earth's evolution has involved the same processes from its origin until today (Lyell 1830–1833).

¹² P.W. Lund a J.C. Reinhardt, Letter dated April 26, 1844, Royal Library, Copenhagen, NKS 2838 4°.

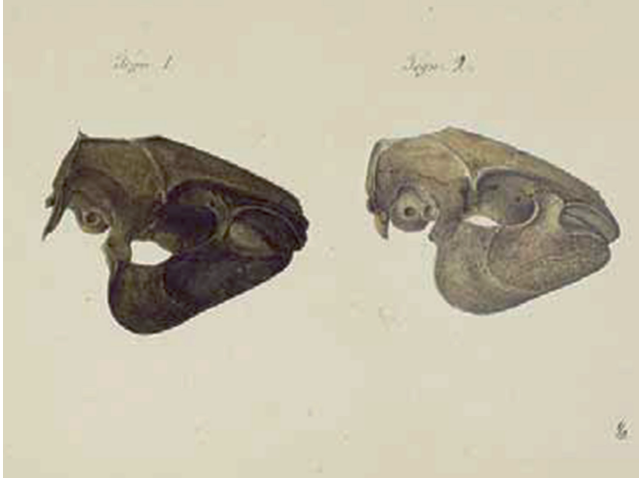


Fig. 2.6 Paca crania: extinct species *Coleogenys laticeps* on the left and living species *Coleogenys paca* on the right. Gouache by Brandt (Royal Library, Copenhagen)

today populate the same continent” (Lund 1841b: 118). In other words, the families have many characteristics in common, but the species have changed.

Despite that underlying certainty, Lund made a deliberate effort to discover if any species were identical in both periods, thus having succeeded to cross the “frontier” separating the extinct from the contemporary. This was a most difficult question to solve, as proof of being identical would require complete skeletons, whereas only a few bones were needed to prove the diversity of species. For a while, Lund believed to have established the identity between fossil and fresh bones of the paca (Cuniculidae family), but, in the end, he had to conclude the existence of three species, two extinct and one contemporary (Fig. 2.6). These species were only distinguishable from one another by a slight cranial variation (Lund 1841b:102).

The following year, a similar investigation, however, led to the opposite result. Lund was able to conclude that the fossil and fresh bones of the spiny rat (*Loncheres elegans*) belonged to the same species: “... a result which, if confirmed, will represent an exception to the rule whereby the species are different in every case for the two periods mentioned” (Lund 1841c:245). Finally, in the fourth memoir written in 1841, he put forward a thesis diametrically opposed to the one proposed in 1837:

... it is, nevertheless, very strange how the number of such forms from the past, which show a more or less notable affinity with present day forms, continually increases so that the probability increases day by day that the complete set of animals living today existed in those former times in a model that was more or less similar but that, at the same time, alongside those similar present-day animal forms, others existed, which to a greater degree were distant from them and that these last mentioned, generally speaking, are distinguished by their more considerable body masses. (Lund 1842b:141)

An important part of the “view of the animal world in Brazil before the last cataclysm of the Earth” is the increasingly diversified and embracing list of the

currently established living and fossil mammal species attached to each memoir. In the later memoirs, these lists demonstrate clearly when a close affinity occurs between a fossil and its similar living species. When Lund, for instance, names the spiny rat *Loncheres elegans* and its fossil equivalent *Loncheres affinis eleganti* (i.e., “in affinity with “*elegans*”), he is killing two birds with one stone, indicating both the affinity and the slight differences between the two species. In the list attached to the fourth memoir, Lund enumerates 88 living and 111 extinct species. Among them, the term “*affinis*” is attributed to 38 fossil species, marking their representation among both the contemporary and the fossil species.

Already in his 1796 description of the *Megatherium*, Cuvier had noted the close relation between this huge animal and the tiny, modern day sloth. Lund continued in the same direction with his indication of the close relations between extinct and living species, despite the remarkable differences in size. In this way, he provided a demonstration of a long-term development which was highlighted by Darwin in *The Origin of Species* as a decisive inspiration:

That relationship is even more clearly seen in the wonderful collection of fossil bones made by MM. Lund and Clausen in the caves of Brazil. I was so much impressed with these facts that I strongly insisted, in 1839 and 1845, on this ‘law of succession of types’ – on ‘this wonderful relationship in the same continent between the dead and the living.’ (Darwin 1859, p. 338).

Lund’s discovery of human remains in the same layers as those of extinct animals posed the crucial question of contemporaneity of humans and extinct species. In 1843, Lund was able to demonstrate that humans had been contemporary with of at least five extinct animal species, and, in his report on the human findings at Sumidouro cave, he made a strong argumentation in support of this thesis (Lund 1845a, b).

Lund’s Personal Evolution

In his student days, Lund had been influenced by the Romantic natural philosophy in vogue at the beginning of the nineteenth century. Faced with the reality of the Brazilian caves, however, he abandoned this line of thought and became adept of an implacable empiricism, which led him to sacrifice any theory that could be contested by observed facts. He was highly precocious in his readiness to admit that the question of the evolution of species was one that must be left totally open.

Lund was a product of his time but advanced beyond it in various aspects, becoming a true pioneer in various areas. One example is the historicity applied in his writings on the vegetation of the Brazilian central plateau (Lund 1837a), where he emphasized the human role in the evolution of nature. Another example is his investigation of owl pellets (1846) establishing for the first time an empirical calculation of the time necessary to fill a cave, making the first steps of establishing a methodology of absolute dating.

Lund continues to surprise us. How was it possible for a lone researcher, far removed from the European scientific milieu, to go so far with his scientific methods and to anticipate scientific development in so many areas? Our belief is that he was able of transforming his isolation from a weakness to a force and that his intense and prolonged contact with the nature he was studying opened the way for his novel approaches. It enabled him to make complete records of the local fauna during an immense time span by the Herculean task of emptying various caves of their entire contents. When he stumbled on a question of special interest, he was able to intensify his searches in this particular area. This enabled him to make one of his most important discoveries, namely, the close similarities between the living and extinct species. In addition to using that revolutionary approach in his own work, he passed it on as a legacy to two of his students who visited him in Lagoa Santa. He gave J.T. Reinhardt the assignment of making a complete collection of the fish fauna of the Das Velhas River and asked Eugen Warming for and an equally complete registration of the Lagoa Santa flora.¹³

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¹³Johannes Theodor Reinhardt (1816–1882), Danish zoologist, son of Johannes Christopher Hagemann Reinhardt. Curator of the Lund-collection at the Zoological Museum in Copenhagen, visited Lund several times in Lagoa Santa. His complete record of the fishes of the Rio das Velhas (Lütken 1875) became an important source for the Manuelzão Project initiated in 1997 for revitalizing this river. Eugene Warming (1841–1924), Danish botanist, Lund's assistant in Lagoa Santa (1861–1863), later director of the Botanical Garden in Copenhagen. His thesis *Lagoa Santa, et Bidrag til den biologiske Plantegeografi* (Warming 1892) and later works laid the ground for defining the notion of ecology.

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