ISSN 0326-1778 (Impresa)
ISSN 1853-6581 (En Línea)

HISTORIA NATURAL

Tercera Serie | Volumen 11 (1) | 2021/47-63

Número dedicado a la Historia de las Ciencias Naturales

DRAGON'S EGGS FROM THE "YELLOW EARTH": THE DISCOVERY OF THE FOSSIL OSTRICHES OF CHINA

Huevos de dragón en la "Tierra amarilla": El descubrimiento de avestruces fósiles en China.

Eric Buffetaut

CNRS (UMR 8538), Laboratoire de Géologie de l'Ecole Normale Supérieure, PSL Research University, 24 rue Lhomond, 75231 Paris Cedex 05, France. eric.buffetaut@sfr.fr
Palaeontological Research and Education Centre, Maha Sarakham University, Maha Sarakham 44150, Thailand

AZARA
FUNDACIÓN DE HISTORIA NATURAL

umai Universidad Maimónides

Abstract. Fossil ostrich eggs, mainly from the Pleistocene loess (the "yellow earth", huáng tǔ in Chinese), have been known to the Chinese for a long time. They were sometimes interpreted as dragon's eggs and were valued as curios. Palaeontologists first heard about them at the end of the 19th century, when a missionary in northern China obtained such an egg from a local farmer and sold it to Harvard University, where it was described by Charles Eastman in 1898, who referred it to *Struthiolithus chersonensis* Brandt, 1872, a taxon based on a fossil egg from Ukraine. More eggs obtained by missionaries subsequently found their way to various collections in the United States, Canada, Britain and Italy. The first western scientists to collect fossil ostrich eggs *in situ* in China, in the second decade of the 20th century, were the French Jesuit and naturalist Emile Licent and the Swedish geologist and archaeologist Johan Gunnar Andersson. Andersson's detailed investigations revealed that most of the eggs came from the Pleistocene loess, but eggshell fragments also occurred in older, Miocene deposits. A very large femur collected by Licent in 1925 from Lower Pleistocene sediments was not described until 2021. In a 1931 monograph on fossil ostriches from China, Percy Lowe erected the species *Struthio wimani* (based on a Miocene pelvis), *S. anderssoni* (based on eggs from the loess) and *S. mongolicus* (based on Neogene eggshell fragments from Inner Mongolia). The studies on fossil ostriches by C. C. Young and T. S. Shaw in the 1930s were part of the rapid development of palaeontological research carried out by Chinese researchers at that time.

Key words. Ostrich, Pleistocene, Neogene, China, Eggs, History of research.

Resumen. Los huevos de avestruz fósiles, que provienen principalmente del loess del Pleistoceno, son conocidos por los chinos desde hace mucho tiempo. A veces se los interpretaban como huevos de dragón y se valoraban como curiosidades. Los paleontólogos se enteraron de ellos a fines del siglo XIX, cuando un misionero en el norte de China obtuvo un huevo colectado por un granjero local y lo vendió a la Universidad de Harvard, donde fue descrito por Charles Eastman en 1898, quien lo refirió a *Struthiolithus chersonensis* Brandt, 1872, taxón basado en un huevo fósil de Ucrania. Posteriormente, otros huevos obtenidos por los misioneros llegaron a varias colecciones en los Estados Unidos, Canadá, Gran Bretaña e Italia. Los primeros científicos occidentales en recolectar huevos fósiles de avestruz *in situ* en China, en la segunda década del siglo XX, fueron el jesuita y naturalista francés Emile Licent y el geólogo y arqueólogo sueco Johan Gunnar Andersson. Las investigaciones detalladas de Andersson revelaron que la mayoría de los huevos provenían del loess del Pleistoceno, pero los fragmentos de cáscara de huevo también fueron encontrados en depósitos más antiguos, del Mioceno. Un fémur de gran tamaño recolectado por Licent en 1925 de sedimentos del Pleistoceno Inferior no se describió hasta 2021. En una monografía de 1931 sobre avestruces fósiles de China, Percy Lowe erigió la especie *Struthio wimani* (basada en una pelvis del Mioceno), S. *anderssoni* (basada en huevos provenientes del loess) y *S. mongolicus* (basado en fragmentos de cáscara de huevo del Neógeno del Interior de Mongolia). Los estudios sobre avestruces fósiles realizados por C. C. Young y T. S. Shaw en la década de 1930 fueron parte del rápido desarrollo de la investigación paleontológica llevada a cabo por investigadores chinos en ese momento.

Palabras clave. Avestruz, Pleistoceno, Neógeno, China, Huevos, Historia de las Investigaciones

INTRODUCTION

The ostrich is no longer native to China and, contrary to what has sometimes been claimed (Swinton, 1965), it did not survive there until historical times. According to Laufer (1926: 29), ''the ostrich was first discovered for the Chinese by the renowned general Chang K'ien [Zhang Qian] during his memorable mission to the nations of the west (138-126 B.C.)'', during the Han dynasty. Subsequently, eggs and then living birds were sent to the imperial court by the Parthians and the Persians, and by the time of the Tang dynasty (618-907 A.D.), the ostrich had become familiar to Chinese artists who depicted them in various forms (Laufer, 1926). However, fossil evidence shows that, well before that, ostriches were present in north-eastern Asia during the Pleistocene and there is ample evidence that early humans interacted with them (Khatsenovich et al., 2017; Buffetaut & Angst, 2021). The fossil record of these extinct Chinese ostriches is very largely based on eggs and eggshell fragments from the loess (the "yellow earth", huáng tǔ, of the Chinese) of northern China. The purpose of the present paper is to retrace the history of the discovery of these unusual fossils, in which all sorts of people were involved, from local farmers to missionaries and foreign scientists (the first scientific description having been published in 1898). Pleistocene ostrich remains (mainly eggshell fragments) are also known from Outer Mongolia (Andrews, 1926, 1934; Berkey & Nelson, 1926; Janz et al., 2009) and Siberia (Tugarinov, 1930; Khatsenovich et al., 2017), but the geological context and the circumstances of the early discoveries are rather different and these finds will not be discussed in the present paper.

FOSSIL OSTRICH EGGS IN CHINESE TRADITION AND HISTORY

Fossil ostrich eggs are found from time to time in the loess of northern China and these remarkable objects must have attracted the attention of the local people for a long time, but few records of early finds are known. It is worth noting that Eastman (1898), in his description of the first fossil ostrich egg from China to have been sent to a western country (see below), noted that the Chinese farmer who found it, together with a second, broken, specimen, considered them as a pair of ''dragon's eggs''. Fossil bones have traditionally been regarded as dragon bones in China (Buffetaut, 1987, 2017) and it is interesting that fossil eggs were similarly associated with that mythical being which is so important in Chinese culture. The term ''stone egg'' apparently was also sometimes used (Andersson, 1923, 1934).

Andersson (1923, 1934) reported that a fossil ostrich egg (*Struthiolithus*) was kept in the ''Art Museum in the Forbidden City'' in Beijing, with a label indicating that it belonged to emperor Qianlong (Qing dinasty, ruled from 1735 to 1796). The specimen does not seem to be on display at the Forbidden City at the moment and it would be interesting to investigate whether it is still part of the collections. The imperial collection was not the only one to possess a fossil ostrich egg: Bensley (1921) mentions that, according to his informant Mr Clark (see below), such an egg was kept in an ''educational museum'' at Tongzhou, near Beijing, and was destroyed during the Boxer uprising in 1900.

Fossil ostrich eggs have attracted the attention of humans for a long time in China. Andersson (1923) mentioned that numerous ostrich eggshell fragments had been found in 1922 at an archaeological site of the Neolithic Yangshao culture in Henan.

As the fragments had the same appearance as those from the loess, he concluded that Neolithic men had found a fossil egg of an extinct ostrich and he mused about what prehistoric humans may have thought about such finds (Andersson, 1934). That Neolithic humans used fossil ostrich eggshell as a material to make beads has been confirmed by subsequent discoveries –this was in fact a continuation of a practice started earlier, when Palaeolithic and Mesolithic humans could use the eggs of living ostriches, before that bird became extinct in north-eastern Asia (Khatsenovich et al., 2017).

At later periods fossil ostrich eggs were valued as ''curios''. Bensley (1921) mentioned that the specimen presented to the Royal Ontario Museum in 1919 had been in the possession of a curio dealer, after having been exhibited at fairs in a village in Henan Province. Similarly, Andersson (1923) mentioned that in September 1919 a curio dealer came to his home in Beijing to offer him an especially large fossil ostrich egg for sale. Andrews (1932: 282) noted that ''in the loess of China, *Struthiolithus* eggs are so frequently discovered that it is possible to buy them in many curio shops of Peking'', which seems to be an exaggeration!

Little seems to be known about beliefs that may have been attached to fossil ostrich eggs in China, although Andersson (1923: 63) reports that when such an egg from the loess was found floating on the Yellow River at the beginning of the 20th century, the discovery ''was considered by the villagers as an omen full of significance''. Osborn (in Ingersoll, 1928: VI) noted that it had occurred to him that ''the giant fossil eggs of the extinct ostrich of China […] may have given rise to the myth of the Phoenix or of the Roc''. However, there is no real evidence to support such a view. A search through old Chinese documents and literature might provide more information about ancient beliefs and early interpretations concerning these unusual fossils.

THE FIRST SCIENTIFIC DESCRIPTION: CHARLES EASTMAN AND THE HARVARD EGG (1898)

The first scientist to describe a fossil ostrich egg from China was the American palaeontologist Charles Rochester Eastman (1868-1918; Figure 1), who is mainly remembered for his numerous and important publications on fossil fish (Dean, 1919). The specimen described and illustrated by Eastman (1898a,b; Figure 2) had been sold to the Museum of Comparative Zoology of Harvard University by an American missionary, Rev. James H. Roberts, on behalf of another missionary, Rev. William P. Sprague. The latter had obtained it from its discoverer, a Chinese farmer, who had found it at a

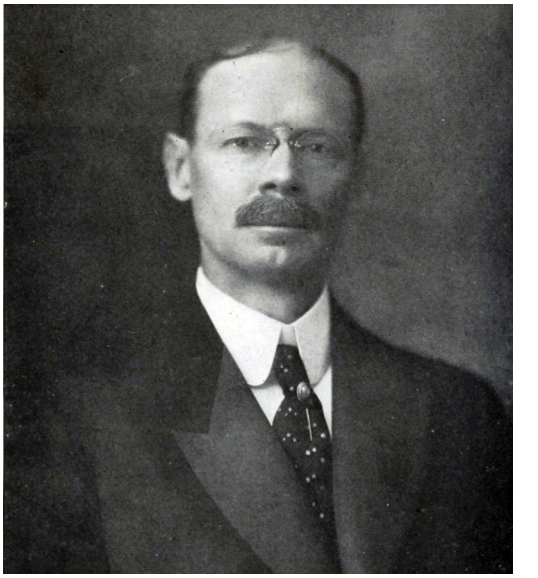

Figure 1 - The American palaeontologist Charles Rochester Eastman, who published the first scientific description of a fossil ostrich egg from China in 1898 (from Dean, 1919).

locality about 50 miles SSW of the city of Kalgan (today Zhangjiakou). Together with the complete egg was a broken one –their discoverer thought they were dragon's eggs. Andersson (1923) investigated the details of the discovery and noted that the eggs had been found at a depth of 6 metres under a bank of clay or loess. Eastman referred the egg to the species *Struthiolithus chersonensis*, erected by Brandt (1872) on the basis of a large fossil egg found floating on the surface of a river near the village of Malinowka, in the district of Kherson in southern Ukraine. Brandt's reason for distinguishing this egg from those of the living *Struthio camelus* apparently was its larger dimensions (180 x 150 mm). Because of the unusual circumstances of its discovery, the exact geological provenance of the type of *Struthiolithus chersonensis* has been much debated. Mikhailov and Zelenkov (2020) refer it to the early Pliocene–early Pleistocene interval, which would make it significantly earlier than the Late Pleistocene loess of China. Brandt could make a plaster cast of the egg, but the original specimen was eventually broken into many pieces (Brandt, 1885). Nathusius (1885) could study some of the fragments and concluded that the egg clearly was that of an ostrich, although the thickness of the eggshell (2.6-2.7 mm) was greater than that of eggs ot the living ostrich (2 mm). Eastman apparently referred the Chinese egg to *Struthiolithus chersonensis* mainly because of their similar dimensions, although the eggshell of the specimen from China was thinner (2.2 mm) than that of the Ukrainian egg. Rothschild (1911) accepted Eastman's identification.

THE NEW YORK AND TORONTO EGGS

In 1915, a second egg was found by a Chinese farmer who had seen it protruding from the bank of the Yellow River (Huang He) in Henan Province. This egg was acquired by the American Museum of Natural History in New York City and identified as *Struthiolithus chersonensis* in a brief anonymous note (Anonymous, 1917), which emphasized the ''perfect condition'' of the specimen and noted that its capacity was more than two quarts (nearly two litres). No fuller description of the specimen seems to have been published and how it came to New York was not explained. The online catalogue of the American Museum of Natural History lists two fossil ostrich eggs from China referred to *Struthiolithus* sp., one (number 6690) without locality details and one (number 6815) from ''Honan or Shantung'' (Henan or Shandong in pinyin transliteration) ; one of them may be the egg in question.

In 1921, Benjamin Arthur Bensley (1875-1934), a professor of zoology at the University of Toronto, described an additional fossil ostrich egg from China. The specimen had been presented to the Royal Ontario Museum of Zoology (of which Bensley was the director) in 1919 by the Reverend Harold M. Clark, of the Presbyterian Foreign Mission, who had previously resided in Henan Province and had obtained the egg from a curio dealer (see above). According to a short item published in *Nature* in 1918, the Reverend Clark, then living in Wuan (then in Henan, now in Hebei), had written to the *North China Herald* that ''eggs of this kind are not uncommon in his neighbourhood and are washed out of the river banks by floods'' (Clark, 1918: 50). Bensley noted that a second egg obtained by the Rev. Clark had been presented to the British Museum. This is the egg NHMUK A 1308, which Lowe (1931) used as type-specimen for *Struthio anderssoni* (see below).

Bensley gave a detailed description of the egg and its surface ornamentation, as well as a good photograph, compared it

with the Harvard egg, and noted that it was significantly larger than the eggs of the living African ostriches. Like Eastman before him, he referred this Chinese egg to *Struthiolithus chersonensis*.

EMILE LICENT: POTSHERDS OR GIANT EGGS?

One the first western scientists to collect fossil ostrich eggs in China was Emile Licent (1876-1952). He was a French Jesuit missionary and naturalist (Cuénot, 1966; Buffetaut, 2019) who travelled extensively in northern China between 1914 and 1938 (Figure 3), collecting specimens for the large and modern natural history museum (Hoang Ho Pai Ho Museum) he built in the city of Tianjin (see Licent, 1945, for a summary of his palaeontological researches in China).

Interestingly, Licent initially misidentified some of the first ostrich eggshell fragments he discovered. In a 1920 article in a French-language general periodical published in Beijing (*La Politique de Pékin*), he described his excavations at a fossil locality in Gansu Province, at which he found abundant mammal bones (Licent, 1920a). Among the bones he found in three places what he described as (my translation) ''fragments of fine pottery, very hard, thin and unornamented''. At that time, Licent thought that the locality was Pleistocene in age and the purported pottery fragments were important evidence of human presence.

In a later paper in the same periodical, however, Licent (1920b) changed his mind. As he had found no evidence of rims, handles or bottoms, he doubted that the fragments could really be ancient potsherds, all the more so that they dissolved completely in hydrochloric acid. In a footnote he

Figure 2 - The first photograph of a fossil ostrich egg from China, sent to the United States by American missionaries, published by Eastman (1898a).

suggested that they were perhaps shell fragments of huge eggs. Andersson (1923) recognized that they were indeed ostrich egg fragments and noted that they were older than those from the loess, since the accompanying mammalian fossils clearly indicated that the locality belonged to the ''*Hipparion* fauna'' (of Late Miocene age) – not to the Pleistocene as initially supposed by Licent.

In the course of his explorations, Licent found ostrich eggshell remains at various localities, ranging in age from Miocene to Pleistocene, as noted in the detailed records of his travels (Licent, 1935). In addition, specimens were sent to him by various correspondents in remote parts of northern China. Licent had established an extensive network of Catholic missionaries, for whom he had written a small manual explaining how to collect natural history specimens; they sent him all kinds of objects for his Hoang Ho Pai Ho Museum in Tianjin. He noted, for instance, how a ''magnificent fossil ostrich egg'' found in 1923 in Shanxi had been sent to the museum by Father Louis Chanel, a missionary stationed there (Licent, 1935: 338). Although, as mentioned above, he also discovered evidence of older, Miocene, ostriches, the eggs or eggshell fragments obtained by Licent largely came from the Upper Pleistocene loess which covers vast areas of northern China. Eggshell fragments were also collected at sites yielding Palaeolithic stone implements, such as those along the Sjara Osso Gol (Salawusu) river, in Inner Mongolia, which Licent discovered and excavated together with the Jesuit and palaeontologist Pierre Teilhard de Chardin. These finds, which demonstrated that early humans had been contemporaneous with the extinct ostriches of China, were discussed at some length in a section on the antiquity of the ostrich in China, in a review of the Chinese Palaeolithic (Boule et al., 1928), in which the authors remarked that although eggshell remains were ubiquitous, extremely few skeletal remains had been discovered. An exception was a large femur, collected by Licent in the Lower Pleistocene beds of the Nihewan Basin, NW of Beijing, in 1925. The specimen was therefore significantly older than the eggs from the loess. It was taken to the Paris Natural History Museum by Teilhard de Chardin in 1927 and, according to a recent study (Buffetaut & Angst, 2021), can be referred to the extremely large and robust extinct ostrich *Pachystruthio*.

JOHAN GUNNAR ANDERSSON: EGG-HUNTING IN THE FIELD

At about the same time as Emile Licent was discovering ostrich eggshell fragments at various localities in northern China, the Swedish geologist Johan Gunnar Andersson (1874-1960) was investigating these unusual fossils in a more systematic way. Andersson (Figure 4) was employed by the Geological Survey of China as an adviser, his original mission being the search for mineral resources, especially iron ore (Andersson, 1927). However, he soon turned his attention to fossils, and then to archaeology (Andersson, 1934; Buffetaut, 2020), with the help of a network of (mainly Protestant) missionaries. As early as 1919, in a short article aimed at the general public, he mentioned what he called ''one of the most fascinating objects to be collected'' in the loess of northern China, viz. the ''gigantic eggs of an extinct *bird*'', which probably belonged to the ostrich group, supposing that hundreds of them had probably been unearthed, although only about 15 were known to him, and noting Eastman's attribution of one of these eggs to *Struthiolithus chersonensis* (Andersson, 1919: 709).

A turning point in the history of

research on fossil ostriches in China was Andersson's 1923 paper ''on the occurrence of fossil remains of Struthionidae in China'', published as part of a series of essays on the Cenozoic of northern China (Andersson, 1923). In it, he reviewed all the known finds of ostrich eggs or eggshell fragments in China, adding a number of occurrences to the rather short list of previously reported discoveries. Most importantly, he investigated many of the localities in detail, in order to ascertain the geological environment of the finds. He listed 18 localities in northern China where ostrich eggs (which he referred to *Struthiolithus chersonensis*) had been found, in the provinces of Shandong, Chihli (today Hebei), Shanxi and Henan (Figure 5). He noted the circumstances of the finds and their stratigraphic position and concluded that all were certainly or probably from the loess. He noted that when found *in situ* in the soil they were generally complete, and that frequently more than one egg was found. In addition, he discussed finds of ostrich eggshell fragments from localities yielding the older *Hipparion* fauna (Late Miocene), including those found by Licent, in Kansu and Henan, and he reported that he had discovered eggshell fragments at localities containing a mammal assemblage reminiscent of the *Hipparion* fauna in Inner Mongolia.

Figure 3 - The French Jesuit and naturalist Emile Licent crossing the Yellow River with his camel caravan in 1920 (after Buffetaut, 2019).

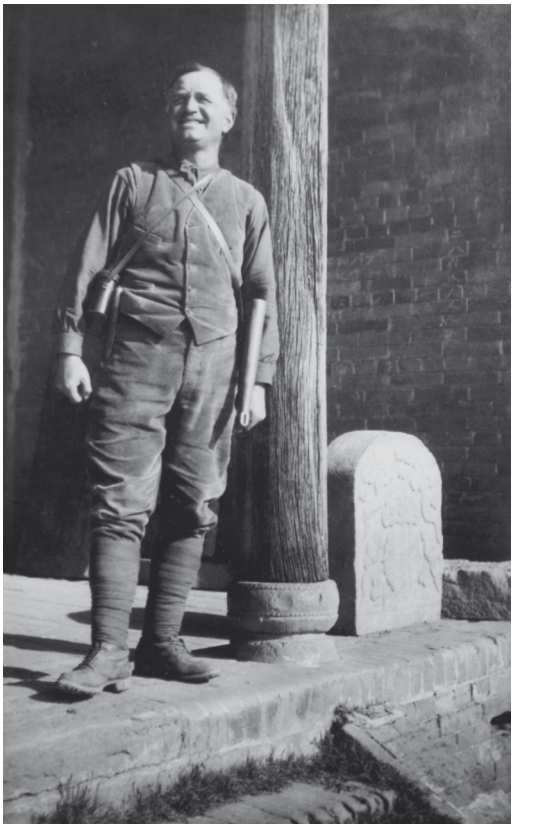

Figure 4 - The Swedish geologist Johan Gunnar Andersson during a field trip to Henan in 1918 (Wikimedia commons).

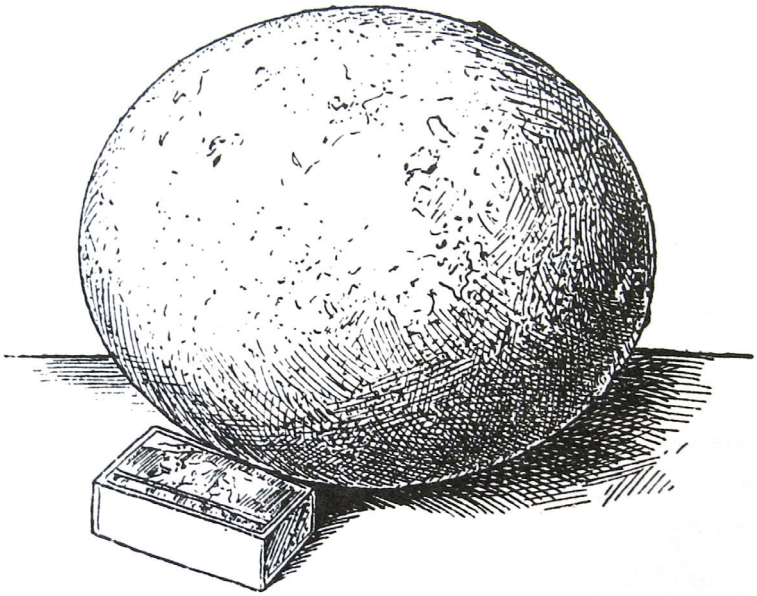

Figure 5 - Drawing of an ostrich egg from the loess of Henan published by Andersson (1934).

As mentioned above, Andersson also mentioned that ostrich eggshell fragments had been found in a ''culture stratum » of the Neolithic Yangshao culture, but concluded that they were the remains of an egg from the loess collected by prehistoric humans who had lived at a much more recent period, well after the disappearance of the ostrich from China. However, many later discoveries have shown that at older periods early humans were contemporaneous with extinct ostriches in China, as well as in Mongolia and Siberia (e.g. Janz et al., 2009; Khatsenovich et al., 2017; Buffetaut and Angst, 2021).

Andersson provided measurements for 12 fossil eggs from the loess and compared them with measurements for three specimens of *Struthio camelus* and for the type specimen of *Struthiolithus chersonensis* from Ukraine, described by Brandt. The Chinese eggs were consistently larger than those of modern ostriches but comparable in size with *Struthiolithus chersonensis.* Andersson therefore referred the eggs from the loess to the latter taxon.

Andersson's researches, although conducted on behalf of the Geological Survey of China, were largely funded by Swedish sponsors (the Kinafonds started by the industrialist Axel Lagrelius: see Mateer & Lucas, 1985). As a result, while part of Andersson's collections remained in China, many important fossils were sent to the palaeontologist Carl Wiman at Upsala University. According to Andersson (1923), all the ostrich eggs he had bought were sent to Wiman, with the exception of one that was presented to the Museum of the Geological Survey of China and one handed over to Dr George Durand Wilder (1869-1946), an American Protestant missionary who lived in China for many years and taught theology at the university of Beijing (the reasons for this gift are not known –Andersson was a fervent Lutheran and Wilder may have been a friend).

Although the great majority of the ostrich

fossils collected by Andersson were eggs or eggshell fragments, he also reported the discovery of an important skeletal element from a *Hipparion* fauna locality at Baode in NW Shanxi. There, one of Andersson's Chinese collectors, Chang, had excavated a large number of bones which had been sent to Upsala. When prepared, one of the specimens turned out to be an ostrich pelvis, as mentioned by Wiman in a letter to Andersson of January 11, 1921. The specimen was subsequently described by Lowe (1931; see below).

The importance of Andersson's work on ostrich remains, especially eggs, from China lies in the fact that he was the first scientist to investigate the geological occurrence of the specimens *in situ*, which led him to conclude that most of the eggs came from the Pleistocene loess, although ostrich remains also occurred in older, Miocene, deposits. Andersson was not a vertebrate palaeontologist by training, and he did not attempt to describe his finds in detail, expecting the descriptions to be done by Wiman or one of his associates.

CHINESE EGGS IN BRITAIN AND ITALY

While Licent and especially Andersson were collecting fossil ostrich remains *in situ* in northern China, eggs kept being sent to western countries and became part of various natural history collections.

Lord Walter Rothschild (1868-1937; Figure 6), a scion of the famous banking family, was a keen zoologist, with a special interest in ornithology, who established a large private museum at Tring, in Hertfordshire (Rothschild, 2008). At the 263rd meeting of the British Ornithologists' Club, held in London on 7th February, 1922, he exhibited a ''fossil egg of *Stuthiolithus* sp.'' (Rothschild, 1922a), which, together with six others, had been washed out of a river bank at Wuan in Henan province (today in Hebei). No collector's name was mentioned. Rothschild added that out of the seven eggs, five were in perfect condition and two were broken. He compared the eggs from China with the type of *Struthiolithus chersonensis* described by Brandt and noted that there were considerable differences between the Chinese specimens and the ''South Russian'' (Ukrainian) egg, adding, however, that there were great variations in size among the Chinese eggs.

At the 265th meeting of the Club on 12th April, 1922, Rothschild (1922b) exhibited a second *Struthiolithus* egg from the neighbourhood of Wuan, the district where most of the eggs had been procured. That specimen, which was one of those mentioned on the previous occasion, had been provided by a Mr Bahr. Rothschild's collection thus included two ostrich eggs from China.

In 1929, in a paper on the fossil eggs in the Tring collection, the famous German oologist Max Schönwetter described the two eggs from Wuan and referred them to *Struthio chersonensis* Brandt –apparently considering *Struthiolithus* as simply a synonym of *Struthio* (Schönwetter, 1929).

A fossil ostrich egg from another locality in Henan was brought to Italy by Father Antonio Panceri, of the Institute of the Foreign Missions of Milan. The egg had been found, together with a second one which fell to pieces, in March, 1927, at a depth of about 9 metres in the bank of a river near the city of Lin-hien (today Linzhou), by Chinese workers extracting earth to make bricks. Father Panceri gave the egg to the Milan Natural History Museum, where it was studied by the ornithologist Edgardo Moltoni, who concluded that it could be referred to the genus *Struthiolithus*, although he considered advisable not to assign it a species name, largely because

Figure 6 - Lord Walter Rothschild, who acquired two fossil ostrich eggs from Wuan for his zoological museum at Tring (Wikimedia commons).

of the considerable distance between the Ukraine (where the type of *Struthiolithus chersonensis* had been found) and Henan (Moltoni, 1929).

PERCY LOWE: CLASSIFYING THE FOSSIL OSTRICHES OF CHINA

Andersson (1923) had expected his ostrich eggs from China to be studied by Carl Wiman or one of his associates. Eventually, however, it was the British surgeon and ornithologist Percy Roycroft Lowe (1870-1948), Curator of Birds at the British Museum (Natural History) from 1919 to 1935 (Kinnear, 1949), who was entrusted with their description. In his monograph on the struthious birds of China, Lowe first described the large Miocene pelvis already mentioned by Andersson and named it *Struthio wimani*, comparing it with other Neogene ostriches from Europe and the Middle East, and referring to it eggshell fragments from Miocene deposits. He then considered the egg material. In addition to fragments, he had at his disposal ten complete eggs from the loess of northern China, seven sent to Upsala by Andersson, the two specimens from Wuan in Lord Rothschild's collection at Tring, and one in the British Museum (Natural History) collection (A 1308, donated by Rev. Clark in March, 1920). Although the Chinese eggs were larger than those of the living *Struthio*, Lowe saw no reason to refer them to a distinct genus and, unlike previous authors except Schönwetter, chose not to use the name *Struthiolithus* to designate them. Instead, he erected the species *Struthio anderssoni* for the large eggs from the loess, with the B.M.(N.H.) specimen A 1308 as type specimen (Figure 7). According to Lowe, *S. anderssoni*, with its thinner eggshell, had to be specifically distinct from *Struthiolithus chersonensis.* Eggshell fragments from ''Locality 34'' in southern Shanxi, of ''Pontian'' age, also were thicker than the shell of *Struthio anderssoni.*

Lowe subsequently described thin eggshell fragments collected by Andersson from various Neogene localities in Inner Mongolia as a third species, *Struthio mongolicus*.

The significance of Lowe's work lies in the fact that, contrary to most of his predecessors, he did not simply refer the fossil eggs from China to Brandt's *Struthiolithus chersonensis*, but considered that they clearly were ostrich eggs, hence his decision to refer them to distinct species of the genus *Struthio*, largely on the basis of eggshell thickness. Considering the uncertainties about *Struthiolithus*

Figure 7 - The type specimen (NHMUK A1308) of *Struthio anderssoni* Lowe, 1931, an egg from the loess of Wuan presented the Reverend H.M. Clark in March 1920, in the palaeontological collection of the Natural History Museum, London (photo by E. Buffetaut). Scale bar = 10cm.

chersonensis, and particularly its geological age, Lowe's conclusions were probably warranted. It is noteworthy that he saw no point in using a parataxonomy to name fossil eggs; however, referring unassociated skeletal elements and eggs to the same taxon may be problematical.

CHINESE SCIENTISTS TAKE OVER: C. C. YOUNG AND T. H. SHAW

Yang Zhungjian (1897-1979), also known as C. C. Young (Figure 8), considered as the ''father'' of Chinese vertebrate palaeontology (Tong & Buffetaut, 1999), started his university studies at Peking University, after which he studied vertebrate palaeontology at the University of Munich, where he obtained a doctorate in 1927 (for a work on fossil rodents from China). He returned to China in 1928 and joined the Cenozoic Research Laboratory, which was in charge of the excavations at the ''Peking Man'' site at Zhoukoudian (''Choukoutien''), some 48 km SW of Beijing, which lasted from 1927 to 1937 and resulted in the discovery of a large number of vertebrate fossils, including remains of early humans (see Qi, 2018, for a comprehensive recent review).

In 1933, Young published a paper on new discoveries of ostrich eggshell remains from northern China, including two complete eggs from the loess of Shanxi and Hebei and eggshell fragments collected by himself and Teilhard de Chardin from various localities of Miocene and Early Pleistocene age in Shanxi and Shaanxi. These discoveries led him to question some

Figure 8 - C. C. Young (Yang Zhungjan) in the 1920s. He was the first Chinese palaeontologist to work on fossil ostriches (Wikimedia commons).

of the stratigraphic conclusions reached by Andersson. In particular, *Struthio anderssoni* did not seem to be restricted to the Late Pleistocene loess but also occurred in somewhat older deposits. Moreover, some distinctions made by Lowe on the basis of eggshell thickness seemed difficult to support statistically (although Lowe's classification was accepted). Interestingly, Young noted that some ''good specimens'' studied by Lowe had just been returned to the National Geological Survey of China – they must have been some of the eggs sent by Andersson to Upsala, returned under the terms of the Sino-Swedish agreement on sharing palaeontological collections (Mateer & Lucas, 1985).

Young also reported that ostrich eggshell fragments had been discovered in the course of the excavations at locality 1 at Zhoukoudian, some of them completely burnt. They were referred to *Struthio anderssoni* on the basis of their thickness.

More details about the ostrich remains from Zhoukoudian were provided by Tsen-Hwang Shaw (Shou Zhenhuang, 1899-1964), considered as the founder of vertebrate zoology in China. In a preliminary paper on the fossil birds from Zhoukoudian (Shaw, 1935), he noted that two femora, one of them incomplete (Figure 9), had been found in the deposits of the Upper Cave, well known for having yielded Late Pleistocene *Homo sapiens* remains, not to be confused with the older *Homo erectus* (''*Sinanthropus*'') specimens that had made Zhoukoudian famous. Shaw referred them to *Struthio anderssoni*. In a later short paper (Shaw, 1937), he gave more details about these femora, noting that they were much larger than those of living ostriches and indicated a bird 1.5 times larger than *Struthio camelus*. Shaw's identification raises the question of the legitimacy of referring skeletal remains to an egg-based taxon. However, it should be noted that according to Buffetaut and Angst (2018), mass estimates based on *Struthio anderssoni* eggs and on the femora from Zhoukoudian are in remarkable agreement (about 270 kg), supporting Shaw's identification.

The researches of Young and Shaw marked a turning point in the study of the fossil ostriches of China. Henceforth such studies would be carried out by Chinese researchers rather than by foreign experts, whether working abroad or temporarily

Figure 9 - One of the ostrich femora from the Upper Cave at Zhoukoudian referred to *Struthio anderssoni* by Shaw (1935, 1937) and subsequent authors (specimen IVPP V6943, in caudal view) (Photo by E. Buffetaut). Scale bar = 10cm.

based in China. This of course reflects a more general shift in the study of fossils from China, with Chinese palaeontologists taking over from foreigners. This change became even more marked after the establishment of the People's Republic of China in 1949, when institutions such as the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP) of the Academia Sinica were founded (the first director of the IVPP was Yang Zhungjian, in 1957).

Research on the fossil ostriches of China by researchers from the IVPP and other Chinese institutions has resulted in a number of papers which will not be discussed here in detail, only a few significant publications being mentioned. Yang and Sun (1960) reported new finds and discussed the stratigraphic distribution of ostrich eggs in northern China, using Lowe's species names. Hou (1993) described the fossil birds from Zhoukoudian in more detail than Shaw had done, and concurred with the identification of the femora from the Upper Cave as *Struthio anderssoni*. A new species of Miocene ostrich, from Gansu, was described by Hou et al. (2005) as *Struthio lingxiaensis*. The large and robust femur found by Licent in 1925 in the Lower Pleistocene of the Nihewan Basin (see above) was referred to the genus of giant ostriches *Pachystruthio* by Buffetaut and Angst (2021). It should be mentioned that complete ostrich eggs keep being discovered in the loess of northern China, mainly by local people, and are visible in many Chinese museums.

CONCLUSIONS

Several stages are discernible in the history of the discovery of the fossil ostriches of China.

Fossil ostrich eggs, especially from the Pleistocene loess, have clearly been known for a long time in northern China and were considered as valuable curiosities (as evidenced by the presence of such an egg in the imperial collection). Unfortunately, beyond the fact that they were considered as dragon's eggs and omens, few details seem to be known about the popular or learned beliefs which may have been associated with them.

The first scientific studies of such eggs, beginning with Eastman's 1898 papers, were based on specimens that had been sent to western countries by missionaries based in China. North American and European museums thus acquired fossil ostrich eggs from China. The eggs were discovered in an accidental fashion by local inhabitants, who then sold them to foreigners. Missionaries were present in many remote areas of China and were often interested in local natural history. Around 1920, both Emile Licent and Johan Gunnar Andersson relied on them to record and notify significant fossil finds. Licent himself was a missionary, although he mainly devoted his considerable energy to the development of his Hoang Ho Pai Ho Museum in Tianjin and to his long collecting trips across northern China.

Licent and Andersson were the first foreign scientists to actually collect ostrich eggs (or eggshell fragments) in China and to investigate their geological occurrence. Andersson's work was especially significant in this regard. Together with some specimens, notably those sent by Rev. Clark and Mr Bahr, acquired by European institutions (including Lord Rothschild's collection) through different channels, the eggs collected by Andersson and sent to Carl Wiman in Upsala formed the basis for Lowe's important 1931 study. Lowe's investigations resulted in the erection of several fossil ostrich species, instead of referring the Chinese eggs to Brandt's *Struthiolithus chersonensis* (based on a somewhat mysterious Ukrainian specimen),

as most earlier authors had done. Lowe's paper is also important for containing the first description of an ostrich skeletal element, viz. a Miocene pelvis, from China.

The next important step was Young's 1933 description of additional fossil egg material from China. It marked the beginning of the study of Chinese fossil ostriches by Chinese palaeontologists. The fact that Young's paper includes a section about eggshell fragments from Zhoukoudian testifies to the significance of the large scale excavations at that site, which attracted considerable attention and underlined the importance of palaeontological research in China. Shaw's papers on the few fossil ostrich bones from Zhoukoudian similarly demonstrated that China was no longer dependent on foreign expertise for the study of its palaeontological heritage.

A point worth mentioning is that the ostrich fossil record in China is heavily dominated by egg remains, skeletal elements being much less frequent (this is not really exceptional, since a similar situation prevails in Africa: Camps-Fabrer, 1963). Fossil eggshell material is one of the main sources of information about the evolution of ostriches (Mikhailov and Zelenkov, 2020). This prevalence of eggs probably accounts for some aspects of the discovery of the fossil ostriches of China: large fossil eggs, even though not really very common, are spectacular and easily recognizable as such. During the 1920s, there was considerable interest in fossil eggs following the discoveries of dinosaur eggs made in Mongolia by the Central Asiatic Expeditions, and, although much more recent, the fossil ostrich eggs from China were often mentioned together with Mesozoic specimens in general reviews of fossil eggs (Joleaud, 1924; Van Straelen, 1928). These ''dragon's eggs'' have attracted the attention of the Chinese for centuries and it is hardly surprising that they were the first evidence of the former existence of ostriches in China to be recorded by palaeontologists.

ACKNOWLEDGMENTS

I am especially grateful to Monique Abud (Centre d'études sur la Chine moderne et contemporaine, Paris) for providing the papers by Emile Licent in *La Politique de Pékin* and to Zhang Xiaxiao (Hoang Ho Pai Ho Museum, Tianjin) for Licent's 1935 *Comptes Rendus*. Access to the type specimen of *Struthio anderssoni* was made possible by Sandra Chapman (Natural History Museum, London). Access to the ostrich femur from Zhoukoudian was made possible by Zhou Zhonghe (IVPP, Beijing). Thanks to Agustín G. Martinelli for inviting me to contribute a paper to this issue of *Historia Natural*.

REFERENCES

Andersson, J.G. (1919). Dragon hunting in China. *Far Eastern Review*, 15, 707-713.

Andersson, J.G. (1923). Essays on the Cenozoic of northern China. *Memoirs of the Geological Survey of China Series A*, 3, 1-152.

Andersson, J.G. (1934). Children of the Yellow Earth. Studies in prehistoric China. Kegan Paul, Trench, Trubner & Co., London, 345 p.

Andrews, R.C. (1926). On the trail of ancient man. Garden City Publishing Company, Garden City and New York, 375 p.

Andrews, R.C. (1932). The new conquest of Central Asia. American Museum of Natural History, New York, 678 p.

Anonymous (1917). [*Struthiolithus* egg from China in American Museum of Natural History]. *American Museum Journal*, 17, 421.

Bensley, B.A. (1921). An egg of *Struthiolithus chersonensis* Brandt. *University of Toronto Studies Biological Series*, 19, 1-7.

Boule M., Breuil, H., Licent, E., and Teilhard, P. (1928). Le Paléolithique de la Chine. *Archives de l' Institut de Paléontologie Humaine*, 4, 1-138.

Brandt, A. (1872). Über ein grosses fossiles Vogelei

aus der Umgegend von Cherson. *Mélanges Biologiques Bulletin de l'Académie Impériale des Sciences de Saint Pétersbourg*, 8, 730-735.

Brandt, A. (1885). Über das Schicksal des Eies von *Struthiolithus chersonensis*. *Zoologischer Anzeiger*, 8, 191-192.

Buffetaut, E. (1987). A short history of vertebrate palaeontology. Croom Helm, London, 223 p.

Buffetaut, E. (2017). Fossiles et croyances populaires. Le Cavalier Bleu, Paris, 164 p.

Buffetaut, E. (2019). Un Jésuite et son musée chinois. *Espèces*, 32, 82-86.

Buffetaut, E. (2020). Johan Gunnar Andersson, chasseur suédois de dragons chinois. *Espèces*, 38, 54-60.

Buffetaut, E. and Angst, D. (2018). How large was the giant ostrich of China? *Evoluçao*, 2, 6-8.

Buffetaut, E. and Angst, D. (2021). A giant ostrich from the Lower Pleistocene Nihewan Formation of North China, with a review of the fossil ostriches of China. *Diversity*, 13, 47. https://doi.org/10.3390/d13020047

Camps-Fabrer, H. (1963). La disparition de l'autruche en Afrique du Nord. Institut Français des Sciences humaines en Algérie, Alger, 111 p.

Clark, H.M. (1918). Eggs of an extinct ostrich in northern China. *Nature*, 101, 50.

Cuénot, C. (1966). Le Révérend Père Emile Licent S.J. *Bulletin de la Société des Etudes Indochinoises*, 41, 1-83.

Dean, B. (1919). Memorial of Charles Rochester Eastman. *Bulletin of the Geological Society of America*, 30, 27-36.

Eastman, C.R. (1898a). On remains of *Struthiolithus chersonensis* from northern China with remarks on the distribution of struthious birds. *Bulletin of the Museum of Comparative Zoology Harvard College*, 32, 125-144.

Eastman, C.R. (1898b). Discovery of a second specimen of the fossil egg of *Struthiolithus*. *Geological Magazine*, 5: 433-439.

Hou, L., (1993). Avian fossils of Pleistocene from Zhoukoudian. *Memoirs of the Institute of Vertebrate Palaeontology and Palaeoanthropology, Academia Sinica*, 19: 165–297.

Hou, L., Zhou, Z., Zhang, F. and Wang, Z. (2005). A Miocene ostrich fossil from Gansu Province, northwest China. *Chinese Science Bulletin*, 50, 1808-1810.

Ingersoll, E. 1928. Dragons and dragon lore. Payson & Clarke, New York, 202 p.

Janz, L., Elston, R.G. and Burr, G.S. (2009). Dating North Asian surface assemblages with ostrich eggshell: implications for palaeoecology and extirpation. *Journal of Archaeological Science*, 36, 1982-1989.

Joleaud, J. (1924). Oeufs de dinosauriens et d'oiseaux paléognathes fossiles. *La Feuilles des Naturalistes*, 45, 44-48.

Khatsenovich, A.M., Rybin, E.P., Gunchinsuren, B., Bolorbat, T., Odsuren, D., Angaragdulguun, G., and Margad-Erdene, G. (2017). Human and *Struthio asiaticus*: one page of Paleolithic art in the eastern part of Central Asia. *Irkutsk State University Bulletin, Series "Geoarcheology. Ethnology. Anthropology"*, 21, 80-106 [in Russian].

Kinnear, N.B. (1949). Percy Roycroft Lowe. *Ibis*, 91, 147-151.

Laufer, B. (1926). Ostrich egg-shell cups of Mesopotamia and the ostrich in ancient and modern times. *Field Museum of Natural History Anthropoolgy Leaflets*, 23, 1-51.

Licent, E. (1920a). Fouilles paléontologiques et paléanthropologiques au Sinn kia keou. *La Politique de Pékin*, 35, 744-747.

Licent, E. (1920b). Les fouilles paléontologiques du Sinn kia keou et environs (Kansou NE.). *La Politique de Pékin*, 42, 905-906.

Licent, E. (1935). Comptes-rendus de onze années (1923-1933) d'exploration, de séjour et d'exploration dans le bassin du Fleuve Jaune, du Pai Ho et des autres tributaires du golfe du Pai Tcheu ly. *Publications du Musée Hoang Ho Pai Ho*, 38, 1-1131.

Licent, E. (1945). Recherches paléontologiques dans le bassin du Pei tcheu ly. *Bulletin de la Société nationale d'acclimatation de France*, 92, 57-69.

Lowe, P.R. (1931). Struthious remains from Northern China and Mongolia, with descriptions of *Struthio wimani*, *Struthio anderssoni* and *Struthio mongolicus*, spp. nov. *Palaeontologia Sinica C*, 6, 1-47.

Mateer, N.J. and Lucas, S.G. (1985). Swedish vertebrate palaeontology in China: a history of the Lagrelius Collection. *Bulletin of the Geological Institutions of the University of Uppsala, N. S.*, 11, 1-24.

Mikhailov, K.E. and Zelenkov, N. (2020). The late Cenozoic history of the ostriches (Aves: Struthionidae), as revealed by fossil eggshell and bone remains. *Earth Science Reviews*, 208, 103270.

Moltoni, E. (1929). Rinvenimento di uova fossili di *Struthiolithus. Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale in Milano*, 68, 221-225.

Nathusius, W. von (1885). Über das fossile Ei von

Struthiolithus chersonensis Brandt. *Zoologischer Anzeiger*, 9, 47-50.

Qi, T., (2018). Choukoutienology. Zhejiang University Press and Archaeopress, Hangzhou, 733 p.

Rothschild, M. 2008. Walter Rothschild. The man, the museum and the menagerie. Natural History Museum, London, 385 p.

Rothschild, W. (1911). On the former and present distribution of the so-called Ratitae or ostrich-like birds with certain deductions and a description of a new form by C. W. Andrews. In: Schalow, H. (ed.), Verhandlungen der V. Internationalen Ornithologen-Kongresses in Berlin. Deutsche Ornithologische Gesellschaft, Berlin. p. 144-174.

Rothschild, W. (1922a). Exhibition of fossil eggs of *Struthiolithus* from Province of Honan, China. *Bulletin of the British Ornithologists' Club*, 42, 71-72.

Rothschild, W. 1922b. Exhibition of fossil eggs of *Struthiolithus* from Province of Honan, China. *Bulletin of the British Ornithologists' Club*, 42: 123.

Schönwetter, M. (1929). Fossile Vogelei-Schalen. *Novitates Zoologicae*, 35, 192-203.

Shaw, T.H. (1935). Preliminary observations of the fossil birds from Chou-Kou-Tien. *Bulletin of the Geological Society of China*, 14, 77-81.

Shaw, T.H. (1937). Einige Bemerkungen zum Oberschenkelknochen des fossilen Strausses *Struthio anderssoni* Lowe von Chou Kou Tien in Nord-China. *Ornithologische Monatsberichte*, 45, 201-202.

Swinton, W.E. (1965). Fossil birds. British Museum (Natural History), London, 65 p.

Tong, H. and Buffetaut, E. (1999). Yang Zhungjian (Chung Chien Young). In: Singer, R. (ed.), Encyclopedia of Paleontology, Fitzroy Dearborn, Chicago & London, pp. 1355-1356.

Tugarinov, A. (1930). Ein fossiler Strauss in Transbaikalien. *Comptes Rendus de l'Académie des Sciences de l'URSS*, 1930, 611-614.

Van Straelen, V. (1928). Les œufs de reptiles fossiles. In: Abel, O (ed.), *Dollo Festschrift der Palaeobiologica*, Emil Haim & Co., Wien & Leipzig, pp. 295-312.

Wei, F. and Wang, D. (2021). Tsen-Hwang Shaw: Founder of vertebrate zoology in China. *Protein & Cell*, 12, 1-3.

Young, C.C. (1933). On the new finds of fossil eggs of *Struthio anderssoni* Lowe in North China, with remarks on the egg remains found in Shansi, Shensi and in Choukoutien. Bulletin of the Geological Society of China, 12, 145-152.

Young, C.C. and Sun, A.L. (1960). New material of ostrich eggs and its stratigraphic significance. *Paleovertebrata et Paleoanthropologia*, 2, 115-119 [in Chinese].

Recibido: 01/03/2021 - Aceptado: 12/03/2021 - Publicado: 30/04/2021