The Dubois collection: a new look at an old collection

John de Vos

Vos, J. de. The Dubois collection: a new look at an old collection. *In*: Winkler Prins, C.F. & Donovan, S.K. (eds.), *VII International Symposium 'Cultural Heritage in Geosciences, Mining and Metallurgy: Libraries - Archives - Museums': "Museums and their collections", Leiden (The Netherlands), 19-23 May 2003. Scripta Geologic, Special Issue*, **4**: 267-285, 9 figs.; Leiden, August 2004.
J. de Vos, Department of Palaeontology, Nationaal Natuurhistorisch Museum Naturalis, P.O. Box 9517, NL-2300 RA Leiden, The Netherlands (vos@naturalis.nnm.nl).

Key words – Dubois, *Pithecanthropus erectus*, *Homo erectus*, *Homo sapiens*, Java.
One of the most exciting episodes of palaeoanthropology was the find of the first transitional form, the *Pithecanthropus erectus*, by the Dutchman Eugène Dubois in Java during 1891-1892. The history of Dubois and his finds of the molar, skullcap and femur, forming his transitional form, are described. Besides the human remains, Dubois made a large collection of vertebrate fossils, mostly of mammals, now united in the so-called Dubois Collection. This collection played an important role in unravelling the biostratigraphy and chronostratigraphy of Java. Questions, such as from where were those mammals coming, when did *Homo erectus* arrive in Java, and when did it become extinct, and when did *Homo sapiens* reach Java, are discussed.

Contents

Introduction

The Dubois Collection of vertebrate fossils was made by Eugène Dubois in the former Netherlands East Indies, nowadays Indonesia, at the end of the 19th century. Cleevely (1983) mentioned it as one of the most famous palaeontological collections in the world. Its importance lies mainly in a molar, femur and skullcap that were attributed by Dubois to a transitional form named *Pithecanthropus* (now *Homo*) *erectus*. This was the first hominid ever to be accepted as evidence for human evolution. Therefore, the Dutch physicist Marie Eugène François Thomas Dubois founded, with his *Pithecanthropus*, palaeoanthropology as a science in 1891-1893 (Shipman & Storm, 2002). Associated with the *Pithecanthropus* remains are tens of thousands of bones and teeth of the Pleistocene vertebrate fauna of Indonesia. The vertebrate fossils and the hominid remains were sent during 1895-1900 to what is now the Nationaal Natuurhistorisch Museum, but was then the Rijksmuseum van Natuurlijke Historie at Leiden, The Netherlands.

After the find of *Pithecanthropus erectus* (1891-1893) on Java and a similar hominid (*Sinanthropus pekinensis*) in China in 1926 (Black, 1926), attention was focused on Asia as the cradle of Mankind in the early part of the 20th century. In the 1960s the attention shifted to Africa, caused by the finds of older and more ape-like hominids (the Australopithecinae) in Olduvai and Lake Turkana. In the early 1980s a new interest was focused on the Javanese *Homo erectus* again, as a result of new interpretations of the Dubois collection.

The general consensus nowadays concerning the evolution of Man is that in Africa one of the Australopithecinae gave rise to *Homo ergaster*. About 1.5 Ma ago this species migrated to Eurasia. The descendants of *Homo ergaster* reached Asia as *Homo erectus*.

The purpose of this paper is to give a historical survey of the role of Dubois in palaeoanthropology, and to show how the Dubois Collection served as a basis for the debate on the arrival and extinction of *Homo erectus*, and the arrival of *Homo sapiens*, in Java. These issues are closely related to the bio- and chronostratigraphy of Java, and faunal dispersal in southeast Asia.

Early theories about the evolution of Man

Theunissen & de Vos (1982), Theunissen (1989), Theunissen *et al.* (1990), Leakey & Slikkerveer (1993), Shipman (2001) and de Vos (1985b, 2002) have described the story of Dubois in great detail. For a good understanding of the role of Dubois in palaeoanthropological research, a summary is given here based on de Vos (1985b, 2002).

Although the first finds of fossil hominids started in 1891, ideas about the evolution of Man started earlier. In 1844 Robert Chambers (1802-1871) published *Vestiges of Natural History of Creation*, in which he set out a development theory. Chambers did not stress the point, but his development hypothesis clearly made Man an immediate descendant of the apes. The anatomist Richard Owen (1855) used his expertise to disprove the theory of evolution at its most controversial point, Man's link with the apes, by pointing out that the heavy eyebrows of the great apes were missing in modern Man. According to Owen, as eyebrows are developed independently, and are not influenced by internal or external factors, Man must have had heavy eyebrows, if Man descended from the great apes; this is obviously not the case (Reader, 1981).

However, a skull with heavy eyebrows was found in 1856 in the Neanderthal near Düsseldorf. The fossil came into the hands of Hermann Schaaffhausen, professor of anatomy at the University of Bonn, who was convinced that the remains were very old and hominid. Their strange morphology was caused by deformation, but the doligocephalic form of the skull was, according to Schaaffhausen, not comparable to any modern race, even not to the most 'barbaric'. The heavy eyebrows, characteristic for great apes, were according to Schaaffhausen typical for the Neanderthal. The skull therefore must have belonged to an original wild race of northwestern Europe. Some even considered it as the skull of an idiot, an 'old Dutchman', or a Cossack.

In 1859 Charles Darwin published *On the Origin of Species*, in which he set out a theory of evolution, characterised by a gradual development in which natural selection is the mechanism. Others were drawing the conclusion that there is no separation between Man and apes. In this context the skull of the Neanderthal became a centre of debate. Two ideas developed, which are still debated today; either Neanderthal Man belongs to Recent Man or Neanderthal Man is a species of its own. Huxley (1863) set the tone of the discussion by describing the morphological characteristics of the Neanderthal as primitive, yet definitely human. He also pointed to the large brain capacity as proof of the Neanderthal's human nature (Theunissen *et al*., 1990). In contrast King (1864), professor of anatomy at Queen's College (Ireland), considered, without giving scientific arguments, that Neanderthal Man was a new species and called it *Homo Neanderthalensis*. Later finds, such as the mandible of La Naulette (1866) and the Spy skeletons (1887) now recognised as Neanderthals, were also usually ascribed to a (primitive) race of modern humans (Erickson, 1976).

Darwin (1871) discussed the position of Man in evolution, but did so on theoretical grounds without using fossils to support his argument. For Ernst Haeckel (around 1887) fossils were not necessary as proof that Man took part in the evolution, because the process could be proven already by anatomy and embryology. He introduced the name *Pithecanthropus* as a theoretical missing link between apes and Man (Theunissen, 1989).

Thus, none of the fossils found before 1887 were considered proof that Man took part in evolution. In that year Eugène Dubois sailed for the Netherlands East Indies in search of the missing link.

The role of Dubois (1858-1940) in palaeoanthropology

Marie Eugène François Thomas Dubois (Fig. 1) was born in 1858, a year before Darwin published his *On the Origin of Species* and two years after the Neanderthal skull had been found. He grew up in a period that witnessed the rapid acceptance and dissemination of the theory of evolution. In the 1860s and '70s the problem of human ancestry was central to many discussions on evolutionary theory. Until far into the '80s opponents and adherents of an evolutionary ancestry for humans agreed that, as yet, no hominid fossils were known that provided proof of human evolution. Dubois was among the first to bring about a change in this climate of opinion (Theunissen, 1989).

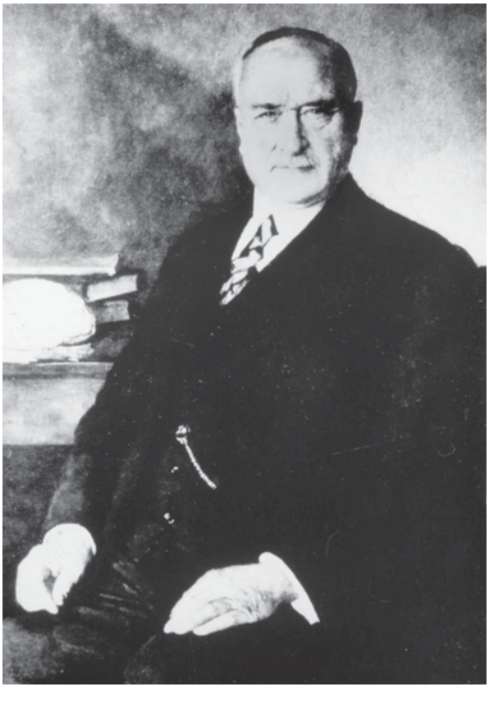

Fig. 1. Eugène Dubois at the age of 70.

Born in Eijsden in the south of The Netherlands, near St. Peter's Mountain where the remains of a mosasaur were found in 1780, Dubois had been interested in palaeontology from his early childhood. The German anthropologist Carl Vogt, who in the late 1860s lectured in The Netherlands on evolutionary theory and human descent, probably encouraged his interest in palaeoanthropology. From 1877 to 1884 Dubois studied medicine at the University of Amsterdam, where he became reader in anatomy in 1886. Although he now seemed to be on the brink of a prosperous academic career, his predilection for palaeoanthropology made him decide to change course; more and more he became possessed by the idea of beginning a search for hominid fossils that might prove human evolution. Following this call, he gave up his position at the university and in 1887 left for the Netherlands East Indies to begin his search for the missing link.

But where to look for? Dubois (1889) referred to Darwin, Wallace and Lydekker to explain this choice. In his *Descent of M*an (1871) Darwin had reasoned that our human ancestors must have lived in the tropics, since human beings had lost their fur pelts in the course of their development. He suggested Africa, where chimpanzee and gorilla live, as the most probable region of human origins. Wallace, on the other hand, had stressed the importance of searching for the ancestors of present-day anthropoids in caves and Tertiary deposits in both Africa and southeast Asia. Lydekker (1879) had described a primate fossil, an incomplete jaw with a number of teeth, from the Siwalik Hills in British India, which seemed to throw some light on human descent. According to Lydekker, this primate, whom he named *Palaeopithecus sivalensis*, could be regarded as a predecessor of the chimpanzee (in those days put in the genus *Anthropopithecus*). Yet, he added that the fossil also showed resemblance to both gibbon and human. Dubois concluded from this that "the Gibbon group which in earlier geological periods had developed further" might have played a role in human evolution (1889, pp. 160-161).

For Dubois the East Indies seemed a suitable area, the more so because this colony of The Netherlands lay wide open to him. To provide himself with an income, he joined the Dutch East Indies Army as a medical officer and in December 1887 arrived in Padang on Sumatra. In May 1888 he was seconded to Pajakombo in the Padang Highlands, where he began to scout for caves suited for palaeontological excavations. By August he had gathered proof that fossil mammals occurred the caves of Sumatra. Thereupon, the colonial government not only enabled Dubois to dedicate all his time to this search, but even charged him to carry out palaeontological excavations on Sumatra and, if necessary, on Java. Two members of the army engineering corps were assigned to his party, along with fifty forced labourers to help him with the excavations.

The Sumatran cave fauna soon proved too young to include any human forerunners. Therefore, in 1890, Dubois decided to continue his excavations on Java, where fossils of supposedly Tertiary age had already been found by, among others, Junghuhn (1857) and Radèn Saléh (1867). Moreover, in 1888, the mining engineer B.D. van Rietschoten had found a fossil skull near the village of Wajak on Java which, though fully human, clearly differed from the modern Javanese population (Dubois, 1890). Java thus held promising prospects.

Cave exploration in Java proved unrewarding and Dubois now turned his attention to the open field. Success was almost immediate. In November 1890, near Kedung Lumbu at Kedung Brubus in the Kendeng Hills, he found a fragment of a mandible that he described as follows: "Amidst the remains of typical representatives of the

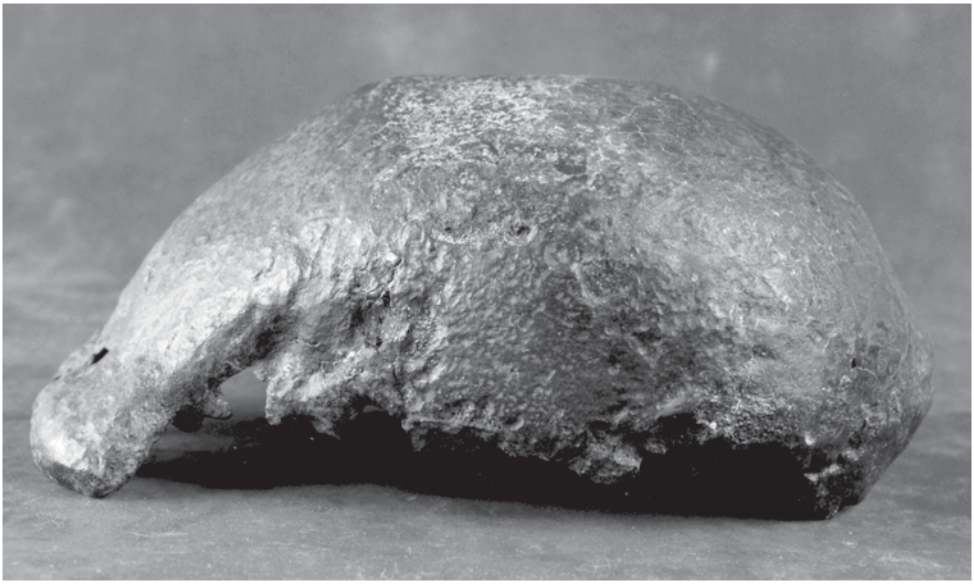

Fig. 2. Skull-cap of *Homo erectus* (Dubois, 1893).

fauna concerned, and in the same layer ..... a human fossil was found, the right side of the chin of a lower jaw with the sockets of the canine tooth and of the first and second premolar.... [T]his fossil [jaw] forms a different and probably lower type than any previously known" (1891, pp.14-15).

In August 1891, during the second digging season on Java, Dubois began excavations at Trinil, a locality that was to acquire historical significance. An enormous number of vertebrate fossils were unearthed and in September the first remains of a primate, a third molar, emerged from the sediments. At first, Dubois ascribed the fossil to a chimpanzee (*Anthropopithecus*). In one of the reports to his superiors he wrote: "This genus of anthropoids, occurring only in West- and Central-equatorial Africa today, lived in British India in the Pliocene and, as we can see from this discovery, during the later Pleistocene in Java" (1892a, pp. 13-14).

The skullcap (Fig. 2) for which Dubois acquired fame was unearthed in October. In the opinion of Dubois it was clearly distinguishable from that of the orang-utan and the gorilla. It had to belong to the same fossil chimpanzee from which a molar had been found a month earlier. Despite having designated the find as a "chimpanzee", Dubois was well aware that he had made an important discovery. The Javanese cranium was higher and larger than that of the recent chimpanzee and substantially more human-like than any known anthropoid, whether fossil or recent (1892b, pp. 14-15).

In August of the following year a third primate fossil was discovered, this time an almost completely preserved left femur. "This thigh bone", Dubois stated, "lay at the same level in which both the other parts were found, yet following the direction of the earlier stream which deposited the tuff material 15 m upstream. From the circumstances of the find and [my] comparative research it is evident that the three skeletal

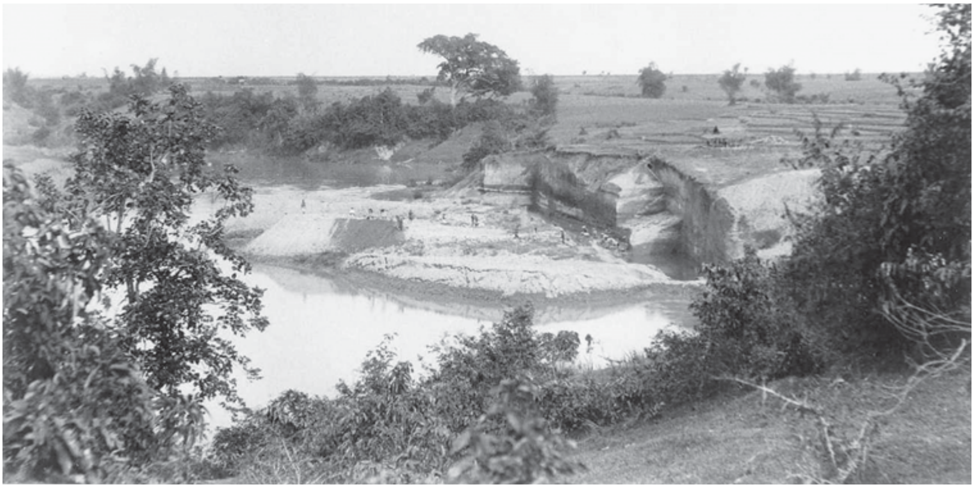

Fig. 3. Excavation at Trinil in 1900.

elements belong to one and the same individual, probably a very aged female" (1893, p. 10). The almost perfectly human characteristics of the femur indicated that the individual must have walked upright and this induced Dubois to christen his "chimpanzee" *Anthropopithecus erectus.* Further, he stated: "In view of all three skeletal elements, especially the femur, *Anthropopithecus erectus* Eug. Dubois approaches modern Man more closely than any of the three great apes, a fact which is in harmony with the thesis of Lamarck, and later of Darwin and others, that the first step in the direction of humanisation of our ancestors was the [acquisition of the] erect position".

Additional investigation of the remains finally convinced Dubois that they represented an intermediary form between humans and apes. He therefore decided that instead of a 'man-ape' or *Anthropopithecus*, it was more appropriate to designate his find an 'ape-man', a *Pithecanthropus* (the name coined by Ernst Haeckel (1868) for the hypothetical link between humans and fossil Apes). In 1894 Dubois published the results of his studies under the title "*Pithecanthropus erectus*, eine menschenaehnliche Uebergangsform aus Java".

One year later he returned to the Netherlands. His assistants continued the systematic excavations until 1900 (Fig. 3). Dubois widely publicised his *Pithecanthropus* finds, and displayed them at several international congresses and scientific meetings. Opinions on his discovery varied, but essentially the critics were divided into two camps. Some gave the *Pithecanthropus* remains the same treatment the Neanderthal fossils had received forty years earlier; they regarded them as primitive, though fully human. Others, however, ascribed the bones to an (upright-walking) ape. Dubois (1896) did not fail to exploit this difference of opinion. He pointed out that for some of his colleagues the fossils were apparently too primitive to be regarded as human, while for others they were too human-like to be assigned to an ape. Consequently, *Pithecanthropus* must have been something in between.

After Dubois had clarified several points and especially during congresses, held from 1894 to 1900, where they had been able to examine the fossils for themselves, a growing number of scientists recognised that they were dealing with a transitional form linking humans with their ape-like ancestors. Thus, they accepted Dubois's belief that a phylogenetic significance could be ascribed to the fossils. Most of them did not agree with Dubois' contention that *Pithecanthropus* stood exactly halfway between human and ape. They relegated him to an extinct side branch of human evolution, for instance, or they thought that he had been much closer to *Homo sapiens* than Dubois was prepared to allow. The crucial factor is, however, that they showed themselves ready to adopt an evolutionist interpretation, meaning that for the first time a group of researchers acknowledged a fossil hominid as a transitional form (Theunissen, 1989).

From that moment on the search for more of such fossils started. First there were discoveries in Africa (Dart, 1925) and China (Black, 1926) before new finds were reported from Java.

Important hominid sites of Java

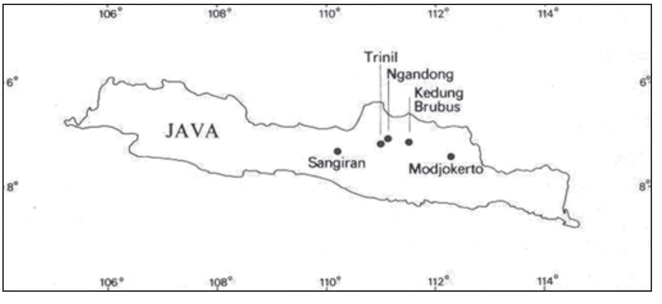

Fig. 4. Map of Java, showing the important hominid sites.

Dubois's excavations at Java showed that *Homo erectus* was present in Trinil, Kedung Brubus in the Kendeng Hills, whereas *Homo sapiens* was found in Wajak (Fig. 4). In 1932, the Dutch geologist W.F.F. Oppenoorth described new hominid finds from the village of Ngandong on the banks of the Solo River. The site, a river terrace some 20 m above sea level, had already been mentioned by Elbert (1907) and turned out to be a rich deposit of fossil vertebrates, including eleven skulls of a new hominid. Oppenoorth (1932) subsequently described this hominid as *Homo soloensis*.

Gustav Heinrich Ralph von Koenigswald (1902-1982), who followed in the footsteps of Dubois, was of tremendous importance for palaeoanthropological and biostratigraphical research in Java. In 1930, via his professor of palaeontology F. Broili, von Koenigswald was offered the post of vertebrate palaeontologist of the Dutch Geological Survey on Java, and he gladly accepted this chance to go to southeast Asia. Already in 1931 he published his first attempt to date the fauna from the 'Trinil beds' (1931), where Dubois had discovered the *Pithecanthropus.* As early as March 1936 von Koenigswald was able to announce the find of 'the child from Mojokerto' (Fig. 5), East Java, which he was sure belonged to *Pithecanthropus*.

Von Koenigswald (1940) collected a lot of hominid fossils in an area called Sangiran. The problem with this area is that there are outcrops of several different formations. As almost all hominid fossils are incidental surface finds, it is not known from which formation they originated.

Fig. 5. Skull of the child from Mojokerto.

Von Koenigswald (1939, 1940) also sampled two fissure fillings near Punung (Java), which yielded a fauna consisting only of dental elements from which the most part of the roots was gnawed by porcupines. Badoux (1959, p. 127) noted that von Koenigswald had told him that the "Punung Collection" material originated from two localities, Punung I near Mendolo Kidul and Punung II near Tabuhan. In the collection there was a hominid dental element, which was considered by von Koenigswald as cf. *Pithecanthropus erectus*. Half of the Punung collection is nowadays in the Nationaal Natuurhistorisch Museum, the other half is in the Senckenberg Museum (Frankfurt, Germany).

The typical preservation of the Punung fauna can also be observed in the material Dubois collected from the Sumatran Caves during 1887-1888. Large numbers of fossils were found here, but, like in Punung, they consist only of dental elements from which the most part of the roots is gnawed by porcupines. The Sumatran collection contains a few dental elements of a hominid, which were attributed to *Homo sapiens* by Hooijer (1948). The close resemblance between the two faunas led to the conclusions that the molars identified as cf. *Pithecanthropus erectus* by von Koenigswald should also be attributed to *Homo sapiens* (de Vos, 1983). So, Trinil, Kedung Brubus, Sangiran, Ngandong and Mojokerto with *Homo erectus*, and Punung and Wajak with *Homo sapiens*, are important sites for the discussion concerning the arrival and extinction of *Homo erectus* and the arrival *Homo sapiens* in Java.

The role of the Dubois Collection in biostratigraphy

Von Koenigswald's official task at the Geological Survey was to provide a division of the terrestrial deposits of Java on the basis of fossil mammals. In 1934 he published his biostratigraphy, but stressed that he would only give a summary of his results and that these had to be regarded as preliminary. Von Koenigswald (1934, 1935) based his biostratigraphy on 'guide fossils' and distinguished, from the hominid-bearing deposits mentioned above, the following faunas from old to young; Jetis (Early Pleistocene), Trinil with *Homo erectus* (Middle Pleistocene) and Ngandong with *Homo soloensis* (Late

Pleistocene). Von Koenigswald was convinced, on the basis of the guide fossils of the Jetis fauna found in the Mojokerto area, that the skull of the child was derived from an older layer than the Trinil finds of Dubois (von Koenigswald, 1936a). Unfortunately, as he stated himself, the skull in question was a surface find. Dubois (1936) contested the age proposed by von Koenigswald (1936a, b). The age of the Mojokerto skull has been in the centre of later discussions, and is as yet still unresolved.

Von Koenigswald considered the fossil assemblage from Punung to be a Trinil fauna, of Middle Pleistocene age, and included it in the faunal list of Trinil. To von Koenigswald it was logical to identify the hominid in the Punung fauna as cf. *Pithecanthropus erectus*, since the species was also found in Trinil. Badoux (1959) gave a full description of the Punung fauna, with the exception of the hominid specimens. He considered the age of the Punung fauna to be younger than the Trinil fauna, but older than the Ngandong fauna. However, he still placed the fauna in the Middle Pleistocene.

The classic Pleistocene vertebrate biostratigraphy of the island Java (Jetis, Trinil and Ngandong) as established by von Koenigswald (1933, 1934, 1935, 1940, 1956) was partly based on composite faunas (de Vos *et al*., 1982). Although von Koenigswald used locality names for his faunal units, some of the faunal assemblages from localities included in these units differed markedly from those collected at the 'type localities'. Besides lumping faunas, von Koenigswald also changed the faunal lists compiled by previous authors, without any clear argumentation. Nevertheless, von Koenigswald's biostratigraphy would provide a standard for more than forty years, and has provided an invaluable guide for all subsequent research in Java. However, new research revealed its serious deficiencies (de Vos *et al*., 1982).

Beside the hominid fossils, Dubois had collected more than 20,000 vertebrate fossils, mostly mammals, from different sites, like Trinil and Kedung Brubus, from 1891 until 1900 (Fig. 6). The fossils came to The Netherlands and were stored at several places from 1900 to 1940 (Holthuis, 1995). Scientifically these animal remains were clearly considered inferior to the all-important hominid fossils, and thus received very little attention. Dr. J.J.A. Bernsen catalogued the collection in the '30s (Brongersma, 1941). This gave Dr. D.A. Hooijer, former curator of the Dubois Collection, the opportunity to describe the fauna from the Sumatran caves and the fossils from Java in detail (e.g. Hooijer, 1946a,b, 1947, 1948, 1957, 1958, 1960, 1962). So, from every specimen from a particular site, the taxon became known. Hooijer didn't use the fossils in a biostratigraphic way. However, his taxonomical work made it possible to study the faunal composition of the hominid 'type localities'. It was the starting point for a new look at the old collection.

In the early 80s of the last century a joint Dutch (Utrecht University and the Nationaal Natuurhistorisch Museum, Leiden) and Indonesian (Geological Research and Development Centre) team started to interpret the faunal succession using only faunas from sites of which the stratigraphical context was known. The Dubois Collection yielded the data for the sites at Trinil and Kedung Brubus (de Vos & Sondaar, 1982). The authors concluded that the Trinil Haupt Knochen Schicht (H.K.) fauna, the layer from which the *Pithecanthropus erectus* of Dubois originated, was older than the one from Kedung Brubus. The latter fauna was in their opinion of the same age as the Jetis fauna of von Koenigswald, which had yielded *Pithecanthropus modjokertensis* (= *Homo erectus*). This was a remarkable conclusion, as the child of Mojokerto had always been considered to be older than the *Homo erectus* from Trinil. After comparing the

Fig. 6. The enormous amount of fossils on the veranda of Dubois' house in Pajakombo, Java.

fauna from Punung with the Sumatran caves material de Vos (1983) concluded that those faunas are similar in faunal composition and age, and suggested that the hominid dental elements from Punung belonged to *Homo sapiens*, like the ones from the Sumatran caves. Comparison of both faunas with the Wajak fauna showed that those faunas were intermediate in age in between Ngandong and Wajak.

The new approach led in a series of papers (Sondaar *et al*., 1983; Sondaar 1984; Sondaar & de Vos, 1984; Leinders, 1985; de Vos, 1985a; Aziz & de Vos, 1989; Aziz & de Vos, 1989; Theunissen *et al*., 1990), and ultimately to a revision of the fauna succession as proposed by von Koenigswald and to a new biostratigraphy for Java, which runs from old to young for the hominid sites: Trinil H.K., Kedung Brubus, Ngandong, Punung and Wajak. Two earlier faunas were also distinguished, namely an island fauna (Satir) and an impoverished Trinil Fauna (Ci Saat) (Fig. 7).

Dispersal of faunas in southeast Asia

At the same time in the early 1980s a new interest came up about the origin of the faunas of Java. Having established when the various faunas inhabited the island, the question of their origin and reasons for faunal turnovers became part of the research programme. In the past there were already speculations about the origin of the Indonesian fauna. Martin (1884), who described some of Java's first recovered fossils, interpreted the mammal remains as descendants of an ancient Indian stock. Dubois

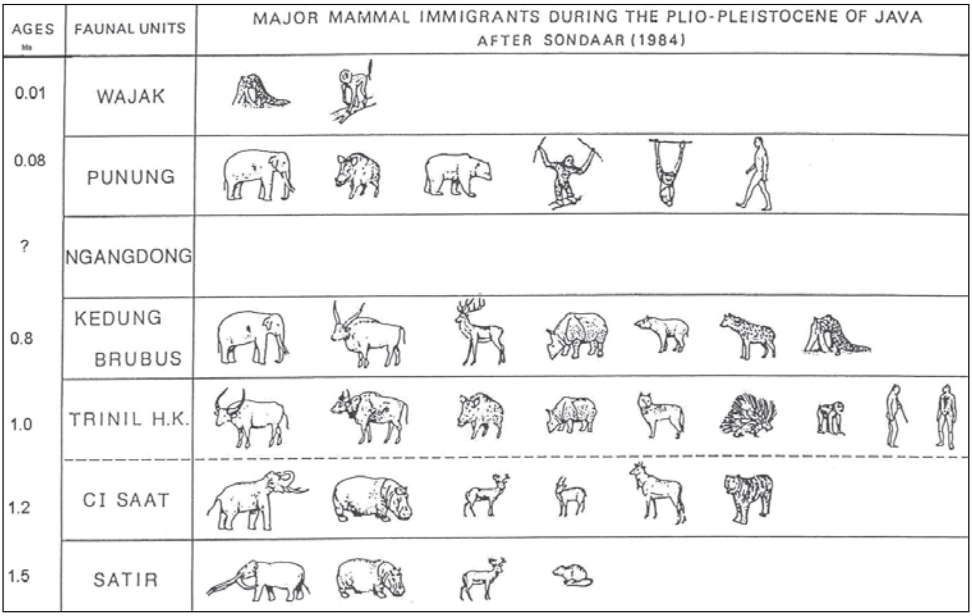

Fig. 7. Biostratigraphy of Java after de Vos (1995). The symbols of animals represent new arrivals.

(1908) recognised the continental and specifically Indian character of extinct mammals of Java. Molengraaff (1922) suggested a dispersal route west, not east, of Sumatra. From Burma, following the Andaman and Nicobar Islands, the islands west of Sumatra could have received faunal elements from Burma. Later, Rensch (1936) proposed that some species could have even reached Java following this route. The islands west of Sumatra as well as the Nicobars and Andamans form the exposed parts of a continuous ridge, mostly submarine, which can be traced from the Arakan Yoma in Burma, along the west coast of Sumatra and Java. More of the ridge could have been exposed in Pliocene and Pleistocene times. The uncertain topography, difficult terrain and heavy overgrowth of the islands present major obstacles for fieldwork and none of the islands has so-far produced remains of an ancient land fauna.

In the 1990s the fauna of the Javanese sites were grouped in clear faunal associations (de Vos, 1996; Sondaar *et al*., 1996). The hominid sites showed a clear bipartition in the fauna from the localities with *Homo erectus* and those containing *Homo sapiens*. The sites with *Homo erectus* yielded the *Stegodon-Homo erectus* fauna association**.** The faunas from the hominid sites Trinil, Kedung Brubus and Ngandong are attributed to this faunal association, characterised by archaic faunal elements like the proboscidean *Stegodon* and *Homo erectus*. It clearly shows affinities with the faunal association from the Indian Subcontinent (the Siwaliks) and Burma. Five species and one genus have a direct relation with the fauna of the Siwaliks, viz., *Hexaprotodon sivalensis, Hyaena brevirostris, Caprolagus* cf. *sivalensis, Homotherium ultimum, Nestoritherium* cf. *sivalense*, and the genus *Megantereon*. Three species are closely related to Siwalik species, viz., *Stegodon trigonocephalus* with *Stegodon ganesa*, *Elephas husudrindicus* with *Elephas hysudricus* and *Duboisia santeng* with the Boselaphini. De Vos (1995, 1996) concluded that the

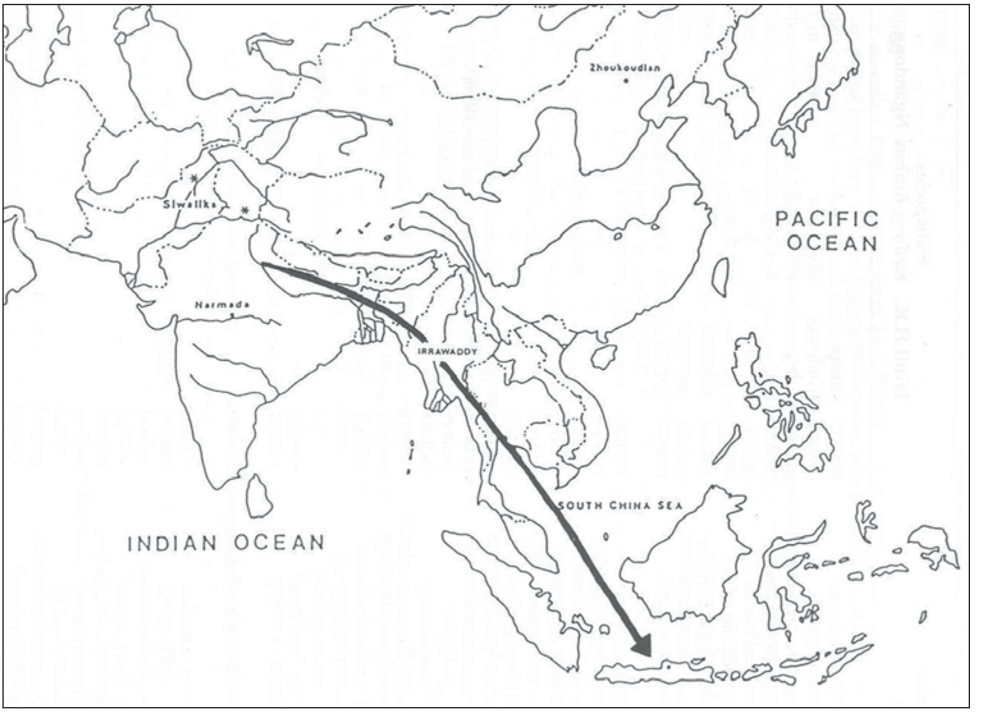

Fig. 8. The migration of mammals during the Early-Middle Pleistocene via the Siva-Malayan route (after de Vos, 1995).

Stegodon-Homo erectus fauna association originated from the Siwaliks (the Indian subcontinent) and reached Java via the so-called Siva-Malayan Route (Fig. 8).

At the end of the Middle Pleistocene the *Stegodon-Homo erectus* fauna association became extinct. A faunal turnover took place and a new fauna migrated into the Indonesian Archipelago; the *Pongo-Homo sapiens* fauna to which the site Punung is attributed, as well as the material from the Sumatran caves. In this fauna we find the Indian elephant (*Elephas maximus*), orang-utan (*Pongo pygmaeus*), the gibbon (*Hylobates syndactylus*), the pig-tailed Macaque (*Macaca nemestrina*) and the Malayan bear (*Ursus malayanus*), all species which are still extant on the continent or in other places of the Indonesian Archipelago, but are no longer found on Java. The large quantity of orang-utan and the presence of other primates indicate a humid tropical rainforest environment. Similar faunas with orang-utan (*Pongo pygmaeus*) are also found in fossil sites of the continent, like Vietnam (Lang Trang Cave), Cambodia (Phnom Loang), and China (de Vos 1984, Vu the Long *et al*., 1996).

Based on the balanced character of the faunas of Punung and Sumatra, and the fact that we are dealing with a tropical rainforest, which cannot cross a water barrier, we may assume that the connection with the mainland became more continuous. Probably between 126,000 and 81,000 years ago (Storm, 2001) there was such a lowering of the sea level, which connected Sumatra, Java and Kalimantan (the Sunda shelf) to the continent. In that period there was an immigration of a tropical rainforest fauna with *Homo sapiens*

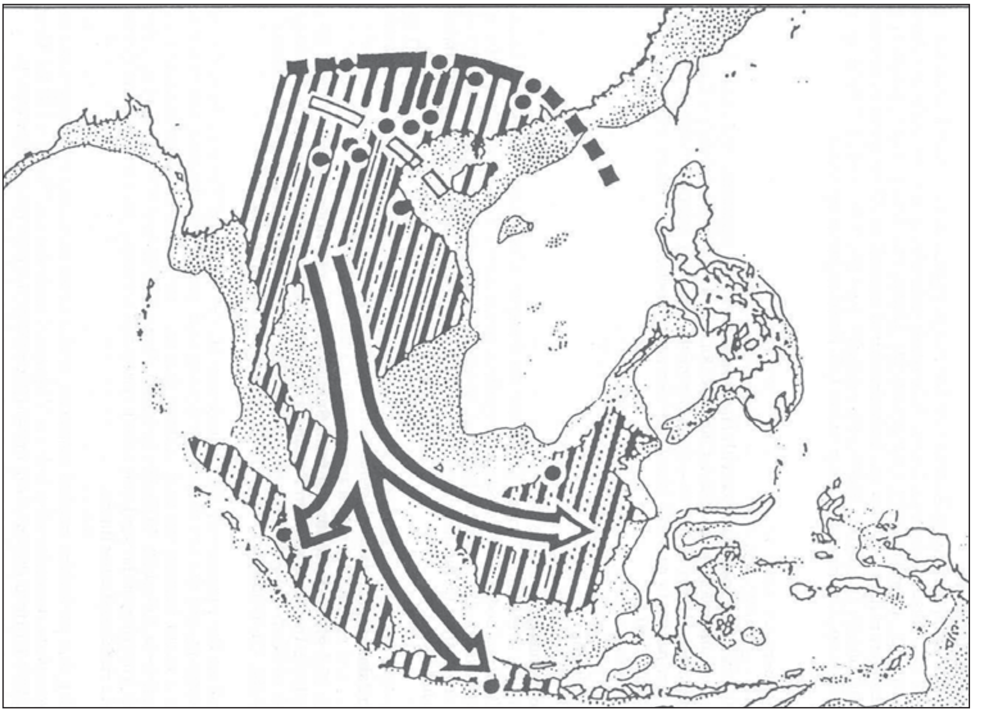

Fig. 9. The migration of mammals during the Late Pleistocene via the Sino-Malayan route (after de Vos, 1995).

from China, via Vietnam, Cambodia, the Malay Peninsula to the Sunda shelf (de Vos & Long, 2001). Based on the presence of orang-utan and other elements of the fauna de Vos (1995), van den Bergh *et al*. (1996,) and de Vos *et al*. (1999) deduced that the fauna from Sumatran Caves, Niah (Kalimantan) and Punung (Java) came from South China during the Late Pleistocene, via the so-called Sino-Malayan route (Fig. 9).

The chronostratigraphy of Java

The faunal succession gives a good idea about the relative age of the faunas, but in order to make correlations with mainland faunas, it is better to have them in a chronostratigraphic framework. From the 1960s this problem has been tackled by methods of absolute dating. Radiometric ages have been reported for various lithologic units and tektites in Java. Many of these dates, however, are contradictory and confusing when applied to the dating of various geologic and palaeontologic events.

Von Koenigswald (1964, 1968) published two potassium/argon (K/Ar) dates. The first was based on a 'typical Trinil' fauna with the age of 495,000 ± 100 to 60,000 yr; the second on a tektite from the Trinil layers at Sangiran, which was 730,000 ± 50,000 yr. Von Koenigswald supposed the first date represented the age of the upper Trinil.

Jacob & Curtis (1971) gave a preliminary K/Ar dating for early humans in Java. A sample from Mojokerto gave a result of 1.9 ± 0.4 Ma. According to Curtis (1981), however, the date is of little value due to the very high atmospheric-acid content of the sample. No consensus was reached on the interpretation of these K/Ar dates of about two Ma for the Jetis beds. Von Koenigswald held the opinion that the date for Mojokerto is 'good for the upper Jetis only' (1975, p. 306), but others maintained that the two dates represent maxima and that the average of the Jetis vertebrate fauna is closer to 1 Ma (e.g., Isaac & Pilbeam, 1975).

In a survey of the available literature, Orchiston & Siesser (1982) reported that radiometric approaches involving the K/Ar method have been popular attempts to date the fossil hominid bearing formations in Java. Yet in their view, most of the available dates are inadequate. Few were reported in detail, some were published without standard deviations, and all of them lacked adequate stratigraphic information.

In 1975, as the University of Tokyo and the Geological Survey of Indonesia became equally convinced of the importance and necessity of a project for unravelling the bio-, litho -and chronostratigraphy of the hominid-bearing deposits of Java, they agreed to plan and implement a joint research project. The team concentrated on Sangiran, where most of the hominids were coming from, and was the first to carry out large-scale systematic excavations in all fossil beds in this area. The project was carried out in the years 1976 until 1979 (Watanabe & Kadar, 1985). A broad spectrum of approaches was followed, including petrologic and magnetostratigraphic investigations; fluorine analyses of bones, antlers and teeth of fossil mammals; pollen analysis; and fission track dating, all conducted under controlled stratigraphic conditions. In the Sangiran area several tuff layers could be distinguished and dated (Suzuki *et al*., 1985). The fauna succession as suggested by the Dutch-Indonesian team, based on the Dubois Collection, fits the results of the excavations of the Indonesian-Japanese team (Watanabe & Kadar, 1985). Leinders *et al*. (1985) correlated the faunas with the Indonesian-Japanese dates, and also based on Shutler *et al*. (2004) and Storm (2001), the following ages for the hominid sites were obtained (Fig. 4):

The Wajak fauna between 12,930-12,140 years (Shutler *et al*. , 2004).
Wajak Man between 7,670-7,210 years (Shutler *et al*., 2004).
The Punung fauna must have an age about 81,000-126,000 years (Storm, 2001).
The Ngandong fauna is considered to be younger than the Kedung Brubus fauna (Leinders *et al*., 1985).
The Kedung Brubus Fauna is considered about 0.8 Ma (Leinders *et al*., 1985).
The Trinil H.K. and Ci Saat faunas are between 1 and 1.2 Ma (Leinders *et al*., 1985).

Time of arrival of *Homo erectus* and *Homo sapiens* in Java

Two main theories have been put forth to explain modern human origins, the Multiregional Evolution Model and the Out of Africa theory. The Multiregional Evolution Model (Wolpoff *et al*., 1984), proposes that *Homo erectus* migrated from Africa to Eurasia about 1.5 Ma ago and gave rise to modern humans in various regions of the Old World over a long period of time. The result is the evolution of a single, widespread species, *Homo sapiens*, which preserves specific regional traits. In this model, in Java, *Homo erectus* gave rise, via Ngandong Man and Wajak Man, to the Recent Australian aboriginals (*Homo sapiens*). Storm (1995) showed, based on the Wajak skull in the Dubois Collection, that this scenario is not valuable for Java.

The second Out of Africa theory (Stringer, 1992), suggests that after *Homo erectus* left Africa around 1.5 Ma ago and dispersed over The Old World, *Homo sapiens* developed about 150,000 years ago also in Africa and also dispersed over the Old World. In this scenario *Homo sapiens* replaced archaic hominid populations (*Homo erectus*) throughout the Old World.

The ungoing debate about the arrival and extinction of *Homo erectus* in Java is concentrated around two radiometric dates (Swisher *et al.*, 1994, 1996). For the arrival Swisher *et al.* (1994) claimed that *Homo erectus* was already present on Java at 1.81 ± 0.04 Ma, based on dating of minerals from the supposed site of the Mojokerto child. This date is much older than the supposed 1.5 Ma of the *Homo erectus* (OH-9) from Africa and is in contrast with the date for the Kedung Brubus fauna of about 800,000 by Leinders *et al.* (1985). De Vos & Sondaar (1994) disputed the dating of Swisher *et al*. (1994) based on the lack of a solid lithostratigraphy as was given by the Japanese-Indonesian team. This team had concluded that at 1.8 Ma Java was still below water level (de Vos & Sondaar 1994). If the date of 1.8 Ma is true, *Homo erectus* must have migrated from Africa much earlier than the general accepted 1.5 Ma. Swisher *et al*. (1994) suggested that the ancestor of *Homo erectus* ventured out of Africa before 1.5 (probably 1.8 Ma), and that a second migration of *Homo ergaster* followed at around 1.5 Ma.

For the extinction Swisher et al. (1996) claimed a very young date (27,000 ± 2,000 years ago) based on fossil bovid teeth from Ngandong. These dates are, according to Swisher *et al.* (1996), surprisingly young and, if proven correct, imply that *Homo erectus* persisted much longer in Southeast Asia than elsewhere in the world, indicating that *Homo erectus* existed beside *Homo sapiens.* In this case the Multiregional Model doesn't stand. According to the Dutch-Indonesian team these dates are indeed too young. The Punung fauna with orang-utan and *Homo sapiens* had an age between 81,000-126,000 years and was younger than Ngandong fauna including Ngandong Man. If the data of Swisher *et al.* (1996) are correct than one would expect a mixed fauna consisting of *Homo erectus,* archaic faunal elements (like the proboscidean *Stegodon*) and Recent faunal elements (like *Pongo*) with *Homo sapiens*. However, this is not the case; there are only archaic faunal elements in Ngandong.

The question is "what is the value of those absolute dates". Anyway, the debate will continue for some years.

Conclusion

The Dubois Collection owns its fame as an important part of cultural heritage to the famous skullcap and femur that gave the first physical proof of a transitional form between apes and Man. The remainder of the fossils initially received little attention and were stored from 1900 till about 1940 at several places. Much progress was made in the study of fossil man on Java as new finds were made in the 1930s. Other vertebrates were considered of minor importance, although von Koenigswald used them for a first biostratigraphical scheme.

The role of the Dubois collection was restricted to the hominid fossils, until Bernsen started cataloguing the other fossil material, after which Hooijer started the task of systematic descriptions. This work set stage for a new role for the collection.

These vertebrate remains provided new and valuable insights in the biostratigraphy of the region. Secondly, they allowed the reconstruction of the ecological changes in southeast Asia. Thus, the Dubois Collection got a new life, and provided the basis for evolutionary scenarios concerning the dispersal of *Homo erectus* and *Homo sapiens*.

References

Aziz, F. & Vos, J. de. 1989. Rediscovery of the Wadjak Site (Java, Indonesia). *Journal of the Anthropological Society of Nippon*, **97**: 133-144.

Aziz, F., Sondaar, P.Y., Leinders, J.J.M. & J. de Vos, J. de. 1989. Fossil faunas and early Man of Java. *Publication of the Geological Research and Development Centre, Paleontology series*, **6**: 1-3.

Badoux, D.M. 1959. *Fossil Mammals from two Fissure Deposits at Punung (Java)*. Kemink en Zoon N.V., Utrecht: 151 pp.

Bergh, G.D. van den, Vos, J. de, Sondaar, P.Y. & Aziz, F. 1996. Pleistocene zoogeographic...evolution of Java (Indonesia) and Glacio-Eustatic sea level fluctuations: a background for the presence of *Homo*. *Indo-Pacific Prehistory Association Bulletin*, **14** (*Chiang Mai Papers, Volume 1*): 7-21.

Black, D. 1926. Tertiairy man in Asia: The Chou Kou Tien discovery. *Nature*, **118**: 733-734.

Brongersma, L.D. 1941. De verzameling van Indische Fossielen (Collectie-Dubois). *De Indische Gids*, **1941** (Maart): 97-116.

Chambers, R. 1844. *Vestiges of Natural History of Creation*. J. Churchill, London: 231 pp.

Cleevely, R.J. 1983. *World Palaeontological Collection*s. British Museum (Natural History), London: 365 pp.

Curtis, G.H. 1981. Establishing a relevant time scale in anthropological and archaeological research. *Philosophical Transactions of the Royal Society*, B, **292**: 7-20.

Dart, R. 1925. *Australopithecus africanus*: The Man-Ape of South Africa. *Nature*, **115**: 195-199.

Darwin, C. 1859. *On the Origin of Species by means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*. John Murray, London: 490 pp.

Darwin, C. 1871. *The descent of man and selection of relation to sex*. John Murray, London: 475 pp.

Dubois, E. 1889. Over de wenschelijkheid van een onderzoek naar diluviale fauna van Ned. Indië, in het bijzonder van Sumatra. *Natuurkundig Tijdschrift voor Nederlandsch-Indië*, **48**: 148-165.

Dubois, E. 1890. Uit een schrijven van den Heer Dubois te Pajacombo naar aanleiding van een aan dien Heer toegezonden schedel, door den Heer van Rietschoten in zijn marmergroeven in het Kedirische opgegraven. *Natuurkundig Tijdschrift voor Nederlandsch Indië*, **49**: 209-210.

Dubois, E. 1891.Palaeontologische onderzoekingen op Java. *Extra bijvoegsel der Javasche Courant, Verslag van het Mijnwezen over het 4e kwartaal* 1890: 14-18.

Dubois, E. 1892a. Palaeontologische onderzoekingen op Java. *Extra bijvoegsel der Javasche Courant, Verslag van het Mijnwezen over het 3e kwartaal* 1891: 12-14.

Dubois, E. 1892b. Palaeontologische onderzoekingen op Java. *Extra bijvoegsel der Javasche Courant, Verslag van het Mijnwezen over het 4e kwartaal* 1891: 12-15.

Dubois, E. 1893. Palaeontologische onderzoekingen op Java. *Extra bijvoegsel der Javasche Courant, Verslag van het Mijnwezen over het 3e kwartaal* 1892: 10-14.

Dubois, E. 1894. *Pithecanthropus erectus, einen menschenaenliche Uebergangsform aus Java*. Landesdruckerei, Batavia: 39 pp.

Dubois, E. 1896. *Pithecanthropus erectus*, einen menschenaenliche Uebergangsform. *Compte-rendu des séances du troisième Congrès International de Zoologie, Leyde*, 16-21 Septembre, 1895. E.J. Brill, Leiden: 251 –271, pl. 2.

Dubois, E. 1908. Das geologische Alter der Kendeng- oder Trinil-Fauna. *Tijdschrift Koninklijk Nederlansch Aardrijkskundig Genootschap*, 2, **25**: 1235-1270.

Dubois, E. 1936. Nieuwe *Pithecanthropus* ontdekt? *Algemeen Handelsblad*, 18 April, 1936.

Elbert, J. 1907. De nieuwe onderzoekingen over Pithecanthropus-vraagstuk. *Natuurkundig Tijdschrift voor Nederlandsch-Indië*, **67** (3-4): 125-142.

Erickson, P.A. 1976. *Origins of physical anthropology*. Ph.D. thesis, University of Connecticut, Storrs: 348 pp.

Haeckel, E. 1868. *Natürliche Schöpfungsgeschichte; Gemeinverständliche wissenschaftliche Vorträge über die Entwicklungslehre im Allgemeinen und diejenige von Darwin, Goethe, und Lamarck im Besonderen.* Reimer, Berlin: 688 pp.

Holthuis, L.B. 1995. 1820-1958. Rijksmuseum van Natuurlijke Historie. Nationaal Natuurhistorisch Museum, Leiden: 172 pp.

Hooijer, D.A. 1946a. Prehistoric and fossil rhinoceroses from the Malay Archipelago and India. *Zoologische Mededelingen Museum Leiden,* **26**: 1-138.

Hooijer, D.A. 1946b. Some remarks on recent, prehistoric, and fossil porcupines from the Malay Archipelago. *Zoologische Mededelingen Museum Leiden,* **26**: 251-267.

Hooijer, D.A. 1947. On fossil and prehistoric remains of *Tapirus* from Java, Sumatra and China. *Zoologische Mededelingen Museum Leiden*, **27**: 253-299.

Hooijer, D.A. 1948. Prehistoric teeth of Man and of the orang-utan from central Sumatra, with notes on the fossil orang-utan from Java and Southern China. *Zoologische Mededelingen Museum Leiden,* **29**: 175-301.

Hooijer, D.A. 1957. The correlation of fossil mammalian faunas and the Plio-Pleistocene boundary in Java. *Proceedings Koninklijke Nederlandsche Akademie van Wetenschappen,* Series B, **60**: 1-10.

Hooijer, D.A. 1958. Fossil Bovidae from the Malay Archipelago and the Punjab. *Zoologische Verhandelingen Museum Leiden*, **38**: 112 pp.

Hooijer, D.A. 1960. Quaternary Gibbons from the Malay Archipelago. *Zoologische Verhandelingen Museum Leiden,* **46**: 41 pp.

Hooijer, D.A. 1962. Quaternary Langurs and Macaques from the Malay Archipelago. *Zoologische Verhandelingen Museum Leiden,* **55**: 64 pp.

Huxley, T.H. 1863. Man's Place in Nature. *In*: *Collected Essays, 1893-1894, volume 7*. Georg Olms Verlag, Hildesheim: 208 pp.

Isaac, G.L. & Pilbeam, D. Correlation charts compilated at the symposium, Appendix 1. *In*: Butzer, K.W. & Isaac, G.L. (eds.), *After Australopithecines; Stratigraphy, Ecology and Culture Change in the Middle Pleistocene. Papers of the Burg Wartenstein Symposium, July, 1973*. Mouton, The Hague: 889-899.

Jacob, T. & Curtis, G.H. 1971. Preliminary potassium-argon dating of early man in Java *Contributions University of California*, *Archaeological Dating Facility*, **12**: 50.

Junghuhn, F. 1857. Over fossiele zoogdierbeenderen te Patihajam, in de residentie Djapara, eiland Java. *Natuurkundig Tijdschrift voor Nederlansch-Indië*, **14**: 215-219.

King, W. 1864. The reputed fossil man of the Neanderthal. *Quaterly Journal of Science*, **1**: 88-97.

Koenigswald, G.H.R. von. 1931. *Sinanthropus, Pithecanthropus* en de ouderdom van de Trinil-lagen. *De Mijningenieur* (Bandoeng), **12**: 198-202.

Koenigswald, G.H.R. von. 1933. Beitrag zur Kenntnis der fossilen Wirbeltiere Javas I. Teil. *Wetenschappelijke Mededeelingen Dienst Mijnbouw Nederlansch-Indië*, **23**: 1-127.

Koenigswald, G.H.R. von. 1934. Zur Stratigraphie des javanischen Pleistocän. *De Ingenieur in Nederlandsch- Indië*, **1** (4): 185-201.

Koenigswald, G.H.R. von. 1935. Die fossilen Säugetierfaunen Javas. *Proceedings Koninklijke Nederlandse Akademie van Wetenschappen,* **38**: 88-98.

Koenigswald, G.H.R. von. 1936a. Een nieuwe *Pithecanthropus* ontdekt. *Algemeen Indisch dagblad*, 18 March 1936.

Koenigswald, G.H.R. von. 1936b. Pithecanthropus erectus, antwoord dr Von Koenigswald. *Algemeen Handelsblad*, 7 May 1936.

Koenigswald, G.H.R. von. 1939. Das Pleistocän Javas. *Quartär*, **2**: 28-53.

Koenigswald, G.H.R. von. 1940. Neue *Pithecanthropus*-Funde 1936-1938; Ein Beitrag zur Kenntnis der Praehominiden. *Wetenschappelijke Mededeelingen Dienst Mijnbouw Nederlandsch-Indië*, **28**: 1-232.

Koenigswald, G.H.R. von. 1956. The Pleistocene of Java and the Plio-Pleistocene Boundary. *Actes du IV Congrès International du Quaternaire*, *Roma, 1953*, **1**: 5-13.

Koenigswald, G.H.R. von. 1964. Potassium-argon dates and early man. *Report 6 International Congress on the Quaternary, Warsaw, 1961*, **4**: 325-327.

Koenigswald, G.H.R. von. 1968. Das absolute Alter *Pithecanthropus erectus* Dubois. *In*: Kurth, G. (ed.), *Evolution und Hominisation* (2nd ed.). G. Fischer, Stuttgart: 195-203.

Koenigswald, G.H.R. von. 1975. Early Man in Java: Catalogue and Problems. *In*: Tuttle, R.H. (ed.), *Paleoanthropology*. Mouton, The Hague: 303-309.

Leakey, R.E. & Slikkerveer, L.J. 1993. *Man-Ape, Ape-Man. The Quest for Human's Place in Nature and Dubois' 'Missing Link'*. Netherlands Foundation for Kenya Wildlife Service, Leiden: 184 pp.

Leinders, J. J. M., Aziz, F., Sondaar P.Y. & Vos, J. de. 1985. The age of the hominid-bearing deposits of Java: state of the art. *Geologie en Mijnbouw*, **64**: 167-73.

Lydekker, R. 1879. Notices of Siwalik mammals. *Records of the Geological Survey of India*, **12**: 33- 52.

Martin, K. 1884. Ueberreste vorweltlicher Proboscidier von Java und Banka. *Sammlungen des geologischen Reichs-Museums in Leiden*, 1, **4** (1884-1889): 1-24, pl. 1.

Molengraaff, G.A.F. 1922. Geologie. *In*: Stok, J.P. van der (ed.), *De zeeën van Nederlansch Oost-Indië.* Koninklijk Nederlandsch Aardrijkskundig Genootschap, Brill, Leiden: 272-357.

Oppenoorth, W.F.F. 1932. Ein neuer diluvialer Urmensch von Java. *Natur und Museum*, **62**: 269-279.

Orchiston, D.W. & Siesser, W.G. 1982. Chronostratigraphy of the Plio-Pleistocene fossil hominids of Java. *Modern Quaternary Research in Southeast Asia*, **7**: 131-149.

Owen, R. 1855. London: Of the Anthropoid Apes and their relation to Man. *Proceedings of the Royal Institution of Great Britain 1854-1858*, **3**: 26-41.

Radèn Saléh. 1867. Over fossiele beenderen van den Pandan. *Natuurkundig Tijdschrift voor Nederlansch Indië*, **29**: 422-423, 426-429, 433-437, 448-451, 455-459.

Reader, J. 1981. *Missing Links; The hunt for earliest Man*. Collins, London: 272 pp.

Rensch, B. 1936. *Die Geschichte des Sundabogens: eine tiergeographische Untersuchung*. Verlag Gebrüder Borntraeger, Berlin: 318 pp.

Shipman, P. 2001. *The man who found the missing link; Eugène Dubois and His Lifelong Quest to prove Darwin Right.* Simon & Schuster, New York: 514 pp.

Shipman, P & Storm, P. 2002. Missing Links: Eugène Dubois and the Origins of Paleoanthropology. *Evolutionary Anthropology*, **11** (3): 108-116.

Shutler, R., Head, J.M., Donahue, D.J., Jull, A.J.T., Barbetti, M.F., Matsu'ura, S., Vos, J. de & Storm, P. 2004. AMS radiocarbon dates on bone from cave sites in southeast Java, Indonesia including Wajak. *Modern Quaternary Research Southeast Asia*, **18**: 1-5.

Sondaar, P.Y. 1984. Faunal evolution and the mammalian biostratigraphy of Java. *Courier Forschungsinstitut Senckenberg*, **69**: 219-235.

Sondaar, P.Y. & Vos, J. de. 1984. Faunal evolution and Early Man on Java. *Résumés des Communications de Table-Ronde; L'Homme fossile et son Environnement a Java; Marseille*: 29-32.

Sondaar, P.Y., Vos, J. de & Leinders, J.J.M. 1983. Facts and fiction around the fossil mammals of Java. *Geologie en Mijnbouw*, **62**: 339-343.

Sondaar, P.Y., Aziz, F., Bergh, G.D. van den & Vos, J. de. 1996. Faunal Change and Hominid Evolution During Quaternary of Jawa. *Geological Research and DevelopmentCentre*, *Paleontology Series*, **8**: 1-10.

Storm, P. 1995. The evolutionary significance of the Wajak skulls. *Scripta Geologica*, **110**: 247 pp.

Storm, P. 2001. The evolution of humans in Australasia from an environmental perspective. *In*: Dam, R.A.C. & Kaars, S. van der (eds.), *Quarternary environmental change in the Indonesian region. Palaeogeography Palaeoclimatology Palaeoecology*, **171**: 363-383.

Stringer, C.B. 1992. Replacement, continuity and the origin of *Homo sapiens*. *In*: Bräuer, G. & Smith, F.H. (eds.), *Continuity or Replacement, Controversies in Homo sapiens Evolution*. A.A. Balkema, Rotterdam: 9-24.

Suzuki, M., Budisantoso, W., Saefudin, I., & Itihara, M. 1985. Fission track ages of pumice tuff, tuff layers, and javites of fossil homonid fossil-bearing formations in Java. *Special Publication of the Geological Research and Development Centre*, **4**: 309-357.

Swisher III, C.C., Curtis, G.H., Jacob, T., Getty, A.G., Suprijo, A. & Widiasmoro. 1994. Age of the earliest known hominids in Java, Indonesia. *Science*, **263**: 1118-1121.

Swisher III, C.C., Rink, W.J., Antón, S.C., Schwarcz, H.P, Curtis, G.H., Suprijo, A. & Widiasmoro. 1996. Latest *Homo erectus* of Java: Potential Contemporaneity with *Homo sapiens* in Southeast Asia. *Science*, **274**: 1870-1874.

Theunissen, B. 1989. *Eugène Dubois and the ape-man from Java.The history of the first "missing link " and its discoverer.* Kluwer Academic Publications, Dordrecht: 216 pp.

Theunissen, B. & Vos, J. de. 1982. Eugene Dubois, ontdekker van de rechtopgaande aapmens. *Natuurhistorisch Maandblad*, **71**: 107-111.

Theunissen, B., Vos, J. de, Sondaar, P.Y. & Aziz, F. 1990. The establishment of a chronological framework for the hominid-bearing deposits of Java; a historical survey. *Geological Society of America, Special Paper*, **242**: 39-54.

Vos, J. de. 1983. The *Pongo*-faunas from Java and Sumatra and their significance for biostratigraphycal and paleo-ecological interpretations. *Proceedings Koninklijke Nederlansche Akademie van wetenschappen, series B*, **86**: 417-425.

Vos, J. de. 1984. Reconsideration of Pleistocene cave faunas from South China and their relation to the faunas from Java..*Courier Forschungsinstitut Senckenberg*, **69**: 259-266.

Vos, J. de. 1985a. Faunal stratigraphy and Correlation of the Indonesian Hominid Sites. *In*: Delson, E. (ed.), *Ancestors: The Hard Evidence*. Alan R. Liss, Inc., New York: 215-220.

Vos, J. de. 1985b. De Collectie Dubois. *Cranium*, **2**: 26-32.

Vos, J. de. 1995. The migration of *Homo erectus* and *Homo sapiens* in South-East Asia and the Indonesian Archipelago. *In*: Bower, J.R.F. & Sarton, S. (eds.), *Human evolution in its Ecological Context*, *Proceedings of the Pithecanthopus Centennial 1893-1993 Congress, Vol. I, Evolution and Ecology of Homo erectus*: 239-260.

Vos, J. de. 1996. Faunal Turnovers in Java in relation to faunas of the continent. *Odontologie, Association for comparative Odontology*, **1**: 32-36.

Vos, J. de. 2002. A Century of Dutch Paleo-Anthropological Research in Indonesia. In: Vermeulen, H. & Kommers, J. (eds.), *Tales from Academia; History of Anthropology in the Netherlands,* Part 2. *Niccos, Nijmegen Studies in Development and Cultural Change*, **40**: 1095-1116 [Verlag für Entwickelungspolitik Saarbrüken GmbH.]

Vos, J. de & Aziz, F. 1989. The excavations by Dubois (1891-1900), Selenka (1906-1908), and the Geological Survey by the Indonesian -Japanese Team (1976-1977) at Trinil (Java, Indonesia). *Journal of the Anthropological Society of Nippon*, **97**: 407-420.

Vos, J. de, Aziz, F., Sondaar P.Y., & Bergh, G.D. van den. 1999. *Homo erectus* in S.E. Asia: Time Space and migration routes; a global model III. Migration Routes and Evolution. *In*: Gibert, J., Sánchez, F. Gibert, L. & Ribot, F. (eds.), *The hominids and their environment during the lower and middle Pleistocene of Eurasia.* Proceedings of the International Conference of Human Paleontology, Orce 1995: 369-383.

Vos, J. de, Sartono, S., Hardja-Sasmita S. & Sondaar, P.Y. 1982. The fauna from Trinil, type locality of *Homo erectus*; a reinterpretation. *Geologie en Mijnbouw*, **61**: 207-211.

Vos, J. de & Sondaar, P.Y. 1982. The importance of the "Dubois Collection" reconsidered. *Modern Quaternary Research in South-East Asia*, **7**: 35-63.

Vos, J. de & Sondaar, P.Y. 1994. Dating Hominid Sites in Indonesia. *Science* **266**: 1726-1727.

Vos, J. de & Vu the Long. 2001. First settlements: Relations between continental and Insular Southeast Asia. *In*: Sémah, F., Falguères, Ch., Grimaud-Hervé, D. & Sémah, A.M. (eds.), *Origine des peuplements et chronologie des Cultures paléolithiques dan le Sud-est Asiatique*: 225-249.

Vu the Long, Vos, J. de & Ciochon, R. 1996. The fossil mammal fauna of the Lang Trang Caves, Vietnam, compared with southeast Asian fossil mammal faunas: The geographical implications. *Indo-Pacific Prehistory Association Bulletin*, **14** (*Chiang Mai Papers, Volume 1*): 101-109.

Watanabe, N. & Kadar, D. (eds.). 1985. Quaternary Geology of the hominid fossil bearing formations in Java. *Special Publication of the Geological Research and Development Centre*, **4**: 1-378.

Wolpoff, M.H., Wu Xin Zhi, & Thorne, A.G. 1984. Modern *Homo sapiens* origins: a general theory of hominid evolution involving the fossil evidence from East Asia. *In*: Smith, F.H. & Spencer, F. (eds.), *The Origins of Modern Humans: a World Survey of the Fossil Evidence*. A.R. Liss, New York: 411-483.