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The many faces of Wadjak Man

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Abstract

In 1888, 'Wadjak Man' became the first fossil hominid to be found in southeast Asia. It has generally been believed (following Dubois 1922) that 'Wadjak Man' was ancestral to the Australian Aborigines. This view has been repeatedly challenged, mostly through differing interpretations of morphometric data. However, there have been three reconstructions of the Wadjak I skull and there are at least five sets of cranial measurements in the literature.

A critical problem has been the fact that no absolute dates are available for this site. Faunal and elemental analyses can only suggest that the material is sub-recent. Now that dates for the first occupation of Australia are well into the Pleistocene, the role of Proto-Australian for 'Wadjak Man' no longer appears tenable.

Additional skeletal material excavated by Dubois from rockshelters in the Wadjak area has recently been described and may be of similar age to the original fossil.

To securely place 'Wadjak Man' in southeast Asian prehistory a reevaluation of the attributes of fossil and modern hominid material and a reconsideration of many methods of analysis will be required.

'Wadjak Man' has been the subject of controversy since its discovery just over a hundred years ago. Dubois initially delayed publication for some thirty years and then described these fossils as the remains of an 'optimate form', ancestral to the Australian Aborigines (1992:1030). Widely accepted for many years, this opinion is now not generally held. The debate concerning Wadjak's true place in southeast Asian prehistory centers on its cultural and biological affinities and chronological position. The importance of the Wadjak remains is due to the site's location in Java — on the 'island highway' over which the early inhabitants of Australia must have passed (Fig. 1). The Wadjak fossils could be important in three broad areas of research: human evolution in southeast Asia, the peopling of Australia, and the biology and history of the various recent populations of Indonesia and adjacent areas in southeast Asia. The first area pertains if the fossils are given a very early date, the second if a later date is true, and the third with a more recent date. In any case, we must first attempt to understand 'Wadjak Man' himself, in order to better place him in a broader regional context.

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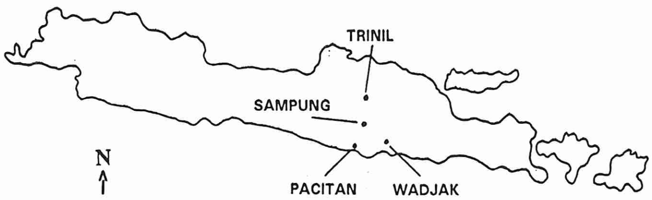

Figure 1. Java, Indonesia, showing location of the sites mentioned in the text (after Jacob 1967).

'Wadjak Man' can also be seen as a case study, which exemplifies some general problems that plague the study of human evolution. The site is best known by a single skull, referred to as Wadjak I, or 'Wadjak Man' (although more material is present). Establishing the affinities of an isolated skull, with no absolute date and no cultural context, is extremely difficult. This is compounded when there is little agreement concerning the 'type' of morphology of the populations to which it is compared.

In light of these issues, our main objective is to summarize what is known about the Wadjak site by reviewing previous work on material as well as the history and literature of that site. Such a review is important because it is not generally recognized that there is more than just one 'Wadjak Man', that there have been several reconstructions of the Wadjak crania, and that no consensus exists with regard to the interpretation of the site. We also consider here material from three nearby rockshelters also excavated by Dubois.

In this paper, the term 'Wadjak Man' will occasionally be used to maintain consistency with the literature. However, the term is generally inappropriate as there is more than one individual present.

Discovery of the Wadjak site

The skull of 'Wadjak Man' was discovered by Mr. B.D. Van Rietschoten in 1888 in the course of marble prospecting on terrace deposits of the Gunung Lawa near the town of Wadjak (present day Wajak, Java, Indonesia; Figs 1 and 2). The skull was sent to Eugene Dubois, who was then searching for early man in Sumatra. The find prompted Dubois to move his search to Java. He worked the Wadjak site in 1890, when he found fragments of a second fossilized skull, post-cranial skeleton fragments and mammal bones.

Figure 2. The Gunung Lawa. This view was assembled from two of Eugene Dubois' original photographs, taken in 1890. The white arrows point to the three hominid bearing sites, left to right: Hoekgrot, Wadjak, Goea Ketjil. Photograph property of the Dubois Collection, National Museum of Natural History, Leiden.

Dubois (1922) did not believe that he had encountered any artifacts. The first skull was designated 'Wadjak I', the second 'Wadjak II'. Dubois also undertook excavations at other sites in the area; three of which, Hoekgrot and Goea Ketjil on the Gunung Lawa (Fig. 2) and Goea Djimbe, c. 25 km away, produced human remains. It was only after completing his work at Wadjak that Dubois moved to Kedungbrubus and then to Trinil, to discover *Pithecanthropus erectus*, 'Java Man'.

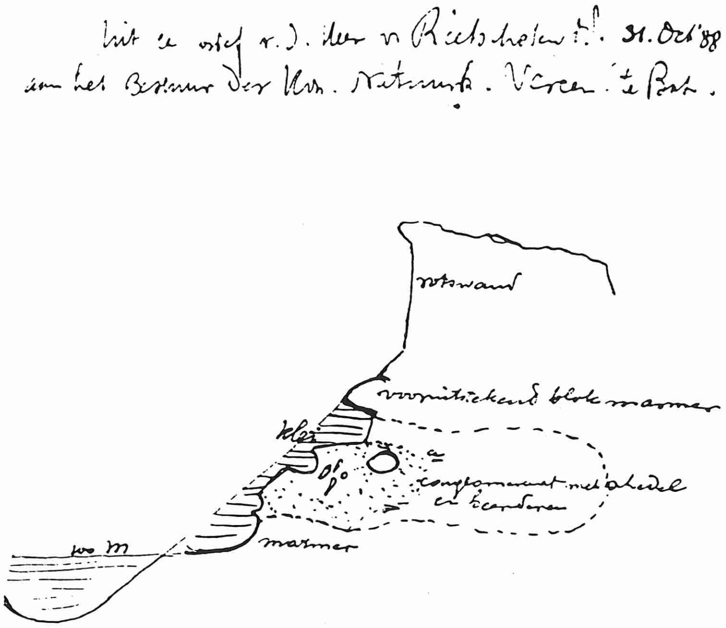

Figure 3. A cross section with accompanying notes of the Wadjak site. Sketch made by C. Sluiter in 1888 after the original discovery of Wadjak I. Property of the Dubois Collection, National Museum of Natural History, Leiden.
The script at the top of the figure reads: 'From a letter of Mr. V. Reitschoten, October 31 1888 to the board of Kon. Natuurk. Veren. in Batavia'. The script in the figure reads, top to bottom: *rotswand* = rocky wall; *vooruitstekend blok marmer* = protruding block of limestone; *klei* = clay; *conglomeraat met schedel en beenderen* = conglomerate with skull and bones; *marmer* = limestone.

The precise circumstances of the discovery of the Wadjak material are unfortunately, obscure. Wadjak I was not excavated under controlled circumstances. A sketch of a cross section of the Wadjak rockshelter made in 1888 by Sluiter (1889) (Fig. 3) and a floor plan indicating where the second skull was found are among the few excavation records that remain. Dubois worked at the site in 1890, but did not publish the major monograph until 1922. Keith (1925) suggested that the delay was due to Dubois' belief that if 'he has placed before the anthropologists of the time the ape-like skull from Trinil side by side with the great-brained skull from Wadjak, both fossilized, both from the same region in Java, he would have given them a meal beyond the powers of their mental digestion' (Keith 1925:441). The delivery of the report was finally prompted by S.A. Smith's monograph on the Talgai cranium in 1918 (Jacob 1967).

Van Stein Callenfels (1936:49) reported that 'the sites have now been completely destroyed in the course of quarrying marble', leading subsequent workers to assume that the site was irrevocably lost. This conclusion was repeated by Coon (1963), Jacob (1967) and Van den Brink (1982). However, with the aid of Dubois' original photographs and notes, the site was relocated by Aziz and De Vos in 1985 (Aziz and De Vos 1989). They demonstrated that the site and some of the original sediments remain (Aziz and De Vos 1989). Furthermore, it is highly probable that there are other promising sites in the area.

Restoration and reconstruction

In the hundred years since its discovery, the Wadjak I skull has undergone several reconstructions and restorations. Dubois first cleaned the skull in 1889. Extensive reconstruction was undertaken in the 1960s by Jacob (1967) at the Institute of Human Biology, Utrecht. Another reconstruction was undertaken in the 1970s by C.B. Stringer and R. Parsons at the British Museum (Natural History) (Fig. 4). In the course of this work, several of the measurements, angles and indices have changed and several morphological traits have become either more or less visible. For example, the cranial index has changed from dolichocranic (72.5, Dubois 1922) to mesocranic (75.5, Jacob 1967) (see also Table 2). Work undertaken on Wadjak II at St. Thomas' Hospital Medical School (London) was reported by Kennedy (1974).

No consensus exists regarding which reconstruction is most accurate. It is possible that none of the reconstructions is 'correct', as some of the differences have arisen in the reconstruction of damaged regions and rebuilding by mirror imaging of asymmetrical portions. The primary references describing these fossils are, for Wadjak I and II, Dubois (1922) and Jacob (1967), with Santa Luca (1980) for Wadjak I and Kennedy (1974) for Wadjak II.

For a preliminary report on the human skeletal material from the three other rock shelters excavated by Dubois, Hoekgrot, Goea Ketjil and Goea Djimbe see Nelson (1989); human artifactual and faunal remains are discussed in Storm (1990).

Relationships

The role of Wadjak in southeast Asian hominid evolution.

Opinions concerning the evolutionary role of 'Wadjak Man' generally fall into two groups, those who see a continuous evolutionary line in Southeast Asia and those who see much greater movement of populations, including replacements and intermixing. In its broadest sense, the continuous line view sees a lineage from *Pithecanthropus erectus*, through to Ngandong hominids and the Wadjak type to modern groups. Sarasin (1926) suggested that Wadjak was 'neanderthaloid' (also later Brace *et al.* 1971), but Oppenoorth (1932) was the first to explicitly postulate a connection from *Pithecanthropus* through Ngandong to Wadjak. Despite an earlier suggestion that Wadjak represented an extinct type (Keith 1925), Keith (1936) and later Weidenreich (1945) saw a continuous line from *Pithecanthropus*, through Ngandong and Wadjak to the modern Aborigines.

Several authors have suggested that the Wadjak hominids did not evolve *in situ* from *Pithecanthropus*. In particular, Santa Luca (1980) explicitly rejected any link between Ngandong and Wadjak. Others have placed the origin of the Wadjak hominids on the Asian mainland. For instance, Howells (1937) believed that Wadjak represented an early example of the Australian type, which originated in Asia. Jacob (1967) suggested that *Pithecanthropus* evolved toward Wadjak by way of a neandertaloid stage represented by the Mapa skull from China. Furthermore, he suggested that Wadjak gave rise to both the Proto-Malays and Austromelanesians (Jacob 1967). Wolpoff (1980 and Wolpoff *et al.* 1984), sees Australia as one of the peripheral ranges of the polytypic species *Homo sapiens*. In this scheme, Wadjak displays similarities to the Aboriginal material, but also the effects of gene flow from the mainland.

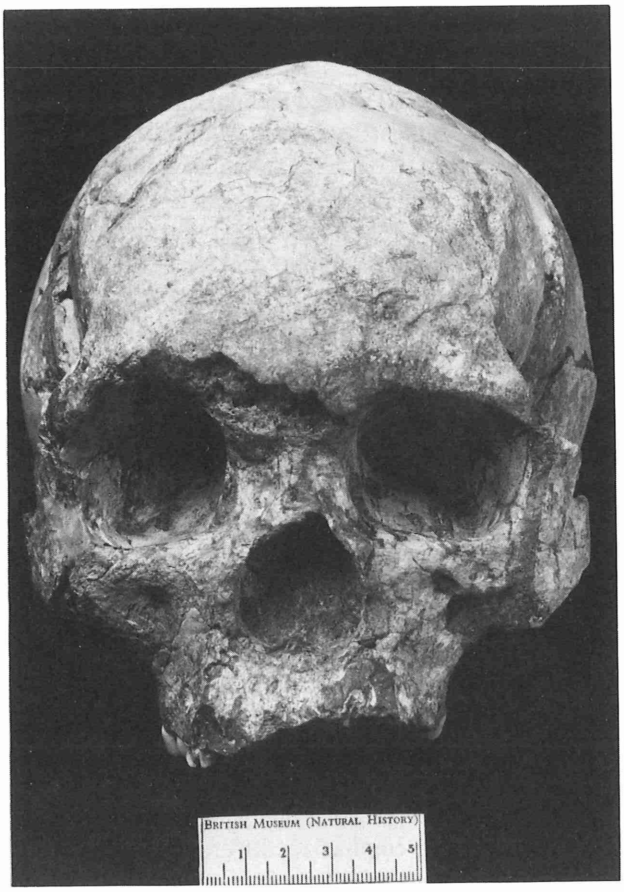

Figure 4. Wadjak I — frontal view. This photograph was taken after the latest reconstruction (scale in mm.). Photograph courtesy of the Trustees of the British Museum (Natural History). Original is the property of the Dubois Collection, National Museum of Natural History, Leiden.

The role of Wadjak in southeast Asian population history.

The most common focus of discussion regarding the Wadjak hominids is in the context discussed above of population movement and gene flow into and out of southeast Asia. Thus it has often been assigned to one or another racial group. It has also been used in discussions of the migrations of early modern *Homo sapiens*. Many scholars have suggested that early populations were very mobile, and that Wadjak may represent one of these groups coming into or leaving southeast Asia.

Dubois' (1889) first impression of the Wadjak material was that it greatly deviated from the 'Malay Type' and more closely resembled the 'Papuan Type'. However, after he found the fragments of Wadjak II in 1890, he decided that the Wadjak material held a closer relationship with modern Australian Aborigines. This association was made on the basis of 17 morphological characters, 16 measurements and 9 indices. Dubois coined the term 'Proto-Australian' and erected a new species *Homo wadjakensis*. Dubois attributed the differences between the Wadjak material and the modern Aborigines to 'Wadjak Man' representing a more vigorous development and greater perfection of the 'type'; *Homo wadjakensis* was an optimum form (Dubois 1922:1030).

Dubois (1922) also noted some similarities between the Wadjak material and Mongoloids, Neandertals and 'Heidelberg Man' (Mauer mandible), although he explicitly discussed differences from the European hominid material. He reasserted his belief that the 'Wadjak Type' differed altogether from the 'Malayan race'.

In 1936, Pinkley suggested that 'Wadjak Man' was most likely to be the ancestor of the 'whites' (especially the Mediterranean race). Pinkley changed the taxonomic designation of the fossils to *Homo sapiens wadjakensis* (by that time Dubois also regarded 'Wadjak Man' as *Homo sapiens* [Pinkley 1936:196]). Von Koenigswald (1952) saw Wadjak as part of a macrodont population of Australomelanesian affinities, which was replaced by migrating modern Indonesians. Birdsell (1949, 1967, 1977) has suggested that Wadjak represented a late representative of the Murrayians, the second of his three waves of migration into Australia.

Shutler (1984) has presented a model in which southern China, between 70,000 and 100,000 years ago, was the dispersal area for the earliest generalized type of *Homo sapiens sapiens*. 'There was a bifurcation of people radiating north and south. Groups left the southern China mainland possibly due to population pressure, moving through insular southeast Asia, crossing Wallacea, and reaching Australia by ca. 50,000 BP' (Shutler 1984:819). In this scheme, the Wadjak hominids, already possessing some Mongoloid traits, would be part of, or a product of, the southern flow. This leaves their role in Australian ancestry open.

Morphology

The Wadjak hominids can be generally described as large brained, large toothed, and anatomically modern *Homo sapiens*. The material is heavily mineralized and has surface mineral concretions, which make the identification of several cranial landmarks somewhat difficult.

The human material from Wadjak represents the remains of at least three individuals, including two skulls, Wadjak I and Wadjak II. The minimum number of individuals is based on the presence of three upper left third premolars (Storm 1990). There is also a collection of postcranial fragments. It is unclear whether the postcranial fragments belong to the same individuals represented by the skull.

Kennedy (n.d.) has suggested that the maxilla and cranial elements traditionally attributed to Wadjak II are in fact from two individuals; the cranial fragments from an older adult, and the maxilla from a young adult. On different grounds, Brown (personal communication) has also suggested that Wadjak II represents two individuals. He thinks that the face (maxilla and zygomatic process) could not have articulated with the frontal bone. However, recent work (Storm 1990) supports the original attribution of the preserved facial elements and frontal bone to a single individual but suggests that individual assignment of the other nine calvarial fragments is difficult.

The two skulls are closely similar in many ways, with the most prominent differences being in the more marked frontal regression and more angled occiput of Wadjak II (Kennedy unpublished manuscript).

Dubois (1922) felt that Wadjak I was female and Wadjak II male, on the basis of size differences. However, on the basis of metric and morphological criteria (following Acsádi and Nemeskéri [1970], Larnach and Macintosh [1966, 1970, 1971], Utterschaut [1983] and Workshop [1980]), Storm (1990) has suggested that both Wadjak I and II are males.

Dubois estimated the cranial capacity of Wadjak I as 1550 cc and of Wadjak II as 1650 cc, based on a ratio relating palate area to cranial volume (Dubois 1922:1023–24). Coon (1963) suggested a figure of 1475 cc for Wadjak I, based on von Bonin's formula for Australoid skulls, while Jacob (1967) estimated it at 1622 cc (method of calculation is not given). Kennedy (1974) estimated the capacity of Wadjak II to be 1395 cc, based on the assumption that the fragmentary calvarial remains all belonged to the same individual. However, with three individuals present and given the fragmentary nature of the calvarial remains, this assumption has to be demonstrated.

Comparative material

In the 1940s, Dubois expanded the 'Wadjak Population' to include the child from Modjokerto, *Pithecanthropus* II and IV, the *Sinanthropus* material from China, and 'Rhodesian Man' from Africa (Dubois 1940a, b, c). This has never been taken seriously by other workers.

Jacob (1967) attributed a fragment of left maxilla (collected by Von Koenigswald in a Hong Kong drug store in the 1930s) to the 'Wadjak population'. He could not estimate its antiquity in relation to Wadjak, but assumed on morphological grounds that it should be later in time. He later (Jacob 1968) remarked that the Hong Kong maxilla was not as heavily mineralized as the Wadjak remains, but that it was still 'wadjakoid'. He used the maxilla as evidence of a migration from southeast Asia to the North.

Other Asian fossils often discussed in relation to Wadjak are Keilor (Weidenreich 1945; Birdsell 1949, 1967; Jacob 1967; Wolpoff *et al.* 1984), and Talgai (Weidenreich 1945; Howells 1937) from Australia, and the Upper Cave of Zhoukoudian (Birdsell 1949, 1967; Wolpoff *et al.* 1984; Habgood 1985), and Liujiang (Birdsell 1949, 1967; Wolpoff *et al.* 1984) from China.

Clearly it would be useful to place the Wadjak material in a population context, but to do so with material from sites so widely separated in time and space may not be appropriate.

Further, determining the appropriate attribution of the Wadjak material raises the vexing problem of definition. In particular, do the various authors have the same conception of the 'Mongoloid Type' or 'Australian Type'? Garn (1971:155–63) has noted that polymorphism in the 'Asiatic Geographical Race' is considerable, due to a wide range of 'climatological' factors. According to him, the 'Mongoloid holotype' of the old schoolbooks is rare, if not completely hypothetical.

A related problem is that although there is overlap, most researchers use or emphasize different measurements, indices and defining morphological characters. Groves (1989) and Habgood (1989) have pointed out that there can be great confusion concerning the polarity and correct interpretation of traits when cladistic methods are employed. Cladistic methods are extremely useful since they force the

Trait	Wadjak I	Interpretation.
Prognathism	present	Australoid (Dubois 1922) — not Australoid (Keith 1925, Pinkley 1936, Brown pers. comm.) — like Broken Hill (Keith 1925) — primitive for all *Homo erectus* and archaic *Homo sapiens* (Habgood 1989)
Receding forehead	present	Australoid (Dubois 1922, Wolpoff *et al.* 1984) — not Australoid (Brown pers. comm) — Mongoloid (Wolpoff *et al.* 1984)
Pronounced superciliary arches	present	Australoid (Dubois 1922, Keith 1925, Jacob 1967) — not Australoid (Pinkley 1936) — not diagnostic (Brown pers. comm)
Supraorbital torus	not present (present: Jacob 1967)	Not Australoid (Dubois 1922) — not like Neandertals (Dubois 1922) — not like Broken Hill (Keith 1925) — not like Solo (Santa Luca 1980)
Prominent nasal bones	not present	Australoid (Dubois 1922, Keith 1925, Wolpoff *et al.* 1984) — not Australoid (Pinkley 1936) — Mongoloid (Wolpoff *et al.* 1984) — too damaged to determine (Brown pers. comm.)

Table 1. Commonly cited morphological traits, their condition on Wadjak I, and a selection of the interpretations derived from these traits.

explicit definition of character states and polarities; however, they are not appropriate when one goal of the analysis is to test the hypothesis of ancestor-descendant relationships. Furthermore, while phylogenetic systematics may work well at higher taxonomic levels, they may not do so at subspecific or racial levels (cf. Turner and Chamberlain 1989). The end result is that at this point no reliable conclusion regarding the affinities of the Wadjak material can be derived from the literature.

Table 1 illustrates the difficulty of dealing with morphological traits and the type concept, showing that there is little agreement regarding the interpretation of five commonly cited morphological traits. The problems with definition, polarity and plesiomorphy are also apparent.

A further problem which makes attribution difficult is that there is no single definitive description of the Wadjak material. As alluded to above, the Wadjak I skull has been reconstructed at least three times and even recent publications cite different sets of measurements (i.e. Cuong 1986 cites Weidenreich 1945; Habgood 1986 cites Coon 1963 and a personal communication from C. Stringer). Table 2 lists some cranial measurements which have appeared in the literature. The difference between some measurements is substantial, particularly those of the cranial vault. Given that skull shape is a major component of many metric studies it is not surprising that many different conclusions have been reached. This problem has been noted by Habgood (1985, 1986), whose k-means cluster analysis placed the 'old' reconstruction (data cited from Coon 1963) in a group with Zhoukoudian Upper Cave 101, Upper Cave 103 and Liujiang. The 'new' reconstruction (data to Habgood from Stringer pers. comm.) was grouped with three African crania (Habgood 1986:134).

	Dubois 1922	Weidenreich 1945	Coon 1963	Jacob 1967	Santa Luca 1980
Calvarial Measurements					
Maximum length	200	200	202	200	201
Maximum breadth	145	149?	148	151	151
Cranial index	72.5	74.5	73.3	75.5	75.1
		dolicocranic		mesocranic	
Cranial capacity	1550	-	1475	1633	-
Basi-bregmatic height	140	140?	136	137	-
Auricular height	-	118	115	118	-
Minimun frontal breadth	99	100	99	99	98
Biauricular breadth	-	133?	-	-	141
Nasion-bregma arc	136	-	136	135	130
Nasion-bregma chord	119	-	119	119	114
Bregma-lambda arc	130	-	130	122	132
Bregma-lambda chord	113	-	113	111	119
Lambda-opisthion arc	-	127?	-	135	127
Lambda-opisthion chord	-	-	-	107	107
Facial Measurements					
Orbit height	33	33	33	35	-
Orbit breadth	42	42	42	44	-
Nasal height	50	-	50	49	-
Nasal breadth	30	30	28	30	-
Internal palate breadth	-	-	42	43	-
External palate breadth	71	-	-	-	-

Table 2. Published cranial measurements of Wadjak I. These measurements represent three major reconstructions of the skull and two sets of measurements from casts (Weidenreich 1945, Coon 1963). All measurements in mm., except cranial capacity (cc).

Date of the Wadjak site

Perhaps the greatest problem with the interpretation of the Wadjak material has been the lack of an absolute date. Opinions regarding the date of the Wadjak site fall into four categories: Pleistocene; Late Pleistocene/Early Holocene; Holocene; undetermined. These opinions are based on degree of fossilization, faunal correlations, and elemental analysis. As yet, no radiocarbon dates have been obtained from Wadjak.

Pleistocene

Dubois (1922) felt that the Wadjak fossils were of 'great age', probably early in the Pleistocene. The basis for his determination was the specific weight of the bones, some 40% greater than fresh bone, indicating that only a very small proportion of the organic component of the bone remained.

Soejono (1984) grouped 'Wadjak Man' with 'Niah Cave Man' and 'Tabon Cave Man' on morphological grounds. On the basis of this association, Wadjak was considered to date to approximately 40,000 years ago.

Late Pleistocene/Early Holocene

Howells (1964) stated that the Wadjak fossils were probably from the Late Pleistocene, although he gave no reason. Jacob (1967) came to the same conclusion, based on the fauna from the Wadjak site, which he judged to be similar to that of the Mesolithic cave of Sampung, Java. In addition, the fossils from the Wadjak cave are well fossilized and chemical tests confirmed Dubois' belief that there was very little organic material remaining in the bone.

A uranium (eU308) test on a sample of Wadjak II yielded a result of 2 ppm (Oakley *et al.* 1975). Jacob (1967) interpreted this figure as representing a Holocene date. However, there is no detectable uranium in Wadjak I (Oakley *et al.* 1975). Further, uranium content is best utilized as a relative rather than absolute dating method. Jacob (1967) also felt that Wadjak's striking resemblance to Keilor suggests similar antiquity. A bone collagen date of 12,000 ± 100 (NZ-1327) places Keilor at the end of the Pleistocene (Brown 1989) (dates placing Keilor in the Holocene are also present in the literature, see Von Koenigswald 1956). Therefore, he concludes that Wadjak is 10,000 years or more old, that is terminal Pleistocene or Early Holocene (Jacob 1967:51, 131).

One of the traditional methods for dating an archaeological site is by cultural association. Unfortunately, the cultural affiliations of the Wadjak remains are still a puzzle, since Dubois found no artifactual material. However, Bartstra (1984) suggested that only the Wadjak hominids could have produced the material culture known as Pacitanian. The Pacitanian belongs to a group of Late Pleistocene/Holocene 'chopper/chopping tool industries' which occurred widely in southeast Asia, China and India (Bellwood 1985). This industry was first discovered in 1935 by Von Koenigswald and Tweedie, in the bed of the Baksoko River near Pacitan in south central Java. Bartstra (1987) suggested that this industry represented a local manifestation of the Hoabinhian complex. On the basis of a geomorphic analysis of the landscape through which the Baksoko River flows, Bartstra (1987) has suggested that the sediments which bear the Pacitanian tools can be dated to the Pleistocene/Holocene boundary. Therefore, he associated the Wadjak hominids and the Pacitanian culture on the basis of assumed contemporaneity. However, Pacitanian tools have not been found at Wadjak, nor have 'Wadjakoid' fossils been found in Pacitanian contexts. Also, others have suggested that many Pacitanian 'tools' may in fact be the result of natural processes (river action) (Das 1968; Tattersall *et al.* 1988).

Dubois (1922) did not recognize any cultural artifacts in the material he excavated at Wadjak. He was aware that artifactual material had been found in the neighboring sites but was of the opinion that these were much more recent than Wadjak. Consequently, he did not find them of interest. However, recent work has uncovered several stone artifacts from the Wadjak site in the Dubois Collection, housed at the National Museum of Natural History in Leiden (Storm 1990). The tools from Wadjak are microlith-like stone artifacts. The material is scanty, but may allow comparisons with other sites. These artifacts are not like Pacitanian tools (Storm 1990).

Holocene

Von Koenigswald (1956) contested Dubois' dating estimates for Wadjak, rejecting the argument for great antiquity based on archaic morphology and degree of fossilization. He felt that there were many indications that the present day Malays were present in Java before the (Late) Neolithic, and that at that time, Java was probably mostly peopled by a mixed population with Australomelanesian affinities. In addition, he cited Snell's finding of a typical 'wadjakoid' palate in modern Javanese. He was of the opinion that Wadjak and Keilor were closely related, and cited C-14 dates for Keilor of 3010 ± 160 BP (W-125) and 8500 ± 250 BP (W-169) (Von Koenigswald 1956:456). (These dates derive from charcoal samples from the Keilor terrace which were not directly associated with the skull (Von Koenigswald 1956). Finally, he felt that the occlusal pattern on the second molars of *Tapiris indicus* in the Wadjak fauna was 'advanced'. Therefore, he saw no evidence to support the suggestion of great antiquity for the Wadjak fauna.

Wolpoff (1980) observed that the Wadjak fauna appeared to be much younger that the Ngandong fauna, and that it could in fact be quite recent. Later, Wolpoff *et al.* (1984) pointed to the fact that a Holocene date could be indicated by the nitrogen levels (Oakley *et al.* 1975) and the similarity with the Sampung fauna (cf. Jacob 1967).

Considerations

Several objections have been made to particular attempts to assign a date to the Wadjak site. Pinkley (1936) first objected to Dubois' use of degree of mineralization to assess 'great age'. The rapid degeneration of the organic component of bone is quite common in areas like southeast Asia. The low nitrogen levels in the samples are indicative of the low level of organic preservation. Unfortunately, this makes it difficult to reliably apply radiocarbon dating to bone collagen. In an attempt to overcome this obstacle, samples from Wadjak and Hoekgrot have been included in a pilot project which is examining the use of accelerator radiocarbon dating on osteocalcin (R.E. Taylor, pers. comm.). Osteocalcin is a non-collagenous protein of bone, which does not decay in the same manner as collagen and is amenable to AMS dating (Ajie *et al.* 1990). Another AMS dating project is also currently underway (Shutler 1990).

Van den Brink (1982) suggested that it is not possible to accurately estimate the age of the Wadjak fauna. She concurred with Jacob (1967) that a number of species co-occur in the Wadjak and Sampung fauna, but pointed out that these similarities did not necessarily imply contemporaneity (the Sampung fauna has been estimated to be 3000 years old by Dammerman (1934) and 3000–4000 by Von Koenigswald (1935)). She hinted that a Late Pleistocene/Early Holocene date might be possible on the basis of the size of the P^4 of *Panthera tigris*.

In fact, with the exception of two species, *Tapiris indicus* and *Cervus kuhlii*, all the species represented in the Wadjak fauna are extant in Java today. It is not entirely clear when these two species became extinct, so their presence in the Wadjak fauna can only indicate that it is 'subrecent'. The fact that the Mesolithic/Neolithic fauna from the Sampung Cave is similar to the Wadjak fauna (Storm 1990), and that the Wadjak bones are well fossilized and contain very little organic matter, make it possible to determine **only** that the Wadjak fossils are from a prehistoric period; they are Late Pleistocene or more recent.

Fauna

Dubois (1922) mentioned only that a few fragments of mammals had been found, and thought that these species were not different from extant species in Java. He did note that all the animal bones were in the same state of fossilization as the human bones. Between 1922 and 1982, three species from the Wadjak fauna were described: *Panthera tigris*, (Brongersma 1937), *Tapiris indicus* (Hooijer 1947), and *Trachypithecus* (= *Presbytis*) sp. (Hooijer 1962). Van den Brink (1982) gave a more detailed description of the faunal material from Wadjak.

Wadjak, the three neighboring caves Hoekgrot, Goea Ketjil and Goea Djimbe, and Sampung all contain faunal elements which can be considered as subrecent. They give a picture of what the fauna was like on the island of Java before it was heavily populated by humans. Several species represented are now extinct in Java: *Tapiris indicus*, *Cervus eldi*, *Cervus kuhlii* and *Capricornus sumatraensis*. *Rhinocerous sondiacus* is now restricted to a game reserve in West Java.

In a comparison of the Wadjak and Punung fauna, De Vos (1983) concluded that the Punung material is earlier than the Wadjak. This conclusion was based on the presence of *Pongo pygmaeus*, *Elephas maximus*, *Ursus malayanus*, *Macaca* sp. and *Hylobates syndactylus* in the Punung fauna; all of these species are absent in the Wadjak and recent faunal successions. He thought that the earlier Punung assemblage represents a humid forest fauna, which probably existed during an interglacial period. The Wadjak assemblage is thought to represent a more open woodland fauna. De Vos (1983) assumed that the climate became drier between the two periods. The fauna from Sampung, Hoekgrot, Goea Djimbe and Goea Ketjil can also be interpreted as representing an open woodland environment.

In light of the differences of opinion concerning continuity or replacement of the hominid populations between Ngandong and Wadjak times, we note that the faunal assemblages from these two periods are clearly different. Although they both represent open woodland environments, only two species, *Panthera tigris* and *Tapiris indicus*, are present in both (Van den Brink 1982; Storm 1990). The intervening Punung assemblages, including *Pongo pygmaeus* and *Hylobates syndactylus*, represent a humid forest environment. Since the Ngandong, Punung and Wadjak faunas are all derived from mainland assemblages (Sondaar 1984), they must represent successive migrations from mainland Southeast Asia (Storm 1990). All modern species were present in the last migration 'wave', possibly including modern humans.

The faunal evidence has also been used to suggest that the transition from *Homo erectus* to *Homo sapiens* may not have occurred on the island of Java. In this case, like the fauna, the successive hominid forms represent successive invasions from a source somewhere on the Asian mainland, probably in the North (cf. Coon 1963, Shutler 1984).

Human material from nearby sites

While excavating the Wadjak site, Dubois made soundings in several other caves in the immediate vicinity. Three other caves yielded human remains, Hoekgrot, Goea Ketjil and Goea Djimbe. Wadjak, Hoekgrot and Goea Ketjil are located in the same cliff face and would all have overlooked a lake (Dubois 1922) (see Fig. 2). Dubois mentioned this other material only once in his Wadjak monograph (1922:1016), where he dismissed it as being much younger than Wadjak and as being different 'anthropological character'. However, he may not have been correct. The material is of interest due to its spatial proximity to, and its possible contemporaneity with, the Wadjak rockshelter. The human material from these sites, mentioned in Habgood (1989:261), was described by Nelson (1989). Storm (1990) has undertaken further analysis of the human material from Hoekgrot and Wadjak.

Elemental analysis of some bone fragments from Hoekgrot indicates that there is very little organic material left in the fossils. The nitrogen content of the Wadjak fossils is 0.38% (W-I) and 0.0% (W-II), (Oakley *et al.* 1975) and for Hoekgrot, 0.12% (Nelson 1989). This would seem to indicate that the Hoekgrot material and the Wadjak fossils have undergone a similar amount of diagenesis. Fluorine uptake rates are known to vary from site to site, but it is possible that the rates from Hoekgrot and Wadjak, two deposits in the same cliff face a short distance apart, may be similar. Initial fluorine tests returned unreliable results (Nelson 1989) although recent analysis suggests that the Hoekgrot material may be somewhat younger than Wadjak (Shutler 1990).

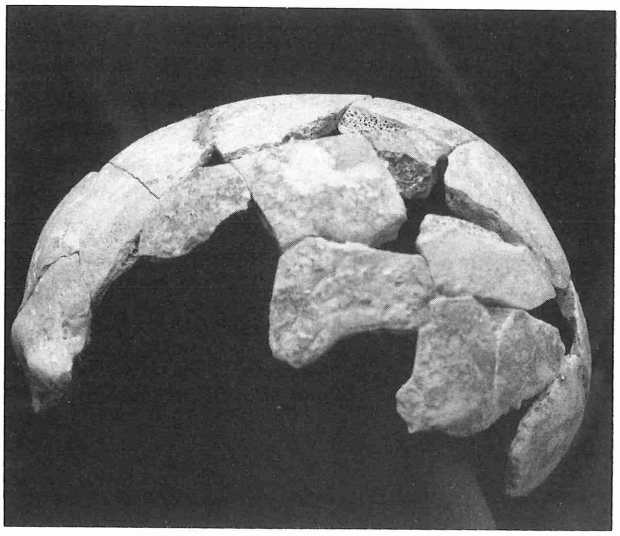

Figure 5. The Hoekgrot calotte, lateral view of the left side. Reconstructed by A. Nelson, 1988. Original is the property of the Dubois Collection, National Museum of Natural History, Leiden. Photograph: A. Nelson.

The faunal material from these caves is not identical to that of Wadjak, but it falls into the same general subrecent succession (Storm 1990).

The material from Hoekgrot includes a full calotte and fragments from at least three additional individuals (Nelson 1989) (Fig. 5). Many of the bones (probably all from one individual) are stained with an iron oxide (identified by X-ray fluorescence), probably ochre. The use of ochre in burial rites has been noted elsewhere in southeast Asia, including the Mesolithic/Neolithic Javanese sites of Sampung (Van Stein Callenfels 1932) and Gua Kepah (Jacob 1967). The presence of staining on articular surfaces and on the sphenoid bone suggests that it may have been applied after disarticulation.

Dubois (1922) believed that this material was not of the same anthropological character as Wadjak, in part due to his assessment of the cranial index — brachycranic as opposed to Wadjak I's dolichocranic index. However, the cranial index of Wadjak I, based on the most recent reconstructions, is mesocranic — as is the Hoekgrot calotte (cranial index = 76.4, Nelson 1989). The Hoekgrot calotte is however, much smaller and more gracile, without pronounced muscle markings. It has moderately developed superciliary arches and frontal bosses and strongly developed parietal bosses. The size of the skull and the development of the bosses are reminiscent of the negritoid type — such as the Tasmanoids described by Wunderly and Wood Jones (1933) or the Queensland type 'C' skull, described by Fenner (1939).

The dental and gnathic remains from Goea Djimbe are similar to Wadjak in terms of the horse-shoe shaped maxillary arcade with a flattened apex, premolar construction and in-turned third molars. However, cusp patterns, third molar reduction and development of the cingulum are not consistently similar.

It is difficult to assess the precise relationships between this additional material and the original Wadjak material. There are several morphological similarities, but there are also important morphological and metric differences. It is not presently possible to define the chronological positions of these sites. If the material from these caves is contemporaneous with the Wadjak site, then the local population may have been a very heterogeneous group. However, if these caves were not occupied contemporaneously, then the collection may represent samples of a single evolving lineage, or samples of successive replacements, possibly migrating lineages, moving through Java.

Summary

The site of Wadjak has played an important role in the history of human palaeontology. The discovery of Wadjak I prompted Eugene Dubois to move his search for the missing link to the island of Java. For several decades after its first detailed description (Dubois 1922), 'Wadjak Man' provided the point of departure for discussions concerning the origin of the Australian Aborigines.

Few publications (i.e. Dubois 1889, 1922; Pinkley 1936; Jacob 1967) have dealt in detail with the site and materials from Wadjak. Data derived from the original specimens are generally available in three studies: Dubois (1922), Jacob (1967) and Santa Luca (1980). Other sources of data include references where data are obtained from casts (Weidenreich 1945; Coon 1963), unpublished data (Kennedy 1974, unpublished manuscript; Nelson 1989; Storm 1990) or personal communications. Many workers have used one of another of these primary references and/or personal observations to include Wadjak (usually Wadjak I) in discussion of Asian hominid evolution or population history. Examples of this kind of study are Keith (1925), Wolpoff *et al.* (1984) and Habgood (1985, 1986). Finally, it is not uncommon for the primary or secondary published sources to be used uncritically, with Wadjak playing a parenthetical role in broad surveys of human evolution (i.e. Howells 1964; Trinkaus 1986; Vandermeersch 1981). It is important to point out that the affinities and antiquity of 'Wadjak Man' have not been resolved. Therefore, its true role in southeast Asia prehistory cannot be ascertained with any degree of certainty.

However, it is also important to realize that we know more about Wadjak now than Eugene Dubois did in the 1920s. Recent work has refocused modern methods and knowledge on the material that Dubois brought to Holland from Java (Nelson 1989; Storm 1990). Contrary to Dubois' original belief, a few stone artifacts are in fact present in the Dubois Collection from Wadjak (Storm 1990). Techniques which were unavailable to Dubois, such as elemental analysis (Nelson 1989; Shutler 1990) and carbon dating are currently being applied to the Wadjak material.

Furthermore, the amount of other archaeological and skeletal material from Australia and southeast Asia has greatly increased in the last century. Although the ever earlier dates for human occupation of Australia (Brown 1987; Habgood 1989) have rendered Dubois' term 'Proto-Australian' largely without meaning, a much more complete understanding now exists of the cultural and evolutionary milieu in which 'Wadjak Man' must have lived.

It is clear that any attempt at the resolution of the role of 'Wadjak Man' will require a thorough reconsideration and reevaluation of the morphological and metric attributes of these and other fossils, as well as a better chronological framework. A more complete understanding of the chronology, faunal and cultural context of this material may require a return to the original site of Wadjak and its surrounding rock shelters.

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