

Trinil and Kedungbrubus: the Pithecanthropus-bearing fossil faunas of Java and their relative age

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On biostratigraphical grounds it has been suggested (De Vos et al. 1982) that the Trinil fauna antedates the Kedungbrubus fauna in Java. This opinion, however, is at variance with evidence from stratigraphic superposition, which must take precedence, and also with magnetostratigraphic-radiometric dating. A reconsideration of the biostratigraphic analysis indicates that the Trinil fauna s.str. postdates the Kedungbrubus fauna s.str. The problem is complicated by the fact that the Kedungbrubus material in the Dubois collection comes from a wide complex of strata and that Dubois or his assistants purchased fossils from the local people, which has been denied by De Vos et al. A consideration of the faunal turnover confirms these conclusions. The Trinil fauna includes the species *Rhinoceros kendengindicus*, *Epileptobos groeneveldtii* and *Elephas celebensis*, and three temporal subspecies of *Hippopotamus sivalensis* are present at Kedungbrubus, although this has been denied.

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1. Introduction

In 1982, De Vos et al. published a re-interpretation of the mammalian biostratigraphy of the hominid-bearing Trinil and Kedungbrubus-Jetis faunas. While previous consensus, based not only on biostratigraphy but also on the stratigraphic succession actually found in the field (Bartstra 1983), held that the Trinil fauna is younger than the Kedungbrubus, they consider it to be older.

The ensuing debate in the *Geologie en Mijnbouw* (Bartstra 1983, Hooijer 1983, Sondaar et al. 1983) has, in our opinion, been somewhat inconclusive. The topic is of particular interest as these faunas have produced highly significant remains of early hominids.

De Vos et al. based their conclusions on a purely biostratigraphic analysis, which is in principle a perfectly proper method as long as no additional evidence (such as superposition in the field) is available. According to them, the Trinil fauna is poor in species with many endemics, thus indicating little or no faunal exchange with the Asian mainland, whereas the Kedungbrubus-

Jetis fauna records the influx of a large number of Asiatic elements. These contentions having been challenged by Bartstra (1983) and Hooijer (1983); Sondaar et al. (1983) reply with the somewhat sweeping conclusion: "Bartstra ... and Hooijer ... fail to demonstrate that the conclusions of De Vos et al. (1982) and De Vos & Sondaar (1982) ... are not correct."

In the present contribution, we shall examine the evidence along two somewhat different lines of enquiry: Hooijer from the point of view of biostratigraphy, and Kurtén from that of faunal turnover.

2. Comments on mammalian taxa (by D.A. Hooijer)

De Vos et al. (1982) base their conclusions on the taxa not present at Trinil proper but found at Kedungbrubus, the other *Pithecanthropus* locality in Java, with a fauna "similar to the Jetis fauna". They consider the excess species in the Kedungbrubus fauna to represent invading elements from mainland Asia. As Hooijer (1983: 338) said,

this is not a very original idea. But what they do with these species is original: they deduce from the presence of these mammals in the Kedungbrubus fauna that it is younger than the Trinil fauna because there is a progressive increase in the number of invading Asiatic elements in the Javan sequence and the Trinil fauna is the poorer of the two. This is not only simplistic but also disregards the stratigraphic succession and radiometric age determinations. As Sondaar et al. (1983: 342) say, their findings are "strictly limited to biostratigraphy".

Originally, Koenigswald (1937: 27, 1940: 72) mentioned some invading elements of the Sino-Malayan fauna appearing first in the Djetis (now called Jetis) fauna of Java. He listed specifically the gibbon, orang-utan, Malayan bear, and tapir. There is quite a list of known invading elements of the early post-Villafranchian *Stegodon-Ailuropoda* faunal block of continental S.E. Asia emerging first in the Jetis fauna: *Hylobates*, *Pongo pygmaeus*, *Homo erectus*, *Helarctos malayanus*, *Hyaena brevirostris*, *Panthera tigris*, *Tapirus indicus*, *Rusa unicolor*, *Bibos*, and *Bubalus* (Hooijer 1952, 1957, 1962, 1964) link up the Jetis fauna with the Trinil fauna of Middle Pleistocene age. De Vos et al. (1982: 208) list as invading elements in the Jetis (Kedungbrubus) fauna not present in the Trinil fauna *Manis palaeojavanica*, *Hyaena brevirostris*, *Elephas hysudrindicus*, *Tapirus indicus*, *Rhinoceros kendengindicus*, *Rusa* sp., and *Epileptobos groeneveldtii*; they call this "A fresh influx of Asiatic mammals" (De Vos et al. 1982: 210). However, as will be seen by comparing this list with the longer one, only *Hyaena brevirostris*, *Tapirus indicus*, and *Rusa* sp. listed by De Vos et al. are invading elements; on the contrary, *Manis palaeojavanica*, *Elephas hysudrindicus*, *Rhinoceros kendengindicus*, and *Epileptobos groeneveldtii* are endemic forms that evolved in Java itself and did not invade Java as such from mainland Asia. De Vos et al. (1982: 209/210) cite *Duboisia* as a clear example of endemism in the Trinil fauna; *Duboisia santeng* also occurs in the Jetis fauna (Hooijer 1964: 75), slightly larger in average size than the Trinil form as is true of more forms common to both faunas, including hominids. What De Vos et al. did not realize is that the four species among the excess species in the Kedungbrubus fauna are endemic in Java just as is *Duboisia santeng*, not having been found to occur anywhere else (with the exception of *Manis palaeojavanica* that did survive into the Late Pleistocene of Borneo). To claim that these species are invading forms from the Asiatic

mainland is a grave error. The correct interpretation of these elements profoundly changes the character of the Kedungbrubus fauna as seen by De Vos et al. They say that the Trinil fauna has "many endemics, which points to little or no fauna exchange with the Asia mainland" (De Vos et al. 1982: 207) whereas better land connections are reflected in the Kedungbrubus fauna (1982: 210). With *Manis palaeojavanica*, *Elephas hysudrindicus*, *Rhinoceros kendengindicus*, and *Epileptobos groeneveldtii* as endemic forms in the Kedungbrubus fauna not present in their Trinil fauna, the Kedungbrubus fauna has more endemics than the Trinil fauna, and it is difficult to reconcile this with the statement by Sondaar et al. (1983: 342) that the "Kedung Brubus fauna is more balanced and points to a better faunal exchange with the mainland". It would seem that their faunal lists do not comply with Sondaar et al., and it may be argued that the fauna with most endemic forms, the Kedungbrubus fauna, is older than the Trinil fauna, as it should be according to the principle of superposition.

"Hutton's observations of accumulating sediments demonstrated the fact that, in a sequence of strata, the older beds are successively covered by younger and younger layers. This relationship, first clearly stated by Hutton and implicit in the principle of superposition, is basic to most stratigraphic thinking" (Krumbein & Sloss 1951: 12). In compliance with the basic stratigraphic principle of superposition the Trinil fauna is younger than the Kedungbrubus fauna (which is similar to the Jetis fauna: De Vos et al. 1982: 210). The superposition is abundantly clear from quotations of Von Koenigswald's paper of 1934 as well as from Hooijer's interpolation of 1952 to the effect that the Jetis beds of Kedungbrubus underlie the Trinil beds and are therefore geologically older (Hooijer 1983: 337).

Unperturbed, Sondaar et al. (1983: 339) maintain that the Kedungbrubus fauna is younger than the Trinil fauna, which Hooijer (1983: 338) said "is patently wrong — this is topsyturvy stratigraphy". Topsy-turvy meaning upside down, Hooijer meant to say that Sondaar et al. put the beds in the wrong order, the older uppermost. With this they violate the fundamental principle of superposition. Further, as we have seen above, if the faunal lists of Trinil and Kedungbrubus are properly interpreted, we find most of the endemic forms in the Kedungbrubus fauna and not in the Trinil fauna, which upsets the scheme of biostratigraphy

advocated by Sondaar et al.

In view of the observations by Bartstra (1983: 335) that, in places where the skull cap and the femur of *Pithecanthropus* were found, Dubois excavated through two units, the Middle Pleistocene Kabuh beds and the Late Pleistocene terrace sediments, Hooijer (1983: 338) raised the question of whether this may be the solution of the problem encountered by Day & Molleson (1973), viz., that unlike the Chinese and East African *Homo erectus* femora, the Trinil femora fall within the range for *Homo sapiens* and therefore may be later (Late Pleistocene) than the skull cap (Middle Pleistocene). Sondaar et al. (1983: 339) wish to regard the Trinil fauna as a single unit, from one and the same stratigraphic level. They limit themselves to Trinil specimens from levels close to the lowest level of the Solo river, near the main bone-bearing bed, and not from the entire Trinil profile. They quote Bergman & Karsten (1952) as saying that the fluorine dating method establishes the contemporaneity of skull cap and femora at Trinil. However, we have since learned a great deal about the limitations of the fluorine test. Day & Molleson (1973: 144-148) give results of fluorine and other chemical analyses and conclude that it is not possible to distinguish bones of the Jetis and the Trinil faunas at Sangiran, and that results of analyses on material from Ngandong show that it would be extremely difficult to draw any valid relative dating conclusions. The position of the Trinil femora as true *Homo erectus* from the Middle Pleistocene is insecure (Day & Molleson 1973: 151/152). This has been left unrecorded by Sondaar et al. (1983) although they must know of the paper by Day & Molleson.

De Vos & Sondaar (1982: 57) do not accept the presence of *Rhinoceros kendengindicus* at Trinil. Of this species, there is a damaged distal femur portion from Trinil (Coll. Dub. no. 9233; Hooijer 1946: 105) and there are three humerus fragments from Kedungbrubus (1946: 103). These bones clearly exceed their homologues of *Rhinoceros sondaicus* in size but are close in dimensions to those of *Rh. unicornis*. Of the femur, Hooijer (1946: 105) gave only the few measurements that could be reliably taken, and in those the Trinil specimen exceeds *Rh. sondaicus*. De Vos & Sondaar (1982: 57) add the transverse epiphysal diameter, which comes out close to that in *Rh. sondaicus*, and therefore they challenge Hooijer's referral of the bone to *Rh. kendengindicus*. This, however, is not realistic: the distal

transverse diameter cannot accurately be taken in the Trinil bone as both the lateral and the medial surfaces are damaged. This is why Hooijer left it out: if taken, it comes out too small. Consequently, the observation by De Vos & Sondaar does not carry any weight and is in fact misleading: on the basis of Hooijer's data there is every reason to refer the Trinil femur to *Rh. kendengindicus*, just as the Kedungbrubus humeri that De Vos & Sondaar do not dispute.

De Vos & Sondaar (1982: 55/56) and Sondaar et al. (1983: 341) state that Hooijer (1958: 33) made a mistake in giving the locality of an incomplete horn core of *Epileptobos groeneveldtii* (Coll. Dub. no. 2746) as Trinil. It should be Tawang, 2 km S.W. of Trinil. Even if this were the case, we do not think it would make any difference whether the locality of the *Epileptobos groeneveldtii* horn core was Tawang near Trinil, or Trinil proper; the specimen was found 1.5 m above the low level of the Solo river in the dry season, that is, near the level of the main bone-bearing bed of Trinil, and it could not possibly belong to any fauna other than the Trinil fauna.

In discussing lithostratigraphy and chronostratigraphy, Sondaar et al. (1983: 340) miss the point totally. Duyfjes' observations are correct: he distinguished formations on lithological characters (Bartstra 1983: 331), and as Bartstra knows from his fieldwork in the area, these formations are traceable from Trinil to Kedungbrubus. Sondaar et al. (1983: 341) say there are no continuous exposures but this is unfounded.

De Vos & Sondaar (1982: 51) do not wish to accept the presence at Kedungbrubus of the pygmy proboscidean originally referred to *Stegodon hypsilophus* and later to *Elephas celebensis*. Of this species there is a humerus portion from Kedungbrubus (Coll. Dub. no. 4621; Hooijer 1955: 87/88) that is rather small compared to that of *Stegodon trigonocephalus*. De Vos & Sondaar (1982) state that the difference in size between the Kedungbrubus humerus and that of *Stegodon trigonocephalus* is small and that little is known about the variability of the humerus of *Stegodon trigonocephalus*. This is incorrect reporting. We know a great deal of the variation in size of the humerus of *Stegodon trigonocephalus*: six entire specimens and from 15 to 30-odd proximal and distal ends and shafts (Hooijer 1955: 71-74). Despite this wealth of material, the Kedungbrubus humerus remains outside the range of variation of the *Stegodon trigonocephalus* humeri; the difference in size does hold good as

will be evident from the table in Hooijer (1955: 88). It is not fair to present the case of the small Kedungbrubus humerus the way De Vos & Sondaar (1982: 51) do; there is good reason to refer the small proboscidean humerus from Kedungbrubus to *Elephas celebensis*.

Elephas celebensis is also present in the Jetis beds N. of Jetis and Perning, whence the type specimen of *Stegodon hypsilophus* came (Hooijer 1955: 87). A milk molar from Trinil described by Hooijer (1974: 90/91) is not accepted by Sondaar et al. (1983: 341) as evidence of the presence of *Elephas celebensis* in the Trinil fauna since the specimen was not collected but bought at Trinil. Now there is a specimen of *Elephas celebensis* from Sambungmacan upstream from Trinil collected by Bartstra in 1982. It has a double matrix, of the Kabuh beds and of the terrace fill of Late Pleistocene age, respectively (Bartstra 1983: 336). It is, therefore, an allochthonous terrace component and originates from the Trinil fauna. It is the proximal portion of a right scapula very close to that of *Elephas celebensis* from Celeko, Sulawesi (Hooijer 1955: 90). The anterior and posterior borders above the glenoid cavity are incomplete but the spina scapulae is preserved to a height of 20 cm above the glenoid cavity. The measurements of the scapulae of *Elephas celebensis* from Java and Sulawesi are given in Table 1.

In order to keep their Kedungbrubus fauna "pure", that is, representing but a single stage, Sondaar et al. (1983: 340) deny that Dubois would have included in his collection of Kedungbrubus specimens not exactly from the site but from the area around it. However, Bartstra (1983: 329/330 and 332) cites Dubois' own reports to that effect, so that there is no denying that he did. Fossils from various strata occur over a large area and were collected everywhere; the type skeleton of *Manis palaeojavanica* came from somewhere near Kedungbrubus as reported by Dubois himself in 1892 (Bartstra 1983: 332) although De Vos et al. (1982: 208) take the locality reference as it stands (Kedungbrubus) and deduce a Kabuh beds origin of the remains from it. Von Koenigswald (see Hooijer 1983: 337) had argued for a Pucangan beds origin of *Manis palaeojavanica*, in which he was most probably right. We also read in Brongersma (1941: 102) that the search for fossils was carried out in the wide environs of Kedungbrubus and that fossils were found in a very large area; this is also based on Dubois' personal reports. Sondaar et al. (1983: 340) say that an area for possible contamination of Jetis

Table 1. Measurements of scapula of *Elephas celebensis* (cm).

	Sambung- macan	Celeko
Tuber scapulae to posterior border of glenoid cavity	c. 12	12
Anterior-posterior diameter of glenoid cavity	10	c. 9 1/2
Transverse diameter of glenoid cavity	6	5 1/2

and Trinil fauna fossils indicated by Bartstra (1983: 330) was not fossiliferous, but as Bartstra has observed in the field fossils occur in this area north of Kedungbrubus, not only where Van Es and Duyfjes marked them on their maps. The Dubois Collection as it is proves that material labelled Kedungbrubus without any reservation is not all of the same age. The *Hippopotamus sivalensis sivajavanicus* skull no. 2908 (Hooijer 1950: 61-62) labelled Kedungbrubus has the primitive characters of the material from Bumiayu and Cijulang, where *Elephas planifrons* occurs, Late Pliocene according to Von Koenigswald and Early Pleistocene according to Hooijer. It is most unlikely that this skull came from the same beds near Kedungbrubus that yielded the mandibular symphysis Coll. Dub. no. 4908 likewise labelled Kedungbrubus (Hooijer 1950: 85-86) that has the progressive characters of the material from Trinil and Tinggang (Solo Valley), Middle to Late Pleistocene and named *H. s. soloensis* (Hooijer 1950: 75-86). This material most probably came from the Kabuh and later exposures at Kedungbrubus. There is also material labelled Kedungbrubus that belongs to *H. s. koenigswaldi* (Hooijer 1950: 65-75), the subspecies found in the Jetis (Pucangan) deposits north of Jetis and Perning, Early Pleistocene according to Von Koenigswald and Middle Pleistocene according to Hooijer. This concerns a mandible Coll. Dub. no. 2916 (Hooijer 1950: 72-73), as well as two partial symphyses of the mandible (1950: 75) each with the characteristic features of the subspecies.

The hippopotami of Kedungbrubus in the Dubois Collection support the statement by Bartstra (1983: 332) that the Kedungbrubus fauna ranges from Late Pliocene to Middle or Late Pleistocene (Hooijer 1983: 338): it is abundantly clear that the Kedungbrubus fauna is not from one and the same stratigraphic level but comes from a wide complex of strata. Sondaar et al. (1983: 341) try to scout this idea by saying: "The supposed presence of three

subspecies of *Hippopotamus sivalensis* in this fauna is based on little and fragmentary material and is therefore doubtful", and they leave it at that. This is incorrect reporting by Sondaar et al. If one reads about the Kedungbrubus material in Hooijer (1950) as cited above, one must conclude that it is very unfair to say that the material of the three temporal subspecies of *Hippopotamus sivalensis* is little and fragmentary and therefore doubtful.

Sondaar et al. (1983: 340) find Bartstra's remark that Dubois would undoubtedly have bought fossils from farmers "unfair" and continue to say that there is no indication whatsoever that he did. "On the contrary: the chances that he did so are extremely small since in those days unauthorized possession of fossils was severely punished (Brongersma 1941)". Here again Sondaar et al. report incorrectly. In Brongersma (1941: 102) we read that Dubois' assistant De Winter was sent to the Patiayam in Japara in 1891 to collect fossils, that the local population in the beginning was inclined to sell fossils but preferred to sell these to Chinese if the price offered was not high enough, and in the Dubois Collection files there are numerous accounts of small sums of money spent for the purchase of fossils. Punishment for possession of fossils was inflicted upon thieves of the Dubois Collection in statu nascendi at the Patiayam in Japara and upon storage of fossils in private homes there (Brongersma 1941: 103), but this did not interfere with the acquisition of fossils by Dubois or helpers from the local population before or after this measure was operative in Japara, or indeed at any time elsewhere in the Kendeng region.

In two places De Vos et al. (1982: 208 and 209) refer to a review article by Hooijer (1975) in which he allegedly says 1) that the Jetis fauna and the Kedungbrubus fauna are identical, and 2) that the Jetis fauna sensu Von Koenigswald resembles the Kedungbrubus fauna in most respects. However, Hooijer said nothing of the kind in his paper of 1975. Von Koenigswald accepted right away in 1934 that at Kedungbrubus there are both the Jetis and the Trinil fauna, and Hooijer followed him therein, already in 1947 (Hooijer 1983: 337). De Vos et al. (1982: 208) further state: "we accept Von Koenigswald's concept that Kedung Brubus is a Trinil fauna". This is incorrect: from what has been written above it is clear that it is not true that in Von Koenigswald's opinion "Kedung Brubus is a Trinil fauna" alone.

Sondaar et al. (1983: 341) write: "Hooijer (this volume) mentions *Manis palaeojavanica*, which was still present in the fauna of the Niah caves" (40 000 years old) but "has not so far been found at Trinil proper". This substantiates the ideas of De Vos et al. (1982) and De Vos & Sondaar (1992) and contradicts the statement of Bartstra (this volume) that the specimens of this genus (sic) "originated from the so-called Pucangan Formation near Kedung Brubus". It is extremely difficult for us to interpret the last sentence. The fact that Hooijer (1983: 337) said that *Manis palaeojavanica* has not so far been found at Trinil does not make him an adversary of Bartstra (1983: 332), who wrote that *Manis palaeojavanica* came from near Kedungbrubus and most probably from the Pucangan exposures; this has nothing to do with the presence or absence of this species from the Trinil site.

Sondaar et al. (1983) call their reply: "Facts and fiction around the fossil mammals of Java". With the present rectification in hand the reader is in a better position to judge what is fact and what is fiction.

Acknowledgement. Dr. G.J. Bartstra has critically read the manuscript, suggested improvements and added some stratigraphical information; he prefers, however, not to co-author the present paper but to go into further details in a stratigraphic paper.

3. Faunal turnover (by B. Kurtén)

De Vos et al. (1982: 208) give faunal lists for Trinil and Kedungbrubus. They are reproduced here (Table 2) with emendations as discussed below.

For Trinil, the lists for the Dubois and Selenka collections have been combined, as they differ only marginally. The record of *Hippopotamus sivalensis* (which, as the authors point out, was not derived from the main layer of Trinil) has been left out.

Hemmer (1971) shows that *Panthera oxygnatha* and *P. trinilensis* are subspecies of *P. tigris*. His study also shows that *P. trinilensis* is a derived form, in relation to *P. oxygnatha*, and thus likely to be more recent in age. In fact, Hemmer is able to trace a sequence of progressive change throughout the Jetis-Trinil-Ngandong succession.

Table 2. Faunal lists for Trinil and Kedungbrubus, emended from De Vos et al. (1982). Hominids not included. † = extinct species.

	Trinil	Kedungbrubus
† <i>Manis palaeojavanica</i> Dubois	—	+
<i>Acanthion brachyurus</i> (L.)	+	—
<i>Panthera tigris trinilensis</i> (Dubois)	+	—
<i>P. t. oxygnatha</i> (Dubois)	—	+
<i>Prionailurus bengalensis</i> (Kerr)	+	—
† <i>Lutra palaeoleptonyx</i> Dubois	—	+
† <i>Hyaena brevirostris bathygnatha</i> Dubois	—	+
† <i>Mececyon trinilensis</i> Stremme	+	—
† <i>Stegodon trigonocephalus</i> Martin	+	+
† <i>Elephas hysudrindicus</i> Dubois	—	+
† <i>Elephas celebensis</i> (Hooijer)	+	—
<i>Rhinoceros sondaicus</i> Desmarest	+	+
† <i>Rhinoceros kendengindicus</i> Dubois	+	+
<i>Tapirus indicus</i> Desmarest	—	+
† <i>Hippopotamus sivalensis</i> Falconer & Cautley	—	+
<i>Muntiacus</i> sp.	+	+
<i>Rusa</i> sp.	—	+
† <i>Axis lydekkeri</i> Martin	+	+
† <i>Duboisia santeng</i> (Dubois)	+	+
† <i>Epileptobos groeneveldtii</i> (Dubois)	+	+
† <i>Bubalus palaeokerabau</i> Dubois	—	+
† <i>Bibos palaeosondaicus</i> Dubois	+	+
† <i>Sus brachygnathus</i> Dubois	+	—
† <i>Sus macrognathus</i> Dubois	—	+
<i>Trachypithecus cristatus</i> Raffles	+	—
<i>Macaca</i> sp.	+	—

According to Hooijer (this paper), the species *Rhinoceros kendengindicus*, *Epileptobos groeneveldtii*, and *Elephas celebensis* are present in the Trinil fauna. These species are referred to below as REE.

The study of faunal turnover dates back to Lyell (1830–1832), who used the progressively increasing percentage of Recent molluscan taxa in defining the sequence of Cenozoic epochs. The same principle holds for mammalian faunas from the Plio–Pleistocene (Kurtén 1959, 1972). In Europe, for instance, Recent species make up some 6–11 per cent of the total number in the Villafranchian; in the earlier middle Pleistocene,

the percentage rises gradually to about 50% (Kurtén 1968). The trend in North America and in East Asia is similar (Kurtén & Anderson 1980, Kurtén 1960). Thus, the relative number of extant species in a fossil fauna will tend to be inversely correlated with its age; and of two faunas in the same region, the one with a lower percentage of extant species will be the older.

Looking first at Trinil, we find five extant and ten extinct species (or, if REE are left out, as in De Vos et al., five extant and seven extinct). The percentage of extant is thus 33% (alternatively 42%, excluding REE).

The Kedungbrubus fauna comprises three extant and 13 extinct species, or 19 per cent extant. Although the difference as such is not statistically significant, it gains in importance by the fact that most taxa are represented by numerous finds and that it lines up with such information as has been detailed above on microevolutionary trends within evolving lineages.

The figures 33–42 per cent Recent species (alternatives for Trinil) are commonly found in European and Asiatic faunas dating from the early middle Pleistocene (“pre-Mindel” and “early Mindel” in Europe). Ninkovitch & Burckle (1978), on the basis of palaeomagnetic and radiometric studies, suggest an age range of c. 0.7–1.3 Myr for the Kabuh Beds in eastern Java, which carry a Trinil fauna. Dates in this range have been obtained for early middle Pleistocene faunas in Europe (e.g. Coltorti et al. 1982) and this indicates that the faunal turnover proceeded at fairly similar rates in all the regions mentioned.

The Kedungbrubus figure of 19 per cent would, in European terms, correspond to anything from late Villafranchian to basal early middle Pleistocene. Ninkovitch & Burckle date the Pucangan Beds of eastern Java, with their Jetis fauna, at approximately 1.3–2.1 Myr. Again, the consistency is good.

I conclude that the age estimates of Ninkovitch & Burckle are realistic and that there can be no question of the Trinil fauna antedating the Kedungbrubus–Jetis fauna.

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