First fossil insectivores from Flores*

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ABSTRACT: The hominid bearing strata from the Liang Bua cave on Flores have yielded a large amount of microvertebrate remains. Among these are three mandibles of shrews, the first record of fossil insectivores from the island. The fossils, representing two different species, are not referable to any of the known Recent shrews from Flores, and are probably part of the extinct insular fauna. Since mandibles alone do not offer sufficient characters to allow even a generic classification, they are published in open nomenclature as *Crocidura* or *Suncus* sp. A, and sp. B.
Key-words: *Flores, Insectivores, Shrews.*

ΠΕΡΙΛΗΨΗ: Από τα στρώματα με Hominidae από το σπήλαιο Liang Bua της νήσου Φλόρες έχει ανασκαφτεί ένας σημαντικός αριθμός ευρημάτων μικροθηλαστικών. Μεταξύ αυτών και τρεις γνάθοι μυογαλής, που αποτελούν τη πρώτη αναφορά απολιθωμένων εντομοφάγων στη νήσο. Τα απολιθώματα αυτά αντιστοιχούν σε δύο διαφορετικά είδη τα οποία δεν σχετίζονται με κανένα από τα σύγχρονα είδη μυογαλής της Φλόρες, και πιθανόν να αποτελούσαν μέρος, της τώρα εξαφανισμένης, ενδημικής πανίδας. Καθώς οι γνάθοι από μόνες τους δεν παρέχουν αρκετά στοιχεία για τον προσδιορισμό του γένους, δημοσιεύονται με ανοιχτή ονοματολογία ως *Crocidura* ή *Suncus* sp. A και sp. B.
Λέξεις-κλειδιά: *Φλόρες, Εντομοφάγα, Μυογαλής.*

INTRODUCTION

As yet, little is known about the fossil microvertebrates of Indonesia. What we do know we owe largely to the work of Dr. Guy Musser, who described Pleistocene murids for Java (VAN DER MEULEN & MUSSER, 1999) and Flores (MUSSER, 1981). The Flores paper dealt with the fossil rats that had been collected by a Dutch priest, father T h e o d o r Verhoeven, in the cave Liang Toge. The work of Verhoeven, who excavated several sites on the island of Flores, drew the attention of both palaeontologists and archaeologists to this island. As a result, this island in the Lesser Sunda chain east of Bali and southwest of Sulawesi has become one of the best-studied islands in the Indonesian Archipelago. For archaeologists the island is of interest for the study of the dispersal of early Man in the region (SONDAAR *et al.*, 1994). Recently, an insular form of *Homo, H. floresiensis* (BROWN *et al.*, 2004; MORWOOD *et al.*, 2004) was discovered in the Liang Bua cave on Flores. For palaeontologists, the importance of Flores lies with its island fauna, with stegodonts, both pygmy and intermediate-sized (e.g. HOOIJER, 1957a, 1964; SONDAAR, 1987; VAN DEN BERGH, 1999) and rodent faunas with various species of giant rat (HOOIJER, 1957b; MUSSER, 1981). To date, the only fossil micromammals described from Flores were rodents. In this paper we present the first finds of fossil insectivores, which were found during recent excavations in the Liang Bua cave.

LOCALITY AND MATERIAL

Liang Bua (= cold cave) lies in western Flores, about 13 kilometres northwest of Ruteng, the capitol of the Manggarai Regency (S. 8° 31' 50.4'' E. 120° 26' 36.9'') (Fig. 1). The cave is situated at the base of a limestone hill on the southern edge of the valley of the Wae Rancang River, at an altitude of 500 m above sea level. Formed as an underground cavern by karst solution, the cave was exposed at its northern side by down cutting of the Wae Rancang River. Liang Bua is a large cave, measuring forty metres in length, and fifty metres in width. It is fifteen metres high at its entrance.

The first archaeological dig in the cave was made by father Theodor Verhoeven. In 1950, a small test trench just inside the entrance yielded stone artefacts and pottery. This trench was only half a metre deep. A larger excavation was performed in 1965, when Verhoeven uncovered a number of Neolithic burials in a large area on the west side of the main chamber. During the two-week expedition, he dug to a depth of two metres.

Large-scale excavations in Liang Bua started in the late 1970s and 1980s under direction of Professor R.P. Soejono

* Πρώτα στοιχεία απολιθωμένων εντομοφάγων από τη νήσο Φλόρες.

of the Indonesian National Centre of Archaeology (INCA). During the excavations in ten different sectors, the distribution of rocks and cultural materials was mapped in ten centimetre spits, providing 3D-coordinates for each find. The maximum depth, obtained in sector 3, was 425 cm, without, however, reaching the bedrock. The excavations showed that four main cultural layers were represented at Liang Bua; Palaeolithic, Mesolithic, Neolithic and Early Metal Age (e.g. SOEJONO, 1980; 1985).

Excavations at Liang Bua resumed in 2001, when a joint Australian-Indonesian team continued the work started by SOEJONO. The new excavations focussed on Sector IV, a 3 x 3 metre area that had been dug to a depth of 370 cm. The sector, situated in the central part of the cave, lies near a large stalagmitic structure, which extends down below the present-day level of the cave floor. The sector was excavated by removing sediment from ten centimetre spits (or by stratigraphical unit if these were smaller), during which all bones, stone artefacts, shards of pottery and charcoal samples were plotted in 3D. The sediments were also wet-sieved at a mesh-width of 3 mm. Micromammal remains were found both while excavating and on the sieve. During excavations in 2003, a depth of 830 cm was reached, but the bedrock was still not encountered. Partly due to the presence of the stalagmite, the stratigraphical units in Sector IV are not level, but slant sometimes considerably. Since many of the micromammal remains have been collected from the sieve, the exact stratigraphical unit from which they are derived cannot be determined with certainty. Only the spit in which the material has been found is recorded. Preliminary results from the murids, however, suggest that using the spit gives a fair approximation of the stratigraphical level. A remarkable feature in the stratigraphy of the pit is an erosional surface between 370 and 500 cm depth. *Stegodon* remains were, for instance, found below this erosional surface only (VAN DEN BERGH & ROKUS AWE DUE, in press).

The micromammal collections from Liang Bua are currently under study in the National Museum of Natural History, Naturalis. Ultimately they will be stored in the Centre for Archaeology, Jakarta (Indonesia). Preliminary numbers have been given under the code LBM (Liang Bua Micromammals). Measurements have been taken using a Leica measuring microscope. The nomenclature for parts of molars and mandible follows REUMER (1985), with the exception of the entoconid crest and oblique crest, which are here called the entocristid and oblique cristid, respectively. For each mandible the length of the tooth row (IM3I) and the mandibular length (MAL) have been measured according to RUEDI (1995, fig. 2). The length and width of the individual dental elements were measured at right angles. All measurements are in millimetres.

SYSTEMATIC PART

Family Soricidae
Subfamily Crocidurinae

Crocidura or *Suncus* sp. A.

Material:
LBM 319, right hemimandible with i1, m1-m3. Spit 44, collected from the sieve at 17.5.2001 (Fig. 2).
LBM 410, right hemimandible with partial i1, m1-m3. Spit 47, collected from the sieve at 4.5.2001 (Fig. 3).
Measurements

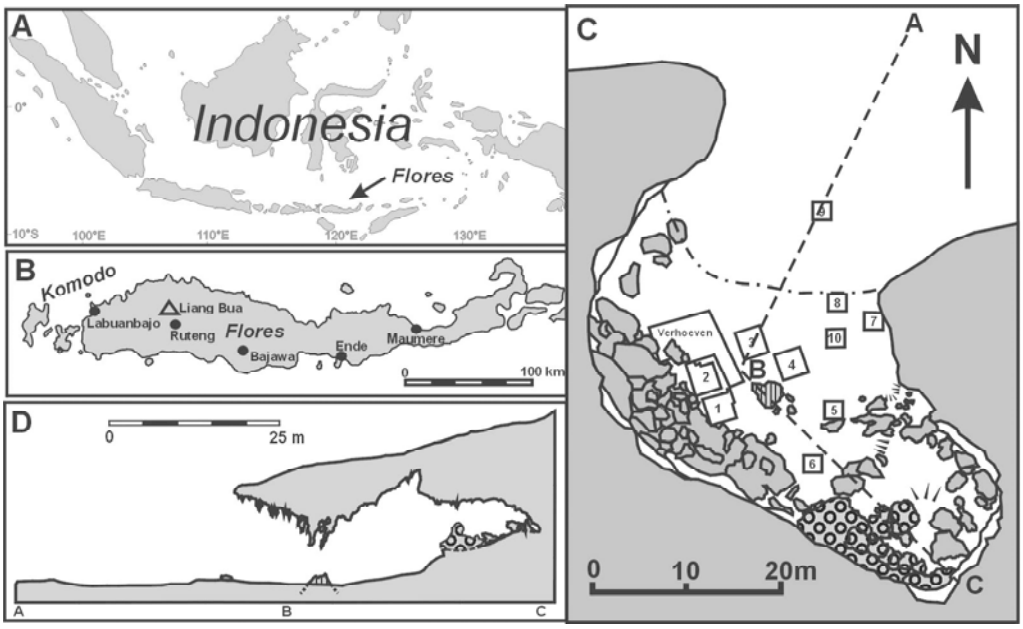

Fig. 1. Maps showing the position of Flores (A) and the Liang Bua (B). The floor plan (C) shows the different excavation sectors, the material described all derives from sector 4, near the stalagmitic structure which is also indicated on the cross section of the cave (D).

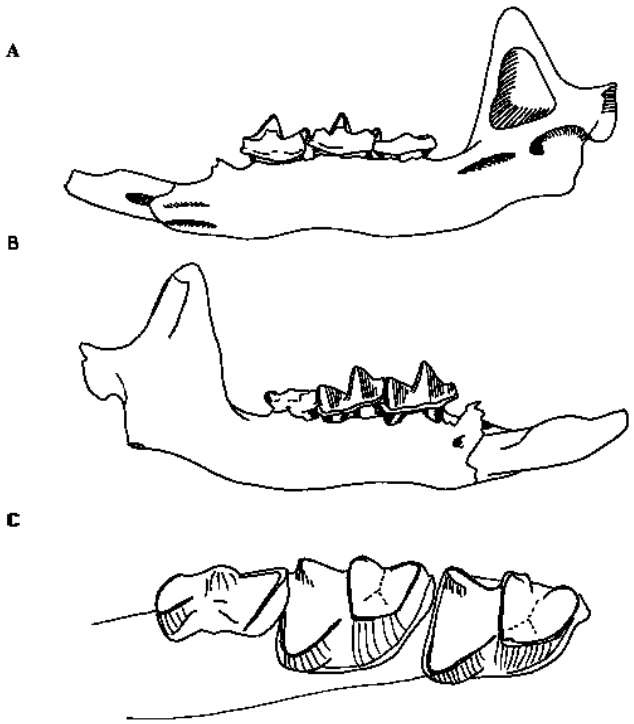

Fig. 2. *Crocidura* or *Suncus* sp. A. right hemimandible, LBM 319. A) Lingual view, B) Labial view, C) Occlusal view of the dentition.

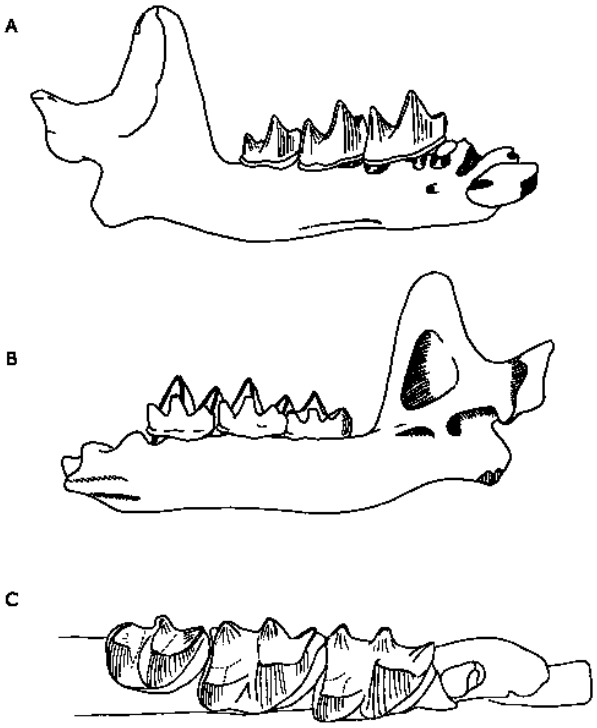

Fig. 3. *Crocidura* or *Suncus* sp. A. right hemimandible, LBM 410. A) Lingual view, B) Labial view, C) Occlusal view of the dentition.

LBM 319 IM3I = 6.4; MAL = 8.9; m1 = 1.83 x 1.26; m2 = 1.81 x 1.15; m3 = - x -.
LBM 410 IM3I = 6.6; MAL = 8.9; m1 = 1.95 x 1.37; m2 = 1.98 x 1.22; m3 = 1.64 x 0.95.

Description

Mandible

The coronoid process has a bluntly rounded tip. A coronoid spicule cannot be observed in the two available mandibles. The anterior side of the coronoid process leans back, making an obtuse angle with the ramus horizontalis. The pterygoid is well developed and the condyle is relatively large. The angular process has not been preserved in either specimen. The internal temporal fossa is deep and high, and reaches over half the coronoid process. At its base the internal temporal fossa is bordered by a conspicuous bar. The mandibular foramen, situated on the centre of this bar, is relatively large. The mental foramen lies underneath the a2 at the end of a shallow sulcus.

Dentition

The molars are relatively short and have sturdy cusps. The trigonid of the m1 is clearly narrower than the talonid. The m2 has a trigonid that is only somewhat narrower than its talonid. In the m3 the talonid is reduced and narrower than the trigonid. On the m1 the paraconid is somewhat set apart by a strong notch in the paralophid. On the m2 the paraconid is connected to the protoconid by a continuous paralophid. As the paraconid is set somewhat more anteriorly on the m1, the trigonid basin on the molar is more open, and the trigonid as a whole is somewhat longer than the talonid. In the m2 the trigonid and talonid are of the same length; on the m3 the trigonid is considerably longer than the talonid.

The oblique cristid ends about halfway the posterior wall of the trigonid, on the m1 a bit more labially than in the m2. On the m3 it does not reach the trigonid, but ends against the lingual wall of the talonid. The hypolophid on the m1 and m2 runs behind the entoconid, and lies directly adjacent to this cusp. The entoconid on the m1 and m2 is triangular in lingual view. Its posterior face is rounded; its anterior face has a wear-facet showing a blunt cristid. There is no metacristid. On the m3 the entoconid is totally incorporated in a crest consisting circling a very small talonid basin. The hypoconid is recognisable as a small elevation in this crest.

The anterior cingulum is well developed on all three molars. The posterior cingulum on the m1 and m2 is somewhat narrower than the anterior cingulum but still fairly strong. The labial cingulum is narrow but clear. The m3 has a clear labial cingulum. A very narrow lingual

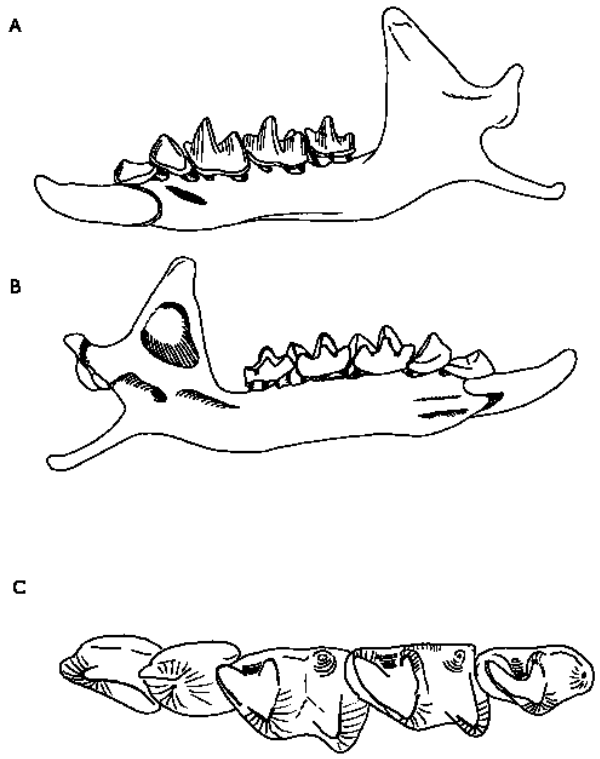

Fig. 4. *Crocidura* or *Suncus* sp. B. right hemimandible, LBM 1206. A) Lingual view, B) Labial view, C) Occlusal view of the dentition.

cingulum is present on the m1 and m2.

Crocidura or *Suncus* sp. B.

Material:
LBM 1206, left hemimandible with i1-m3. Spit 12. Excavated 20.7.1980.

Measurements
LBM 1206 IM3I = 6.4; MAL = 8.3; a1= 1.22 x 0.85; a2 (p4)= 1.18 x 0.94; m1 = 1.70 x 1.24; m2 = 1.73 x 1.14; m3 = 1.37 x 0,81 (Fig. 4).

Description

Mandible

The tip of the coronoid process is acutely rounded. A tiny coronoid spicule is found nearly at the top of the coronoid process. The anterior side of the coronoid process stands nearly perpendicular to the ramus horizontalis. The pterygoid and condyle are smaller than in *Crocidura* sp. A. The angular process is long and slender. The internal temporal fossa is deep and high, reaching over half the coronoid process. A thick bar borders the lower rim of the temporal fossa. A small mandibular foramen lies under the centre of this bar. The mental foramen lies underneath the anterior root of the m1, at the end of a conspicuous sulcus that starts underneath the a1.

Dentition

The two antemolars are heart-shaped in occlusal view. The a1 is more elongated than the a2 (=p4) and has a lower central cusp. This central cusp lies in the a1 in the anterior part of the antemolar, in the a2 more to the centre. The tip of the a1 has two faint posterior ridges bordering a shallow sulcus. The anterior face is rounded sharply. The a2 has only one posterocristid on the lingual side. The central cusp on the antemolar is trilateral, with a more gently curved anterior side. The antemolars have well-developed cingulums on both the lingual and labial sides. The lingual cingulum is a bit thicker than the labial one. The development of the posterior cingulum of the a1 cannot be observed since it is completely covered by the a2. The a2 has a well-developed posterior cingulum, forming a small talonid, which is clearly higher on its lingual than on its labial side.

The trigonid on the m1 and m2 is somewhat longer than the corresponding talonid. The talonid on the m1 is clearly wider than the trigonid; on the m2 trigonid and talonid are about the same width. As the paraconid of the m1 is somewhat lower and more anteriorly positioned than in the m2, the trigonid basin of the m1 is slightly more open than in the second molar. The m3 is greatly reduced, particularly in its talonid. It exists of a small hypoconid only, which is connected to the metaconid by a lingual ridge.

The oblique cristid ends against the posterior wall of the trigonid of the m1 at about three quarts of its length. On the m2 it ends at about two thirds of the length of that wall. The hypolophid on the m1 and m2 ends against the posterolabial flank of the entoconid. The talonid basin on these molars is closed lingually by a low entocristid.

The anterior cingulum is well developed on the m1; wide on the m2 and m3. The anterior cingulum continues as a narrow but clear labial cingulum. The posterior cingulum on the m1 and m2 is wider than the labial cingulum, but less developed that the anterior cingulums. The molars have no lingual cingulums.

DISCUSSION

The Soricidae are represented in the living fauna of Flores by the endemic *Suncus mertensi* and *Crocidura monticola*. MUSSER (1981) added to these *S. murinus*, a widespread species which has been introduced in the region, although this shrew had at the time not been actually recorded from Flores. KITCHENER *et al.* (1994) mention *S. murinus* from a large number of Indonesian islands, including Flores, but did not include specimens from Flores in their analyses.

Insectivores are rare in the faunas from Liang Bua Cave. Among hundreds of murid mandibles and maxillaries of various species, only three lower jaws of soricids have been found. It is rather unfortunate that only mandibles have been found. According to REPENNING (1967) there are no mandibular characters to distinguish between *Crocidura* and

Suncus, the two shrew genera which are currently living on Flores. The two genera differ in the upper dental formula, *Suncus* having one extra antemolar. Since we only have mandibles available, the material could be attributed to either genus.

The material found clearly represents two species. The larger of these, crocidurine A, is represented by two mandibles. Crocidurine B is represented by the mandible LBM 1206, only. In this mandible the oblique cristid ends more labially on the m1 and m2. The talonid on the m3 of crocidurine B is more reduced. It consists of the hypoconid only, whereas in the larger form a small talonid basin is still discernable. Except for the differences in dental morphology, the two species also differ in the shape of the mandible. In crocidurine B, the anterior side of the coronoid process stands perpendicular to the ramus horizontalis, whereas it slants backwards in crocidurine A. The condyle in the latter species is larger than in crocidurine B.

Neither fossil species seems to represent one of the known Recent shrews from Flores. KOCK (1974) found a lower tooth row length between 5.90 and 6.15 for the *Suncus mertensi*, the endemic shrew on Flores. In LBM 1206, the smaller of the fossil shrews, this variable is 6.4 mm, so it is a bit larger than the Recent species. Furthermore, according to the illustration in KOCK (1974; fig. 1), the anterior side of the coronoid process slants backwards, a feature found in the larger of the fossil shrews but not in LBM 1206.

Whereas the fossil Flores shrews are larger than *S. mertensi*, they are too small to be attributed to *S. murinus*. The smallest value for the tooth row length of *S. murinus* found by KITCHENER *et al.* (1994), is 7.4 in a female from Seram. The averages for the various populations from different Indonesian island lie between 8 and 9 mm, which is considerably larger than the 6.8 mm for the largest of our specimens.

The fossil mandibles are also not referable to the Recent *Crocidura* species on Flores, *C. monticola*. Again, this is based on size, *C. monticola* being considerably smaller than the two fossil species. Comparison with *Crocidura* species from other islands in the region is far more difficult. *Crocidura* is a very diverse genus. In his revision of the Indonesian representatives of the genus, RUEDI (1995) recognised twenty different species. Based on the two mandibular measurements he used in his analysis (tooth row length and mandibular length), the Flores mandibles could fit into fourteen out of the twenty species. It is therefore clear that these measurements alone are not sufficient to come to a species distinction, making the identification of fossil mandibles to the species level extremely difficult if not impossible. In the absence of sufficient characters to distinguish the fossil from all known recent *Suncus* and particularly *Crocidura* species in the Indonesian archipelago, we have refrained from assigning a specific name to the fossils. However, the mandibles were found in a micromammal assemblage with many species now extinct (e.g. *Papagomys theodorverhoeveni, Spelaeomys florensis*). Thus it is very well possible that the mandibles represent in fact extinct endemic shrews from Flores.

Having two different species, one from deep spits probably below the erosional surface, and another known only from the higher levels, makes it tempting to assume that they are part of some faunal turnover. After all, Stegodon remains were found only below the erosional surface (VAN DEN BERGH & ROKUS AWE DUE, in press). Of course, no conclusions can be drawn from such a small sample size. Furthermore, the various murid species are found both below and above the erosional surface, showing that the micromammal fauna was apparently unaffected at the time. Given their wide dispersal in the Indonesian archipelago, *Suncus murinus* and *Crocidura monticola* may be relatively new immigrants on Flores, possibly replacing the shrews. With the exception, of course, of *S. mertensi*, which as an endemic can be considered, like the giant rat *Papagomys armandvillei* and the medium-sized murid *Bunomys naso*, a remnant of the insular micromammal fauna from Flores.

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