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10. Late Quaternary faunal successions in South Sulawesi, Indonesia

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1. INTRODUCTION

Sulawesi offers important perspectives on the human impact on island faunas, in terms of the extirpation of indigenous taxa and the introduction of new species. Uniquely among the world's islands, Sulawesi has endemic genera and species that represent nearly half of the world's extant orders of non-marine placental mammals (see Groves 1976; Corbet & Hill 1992). One contributor to the diversity of endemic mammals in Sulawesi has been the proximity of Sundaland and western Sulawesi until the late Miocene, and the heightened scope for faunal dispersal. A second factor is Sulawesi's great environmental diversity in rainfall, seasonality, altitude, and fertility of the soil. In addition, Sulawesi has a minor coterie of Australian taxa whose ancestors arrived on fragments of continent that had drifted westward from Sahulland. Though Sulawesi's endemic fauna is not as diverse as its counterparts on the major islands of the Sunda shelf (Groves 1984; Whitten et al. 1987: 39-42), it vastly outpoints the depauperate faunas that early modern *Homo sapiens* encountered in the islands of Nusatenggara, Maluku, and Melanesia east of New Guinea. The relatively replete ecosystem accordingly rewarded early colonists with a wide range of potential prey and, concomitantly, limited the array of vacant niches for introduced species or, indeed, the need to augment the local standing stock.

Currently no evidence supports any belief in human colonisation of Sulawesi prior to the arrival of fully modern *H. sapiens*. Water-rolled 'choppers' and other artefacts recovered from Cabenge (see Fig. 1) and its environs, spuriously associated with Miocene fossils in the same terraces, are not suspected to be more than 50,000 years old (Keates & Bartstra 1994). Sulawesi's southwest peninsula, that part of the province of South Sulawesi on which this paper concentrates, has been subject to intensive

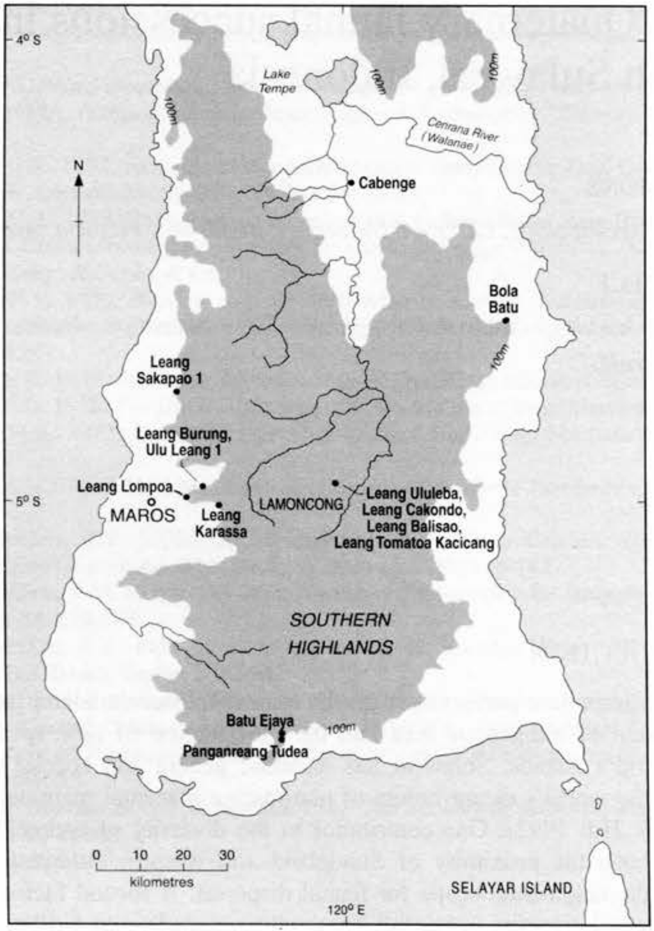

Figure 1. South Sulawesi archaeological sites with faunal remains mentioned in the text.

archaeological study, so that paucity of research cannot be cited as a reason for the lack of evidence of pre-sapient hominids. Admittedly, most of the research in prehistoric archaeology has focused on limestone shelters. These crop up right around the peninsula as a result of uplift of Tertiary marine sediments during the orogenic formation of the peninsula's two volcanic blocks (Katili 1978). To some degree, the focus on shelters curtails the time depth of the well-documented archaeological record, owing to the speed at which limestone cavities have formed, and then been destroyed, in the active hydrological conditions of the peninsula's karsts (Glover 1979). Only two shelters are known with certified Late Pleistocene occupation, in both cases leading up to the Last Glacial Maximum at about 18,000 years ago (see Section 4); all other radiocarbon dates essentially pertain to the Holocene. All of the faunal species identified so far in shelters are still extant somewhere on Sulawesi.

Sulawesi, to our knowledge, has no late Quaternary palaeontological assemblages that include extinct forms. By implication, the late Quaternary entry of humans to Sulawesi did not lay waste to a 'naive' fauna unaccustomed to human predation, or transfigure the island's environment too rapidly for larger species to adapt. We are not, however, proposing Sulawesi as a broadbrush caution against scenarios of humanly induced mass extinctions elsewhere; rather, we stress the degree to which the island's dissected landscape would have retarded human colonists. We also note that climatic change during the late Quaternary would have been restricted to minor variations in temperature and precipitation (Whitten et al. 1987: 19-20, 29) and, accordingly, would be unlikely to have wreaked waves of faunal extinction.

To explain the changes evident in South Sulawesi's faunal record, we advocate a model of faunal succession, to be understood in two senses. One sense is chronological: over time, hunting and forest clearance can be expected to have diminished the ability of the fauna to co-exist with humans in any area. The second sense of succession is spatial, specifically, the exaggerated impact of human activities near the coast compared to the remote interior. We expect the loss of disturbance-sensitive mammals to have characterised faunal assemblages near the coast earlier than assemblages from a remote highland location such as Lamoncong (see Fig. 1). Before explaining how our study will assess the evidence for faunal succession, we should summarise the information on the habitats of the main mammalian taxa in South Sulawesi.

2. MAMMALS OF SOUTH SULAWESI

Two species of anoa, the endemic buffalo of Sulawesi, are known thus far. The Dwarf or Mountain Anoa, *Anoa quarlesi*, was still present in the southern highlands of the peninsula until the twentieth century (Musser 1987: 80; Whitten et al. 1987: 520). The larger *Anoa depressicornis* was once found everywhere in the lowlands of Sulawesi (Clason 1976: 58). Of all the five species of wild cattle in Southeast Asia, the anoa are unique in their adaptation to primary forest as their major habitat (Whitten et al. 1987: 412). No attempt will be made in this paper to differentiate the two species, owing to the difficulties in telling their osteological remains apart, and the similar implications of their presence in reflecting minimal disturbance to the environment.

The Babirusa ('pig deer'), *Babyroussa babyrussa*, and the Celebes pig, *Sus celebensis*, are the two endemic Suidae in Sulawesi today. The Babirusa is a solitary animal or lives in small groups and, being a good swimmer, inhabits woodland swamps and reed jungles. Today it is only found in the north and centre of Sulawesi (Clason 1976: 59). *Sus celebensis* inhabits high grasslands and valleys with dense vegetation at the foot of mountains, and lives together in small groups of two to three animals. It still occurs in reasonable numbers across most of Sulawesi but is now rare in South Sulawesi (Oliver 1993), presumably because forest disruption has proceeded too far here even for this adaptable omnivore. The presence of Babirusa in the Lamoncong assemblages, at almost the same frequency as *S. celebensis*, was considered by Sarasin & Sarasin (1905a: 53) to be one of the most striking points of difference between the subfossil fauna and the recent fauna.

Two species of marsupial are recorded on the mainland of Sulawesi. The Bear Cuscus, *Ailurops ursinus*, inhabits lowland and montane forests, while the smaller *Strigocuscus celebensis* occurs commonly in lowland and evergreen lower montane forest (Musser 1987: 73). Groves (1976: 207) states that the cuscuses seem to be highly adaptable animals. Macaques and tarsiers are the two groups of primates endemic to Sulawesi, but of these only one macaque, *Macaca maura*, has been recorded in South Sulawesi faunal assemblages. Although Sulawesi macaques tend to be mainly lowland forest dwellers (Musser 1987), the vegetation of the southwest peninsula is a mosaic of forest and cleared land, and *M. maura* often comes to ground and can forage in the open (Groves 1980: 91). It seems that this species is a fairly adaptable animal not significantly affected by fragmentation of its habitat, but its range has nonetheless been reduced over the last thirty years and today it is extremely endangered. The other potential arboreal prey is an array of squirrels variably adapted to all levels of the forest, from the low understorey to the canopy. They include endemic species such as *Rubrisciurus rubriventer*, *Hyosciurus ileile*, *Prosciurillus murinus* and *Prosciurillus leucomus*, and the introduced *Callosciurus prevostii* (see Musser 1987: 77-78; Whitten et al. 1987: 41).

Native placental carnivores are restricted to an endemic viverrid, the Sulawesi Brown Palm Civet or *Macrogalidia musschenbroekii* (Musser 1987: 78). The absence of this species outside the northern peninsula today may result from competition by the introduced Palm Civets *Paradoxurus hermaphroditus*, even though the latter are yet to be reported from an archaeological or palaeontological context in Sulawesi (Groves 1976: 208; this paper). Of the six endemic species of Sulawesi shrew only one, *Crocidura rhoditis*, is known for certain to inhabit the lowland evergreen and moss forests of the South Sulawesi peninsula (Musser 1987; Ruedi 1995).

There are 36 known species of murids on Sulawesi, including the following identified from archaeological sites in South Sulawesi: *Lenomys meyeri, Paruromys dominator* and *Maxomys muschenbroekii* occur throughout the lowland and montane forests of South Sulawesi, while *Maxomys hellwaldii* inhabits the peninsula's lowland forest. *P. dominator* is still a favourite forest food of the people living in the mountain villages of central Sulawesi (Musser 1983/84; Corbet & Hill 1992). *Taeromys celebensis* probably occurs in lowland forest throughout South Sulawesi and possibly *Taeromys punicans* as well (Musser 1983/84: 74, 76). Two endemic species of *Rattus* are common in primary lowland and montane forest, but have additionally adapted to the mosaic of gardens and regrowth so widespread throughout South Sulawesi. *R. hoffmanni* is common in tall secondary growth and well-shaded coffee plantations, while *R. xanthurus* abounds in the small plantations (especially shaded coffee groves) and secondary forest near villages (Musser 1983/84). Finally, the introduced Black Rat *Rattus tanezumi* (formerly *R. rattus*) and Ricefield Rat *Rattus argentiventer* are ubiquitous throughout Indonesia in and around human habitation, including those parts of Sulawesi where the original forest has been removed or severely modified (Musser 1983/84: 80; Corbet & Hill 1992: 337).

Only one species of deer, *Cervus timorensis*, lives in Sulawesi today. It was clearly introduced to the island, as in Timor where deer arrived only after 4500 BP, along with other introduced mammals such as monkeys and goats (Glover 1986: 212). This view would be consistent with an accelerator mass spectrometry date of 2810 ± 50 BP

(OZE132), on a fragment identified by Colin Groves as a deer's terminal phalanx, from the Neolithic site of Minanga Sipakko, immediately northwest of our study area. Groves (1976: 209) states that deer are known to be carried around and deliberately released on islands as a meat supply. Hence it may be inferred that this species is highly adaptable, and tolerant of habitats disturbed by humans.

Several domestic animals have been brought to Sulawesi. They include Water Buffalo (*Bubalus bubalis*), cattle (*Bos taurus* and *Bos javanicus*), cats (*Felis cattus*), dogs (*Canis familiaris*), goats (*Capra hircus*), and chickens (*Gallus gallus*). Domestic pigs (*Sus scrofa*), larger and fatter than *S. celebensis* (see Groves 1981: 74-76), were also introduced. Today pigs are virtually absent from the South Sulawesi peninsula as the Bugis and Makasars, who make up the great bulk of the population, underwent wholesale conversion to Islam in the seventeenth century (Pelras 1996).

3. MATERIALS AND METHODS

The materials in this study are 3411 faunal identifications, mostly extracted from the literature, relating to 13 late Quaternary rockshelter assemblages in the South Sulawesi peninsula. As discussed in the relevant sections, the sites are dated through uncalibrated radiocarbon determinations and/or chronologically discrete artefacts, or (as a last resort) by drawing parallels with dated assemblages of a similar character. The vast majority of the identifications involve endemic mammals adapted to the peninsula's widespread monsoon forests and the rainforest along the ranges. However, species introduced to South Sulawesi during the upper Holocene, comprising domesticates and non-domesticates in about equal number, are responsible for up to 20-40% of identifications in the most recent assemblages. Most of the faunal material has resulted from hunter-gatherer predation, notwithstanding minor contributions by small carnivores (endemic or introduced), and some use of the shelters by farmers over the last few millennia. The latter two factors will be discussed below in the context of the condition of the material, and the degree of heat exposure and processing marks observed on the fragments.

The data for Leang Burung 1, Batu Ejaya 2 and Leang Karassa (see Fig. 1), excavated during the 1969 Australian-Indonesian Archaeological Expedition to South Sulawesi (Mulvaney & Soejono 1970), come essentially from Simons (1997). They are based on all identifiable taxonomic elements, of which only a minority are teeth, and are largely compiled from expert identifications made by Colin Groves, Ken Aplin, Wietske Prummel and Guy Musser. Recently, Guy Musser (pers. comm.) has augmented Simons' data with identifications of the post-cranial murid elements. Sieves with a quarter-inch mesh were employed during the 1969 Expedition, while Ian Glover, who excavated Leang Burung 2 and Ulu Leang 1 (see Fig. 1), collected the eighth-inch fraction too. Glover's faunal remains have been studied by Clason (1980, 1989) in terms of all identifiable elements.

In contrast, Hooijer's (1950) identifications from Bola Batu, Panganreang Tudea, Batu Ejaya 1 and Leang Tomatoa Kacicang ('a cave north of Cani') (see Fig. 1) are based only on teeth and jaws, except for a small number of anoa and *Strigocuscus celebensis* post-cranial elements. Our Batu Ejaya 1 data set combines the counts from the excavations by Van Stein Callenfels (Hooijer 1950), and Mulvaney & Soejono (Simons 1997). Note that Musser (1983/84) reviewed Hooijer's rodent identifications, and his amendments are therefore preferred. The data for the Lamoncong shelters excavated by Sarasin & Sarasin (1905a) are based mainly on teeth and jaws, apart from some anoa post-cranial elements. The latter do not, however, affect the totals, owing to the Sarasins' method of counting their faunal inventories.

Sarasin & Sarasin (1905a) summarised their faunal counts in terms of the Minimum Number of Individuals (MNIs) and, in that sense, anticipated the growing trend among zooarchaeologists to turn to MNIs after the 1950s (see Reitz & Wing 1999: 194-195). On the other hand, numbers of individual specimens (NISPs) are supplied by Clason (1976, 1980, 1989). Following Grayson (1984: 90), Simons (1997: 50) preferred NISPs over MNIs, as the latter statistic tends to reduce total faunal counts depending on the degree to which groups of excavated units are aggregated into larger assemblages, a procedure that is susceptible to subjective bias. Further, NISPs are more easily calculated than the MNIs from Hooijer's (1950) identifications. The discrepancy between the MNIs provided by the Sarasins, and the NISPs that constitute the remainder of our data set, may not be serious because, as shown by Grayson (1979), both variables tend to be highly correlated, at least in better-sampled faunal sets.

Amorosi et al. (1996: 131) point out that the research questions should be tailored to the reliability of the zooarchaeological data at hand. In our case, we essentially have teeth and jaws from non-Maros sites excavated without sieves in the early twentieth century, to compare with all identifiable elements from Maros sites sieved during their excavation in the 1960s and 1970s. The former assemblages should be biased towards a reduced representation of faunal diversity, for the following reasons. As the earlier excavated sites were not sieved, small mammals such as rodents would often have been missed. On the other hand, the counts of large mammals would also have been reduced by the focus on teeth and jaws. Hooijer and the Sarasins typically failed to identify post-cranial elements, as would have been associated with meaty parts of a carcass that were more likely to have been carried back to camp after large game was butchered elsewhere (see Bettinger 1991: 75; Reitz & Wing 1999: 204). The bias towards greater faunal diversity in the Maros assemblages is evident in the tables that follow. The large suite of murids identified at Batu Ejaya 2 may also reflect this bias to a degree (see section 5). Accordingly we shall avoid drawing implications on the basis of faunal diversity. Indeed, given the lack of consistency between assemblages in their methods of faunal collection and identification, we shall only point out those quantitative inferences that are patently evident.

The condition of the faunal remains is sometimes excellent. Sarasin & Sarasin (1905a: Tafel IV) illustrated a complete rodent cranium, a semi-complete *Sus celebensis* mandibular corpus, and various teeth and dental arcade fragments of both the Babirusa and the Celebes boar. Hooijer (1950: Plates 1-3) photographed semi-complete palates, hemi-mandibles, fragmentary dental arcades and individual teeth of the two phalanger species, the Brown Palm Civet, a shrew, a macaque (*M. maura*), two rodent species and both endemic suids. Musser (1983/84: Plates 7-12) depicted 13 dentary molar rows of murids from South Sulawesi rockshelters. Simons (1997) recorded 117 complete elements, mainly *Sus* heel and extremity bones, and murid limb bones, but also including deer phalanges, rodent pelves, macaque post-cranial bones, bird coracoids, a bovid astragalus, and isolated teeth from bats, a cuscus, a macaque, a *Sus*, a deer and a dog. In general, the faunal material studied by Simons was well preserved, although only some 14% (by weight) could be identified to its taxon. As regards Ulu Leang 1, Clason (1976) remarked on the good preservation of the osteological fragments but found that approximately 77% defied identification. Clason (1989: 70) further noted that the remains from the Late Pleistocene site of Leang Burung 2 were generally less well preserved than those at Ulu Leang 1.

Teeth and bones tend to fragment badly on exposure to intense heat, a process that rarely occurs when the carcass is cooked, but often affects faunal refuse when hearths are lit in rockshelters (Walshe 2000: 78-79). Most of the Leang Burung 2 bone had been burnt (Clason 1989: 70; see also Glover 1981: 12), an indication of repeated hearth construction, and most of the Ulu Leang 1 fragments illustrated by Clason (1976: Fig. 5) appear burnt. Simons (1997) recorded variable percentages (by weight) of burning of the faunal material: about 29% and 21% in Trenches A and B respectively at Leang Burung 1; 9% at Batu Ejaya 1; 5% at Leang Karassa; but only 2% at Batu Ejaya 2. These data concur with archaeological evidence of sustained occupation at the Leang Burung 1 'base camp', sporadic habitation at Batu Ejaya 1 and Leang Karassa, and minimal human use of Batu Ejaya 2 (Simons 1997). Indeed, as discussed below, Batu Ejaya 2 may mainly represent a civet faunal assemblage. Data on the degree to which the osteological material was burnt at the other sites considered in this paper are unavailable.

The introduced dog, not the civet, would appear responsible for the scratching marks observed by Simons (1997) on five fragments, in two cases accompanied by gnawing marks. All five specimens come from contexts that can be dated to the late Holocene, to wit, spits 1 to 11 in Trench A at Leang Burung 1, spit 4 at Batu Ejaya 1, and spit 5 at Leang Karassa. The dogs in question were presumably companions of the human occupants, a relationship suggested by the burial of a dog near the surface of Batu Ejaya 1 (Simons 1997: 123). The vast majority of the butchery marks identified by Simons (1997) can also be dated to the late Holocene. According to Binford's (1981: 106) criteria, they had been produced by metal knives. They occur on 11 bovid specimens and one chicken bone, in very recent contexts (spits 1 to 4 at Batu Ejaya 1, spit 1 at Batu Ejaya 2, and spit 1 in Trench A at Leang Burung 1). The only case Simons (1997) observed of older cut marks involves two parallel incisions, apparently made with a stone tool, on a Babirusa canine from spit 5 in Leang Burung 1, Trench B. Even this instance may have been related to using the tooth as a tool or an ornament, rather than butchery as such. We are unaware of any description of carnivore or cut marks on the other faunal assemblages discussed in this paper.

The late Holocene evidence of pets, faunal refuse from domesticates, and metal knives, does not necessarily rule out hunter-gatherer occupation of the rockshelters, even as late as the 'Iron Age'. Simons (1997) concluded that the indigenous hunter-gatherers had begun to engage in trading relations with farmers, presumably Austronesian language speakers (Bellwood 1997), as soon as the latter arrived in South Sulawesi. At the same time, farmers overnighting at rockshelters on hunting forays may simulate hunter-gatherers in terms of their debris (Gorecki 1991), so we cannot rule out an Austronesian agency for any assemblage dated to the last four thousand years. But in that case, the farmer's hunting refuse could then be treated as though it were hunter-gatherer debris without violating the heuristic integrity of the data. Potentially, a more serious problem could result from denning activities by the brown palm civet, especially in terms of enriching the hunter-gatherers' faunal assemblages with arboreal animals and small prey. However, there are no particular grounds on which to suggest an increase in the contribution made by civets over time, so we shall interpret chronological patterns as evidence of changes in human hunting patterns.

Our following discussion assumes that hunter-gatherer faunal assemblages may be used as a proxy record of the local fauna, with the following provisos. From optimal foraging theory (Bettinger 1991) we would expect large mammals, which contain abundant energy (and protein) compared to the energy expended on processing them, to be preferentially taken. Hence we anticipate a bias towards large mammals as long as they are at all plentiful in the local landscape. A transition towards small mammals should therefore represent reduced numbers of larger mammals in the catchment area of the site, either through overhunting and/or through human-induced disturbance of the necessary habitat. Microfauna, notably rodents, should also be a significant indicator of local vegetation, especially remnant patches no longer of sufficient size to support the larger mammals adapted to that habitat (Reitz & Wing 1999: 307). Our model of an ideal faunal succession would start with a focus on large mammals of the primary forest. It would then move to more eclectic large mammals, along with smaller mammals of both primary and secondary forest. The final stage would involve large mammals (including domesticates) of highly altered landscapes, plus smaller mammals tolerant of forest disturbance. As implied above, hunter-gatherers clinging to vestiges of forests stripped by surrounding farmers, or residents with a mixed economy, or farmers stopping at shelters during a hunting expedition, could all be equally implicated in the accumulation of this last type of assemblage.

4. THE MAROS KARSTS (LEANG-LEANG, LEANG KARASSA)

The Leang-Leang district in Maros has been a focus of archaeological enquiry, and contains assemblages that relate to every period under consideration. Leang Burung 2 has radiocarbon dates on freshwater shell, which would be too old by some as yet undetermined age, falling between approximately 31,000 and 20,000 BP (Glover 1981; see Bulbeck, Sumantri & Hiscock this volume). Ulu Leang 1 spans much of the Holocene but only the faunal remains from Layer II, associated with an early Holocene radiocarbon date of 7170 ± 650 BP, have been reported (Clason 1976, 1980; Glover 1976, 1978). Leang Burung 1, Trench B, represents the middle Holocene, based on its radiocarbon dates of approximately 5000 to 3200 BP (Simons 1997: 54). The lower section of Trench A in Leang Burung 1, i.e. spits 18 to 23, would be older (but probably not much older) than the 2820 ± 210 BP charcoal date (ANU-391) from spit 17 in the trench. Spits 3-17 in Trench A of Leang Burung 1 (upper Trench A), which contain abundant pot sherds throughout (unlike the assemblages cited previously), are considered to date between the circa 2800 BP radiocarbon date and approximately 2000 BP when the shelter began to be used for mortuary purposes (see Bulbeck et al.

2000: 84-85). A short distance from Leang-Leang lies Leang Karassa where, in 1969, Campbell Macknight excavated deposits that lie between radiocarbon determinations of about 2700 and 370 BP (Pasqua & Bulbeck 1998).

Some details require mention. The Leang Burung 2 assemblage (see Table 1) virtually stands on its own as the sole Late Pleistocene representative. The only comparison is Leang Sakapao 1 in the Pangkajene karsts (see Fig. 1), to the north, where five suid specimens were identified in a sparse assemblage of almost identical age to Leang Burung 2 (Bulbeck, Sumantri & Hiscock, this volume). Clason (1989) assigned two Leang Burung 2 specimens to *S. scrofa*, the introduced domestic pig, but this claim has not been repeated in the secondary literature and could be regarded as in need of confirmation. If size of the anatomical element were Clason's (undisclosed) criterion for recognising *S. scrofa*, then these two specimens could conceivably represent large-bodied Late Pleistocene *S. celebensis*, and will here be assigned to *Sus* sp.

As regards Ulu Leang 1 (see Table 2), Clason (1976) did not discriminate between her 664 *Babyroussa* and *Sus* specimens, but subsequently she assigned them all to *Sus* (*verrucosus*) *celebensis* (Clason 1980). Presumably her latter article glossed over the minor representation of *Babyroussa* in the assemblage and, without a better guide on what that representation was, we allow for a *Babyroussa*:*Sus* ratio between 7:39 (as in Layers II-XI at Leang Burung 2), and 9:217 (as in Leang Burung 1). The Leang Burung 1 data exclude the burial of a goat in Trench B, and the evidently redeposited spits 1-2 in Trench A. The exclusion of these spits is regrettable as they contained the only secure *Anoa* specimen identified at Leang Burung 1. The Leang Karassa assemblage excludes 33 specimens of marine fish which, as discussed by Simons (1997), would appear to be intrusive or the result of contamination. Marine fish, for instance in the form of *ikan bakar* (a favourite modern dish), could easily be transported the 45 km distance from the ocean to Leang Karassa after petrol-powered vehicles arrived in South Sulawesi, but probably not beforehand.

Table 1. Faunal identifications from Leang Burung 2.

taxon	layer I	layers II-XI	total
Anoa sp.	27 (17.1%)	5 (1.6%)	32 (6.8%)
Anoa/*Sus*	11 (7.0%)	1 (0.3%)	12 (2.6%)
Babyroussa babyrussa	26 (16.5%)	7 (2.3%)	33 (7.0%)
Babyroussa/*Sus*	31 (19.6%)	51 (16.4%)	82 (17.4%)
Sus celebensis	14 (8.9%)	39 (12.5%)	53 (11.3%)
Sus sp.	1 (0.6%)	3 (1.0%)	4 (0.9%)
Ailurops ursinus	16 (10.1%)	30 (9.6%)	46 (9.8%)
Strigocuscus celebensis	4 (2.5%)	0	4 (0.9%)
Macaca maura	0	12 (3.9%)	12 (2.5%)
carnivore (civet?)	0	4 (1.3%)	4 (0.9%)
Megachiroptera	13 (8.2%)	18 (5.8%)	31 (6.6%)
unidentified murid	8 (5.1%)	96 (30.9%)	104 (22.2%)
unidentified bird	3 (1.9%)	40 (12.9%)	43 (9.2%)
snake	2 (1.3%)	3 (1.0%)	5 (1.1%)
terrapin/tortoise	2 (1.3%)	2 (0.6%)	4 (0.9%)
total	158	311	469

Note: NISPs, based on all identifiable elements. Clason (1989) also recorded 13 fish, no more closely identified, from Layers II-XI.

Table 2. Faunal identifications from Holocene (Toalean) sites in the Maros karsts.

taxon	Ulu Leang 1	Leang Burung 1 Trench B	L. Burung 1 lower Trench A	L.Burung 1 upper Trench A	Leang Karassa	total
Anoa sp.	24 (2%)	0	0	0	0	24 (1%)
Anoa/*Sus*	32 (3%)	0	0	0	0	32 (2%)
Anoa/*Cervus*	0	1 (0.5%)	0	0	0	1 (0.1%)
B. babyrussa	26-101 (2-8%)	4 (2%)	2 (5%)	3 (3%)	0	35-110 (2-7%)
Sus celebensis	563-638 (45-51%)	63 (30%)	12 (31%)	44 (40%)	10 (29%)	692-767 (42-47%)
Sus sp.	0	72 (35%)	6 (15%)	20 (18%)	0	98 (6%)
Ailurops ursinus	7 0.6%)	4 (2%)	3 (8%)	3 (3%)	0	17 (1%)
Strigocuscus celebensis	3 0.2%)	1 (0.5%)	0	0	0	4 (0.2%)
Macaca maura	22 (2%)	7 (3%)	0	2 (5%)	2 (6%)	33 (2%)
Sciuridae	1 0.1%)	0	0	0	0	1 (0.1%)
Megachiroptera	31 (2%)	21 (10%)	3 (8%)	10 (9%)	0	65 (4%)
Microchiroptera	0	3 (1%)	0	1 (1%)	0	4 (0.2%)
Lemomys meyeri	—	2 (1%)	0	3 (3%)	0	5 (0.3%)
Paruromys dominator	—	4 (2%)	4 (10%)	3 (3%)	1 (3%)	12 (0.7%)
Maxomys hellwaldii	—	1 (0.5%)	0	0	0	1 (0.1%)
Rattus hoffmanni	—	0	0	1 (1%)	0	1 (0.1%)
Rattus foramineus	—	0	0	0	2 (6%)	2 (0.1%)
Rattus tanezumi	—	1 (0.5%)	0	0	0	1 (0.1%)
total murids	65 (5%)	13 (6%)	3 (8%)	13 (12%)	7 (20%)	101 (6%)
Cervus timorensis	0	1 (0.5%)	0	0	6 (17%)	7 (0.4%)
Bos/*Bubalus*	0	0	2 (5%)	4 (4%)	4 (11%)	10 (0.6%)
Canis familiaris	0	0	0	0	1 (3%)	1 (0.1%)
Gallus gallus	0	0	0	0	1 (3%)	1 (0.1%)
unidentified bird	0	2 (1%)	3 (8%)	1 (1%)	1 (3%)	7 (0.4%)
unidentified snake	272 (22%)	3 (1%)	0	1 (1%)	0	276 (17%)
terrapin/tortoise	120 (10%)	0	0	0	0	120 (7%)
Varanid	7 0.6%)	4 (2%)	1 (3%)	2 (2%)	0	14 (1%)
total	1248	207	39	111	35	1640

Note: NISPs, based on all identifiable elements. For an explanation of the uncertain number of Babirusa and *Sus celebensis* identifications at Ulu Leang 1, see the text. Leang Burung 1 lower Trench A = spits 18-23. Leang Burung 1 upper Trench A = spits 3-17. Cumulative percentages often diverge from 100% owing to rounding off errors.

The bottom layer at Leang Burung 2, layer I, is the oldest faunal assemblage in Maros and the most distinctive. It is currently undated except being older than the 31,000 BP date on freshwater shell in Layer II. This faunal assemblage contains 24.2% definite and possible *Anoa* identifications, in marked contrast to the 0 to 5% occurrence of this taxon in all the subsequent Maros assemblages (see Tables 1 and 2). Apparently, heavy reduction in anoa numbers in the vicinity of Leang-Leang can be dated as far back as 30,000 years ago. Another remarkable feature of the Layer I assemblage at Leang Burung 2 is the preponderance of the Babirusa over *S. celebensis*, a feature lacking in every other reported faunal assemblage from South Sulawesi. Indeed the Layer I assemblage has all the semblance of a *Blitzkrieg* hunting assemblage, in which hunters walked in on a naive fauna unaccustomed to human predation, and culled the largest mammals at will. Smaller animals were also evidently taken as part of the resource portfolio, although the absence of monkeys may reflect an inability or disinclination to catch these elusive, arboreal mammals.

The assemblage from Layers II to XI at Leang Burung 2 (see Table 1) differs from the Holocene sets at Leang-Leang in three main aspects. Definite and possible *Sus* specimens account for only 20 to 30% of the identifications, murids account for 31%, and birds account for 13%. The corresponding ranges for the Holocene assemblages are 45-65%, 5-20% and 1-8% (see Table 2). These differences do not clearly reflect human predation patterns in the 31,000-20,000 BP period. Rather the civet, whose remains are probably present at Leang Burung 2, may be the agent behind the high representation of murid and bird bones and, as a mathematical consequence, the low frequency of *Sus*. The large proportion of bone which is burnt would not disprove the involvement of a carnivore because, as discussed by Walshe (2000: 79), fire-wielding humans and local carnivores could have rapidly alternated their use of the den. If human agency were held responsible, then, in the ten millennia leading up to the Last Glacial Maximum, the Leang-Leang hunter-gatherers would appear to have adapted to the depletion of anoa and Babirusa by culling large numbers of *Sus*, murids and birds, as well as a small number of macaques.

The early Holocene assemblage from Ulu Leang 2 retains a modest occurrence of the anoa, as also observed in Layers II to XI of Leang Burung 2, but this buffalo is effectively absent from middle to late Holocene Maros assemblages. The Babirusa occurs at low frequencies in all four Leang-Leang Holocene assemblages, whose dominant feature is a high representation of *Sus* (presumably only *S. celebensis*) at rates between 45 and 65%. While we lack morphological evidence to suggest that the Holocene Toalean hunter-gatherers in this locality had domesticated the Celebes boar, there must certainly have been a commensal or even a mutualistic relationship (cf. Reitz & Wing 1999). This close relationship between *H. sapiens* and *S. celebensis* would have provided a suitable basis for human transportation of the Celebes boar to various islands in eastern Indonesia, and the evident contribution of *S. celebensis* to the breeds of domestic pig observed on some of these islands and in New Guinea (Groves 1981).

Two introductions of non-domesticated animals are reflected in the middle Holocene assemblage from Trench B of Leang Burung 1. At least one specimen, and possibly two, represent the deer, *Cervus timorensis*, which accordingly would seem to have been brought to South Sulawesi at approximately the same time as its arrival in East Timor

(Glover 1986). A third fragment has been identified as *R. tanezumi*, a species that in Sulawesi is generally associated with villages and heavily disturbed habitats. Its presence appears so anomalous that Simons (1997) concluded the specimen to be intrusive, even though it could not be related to the goat burial or other evidence of reworked sediments in this trench. The alternative explanation would posit sufficient habitat disturbance on the part of the Toaleans, at least in the vicinity of their major camping sites, to have provided a niche for *R. tanezumi* introduced to the Leang-Leang environment at some stage prior to 3500 BP.

Small numbers of cattle or water buffalo fragments are present in both of the assemblages from Leang Burung 1 Trench A, marking an addition to the diet between 3000 and 2000 BP. As noted by Simons (1997), these food remains more likely represent exchange between the Toaleans and the early immigrant farmers, who would have begun colonising optimal locations in South Sulawesi by approximately 3500 BP (Bellwood 1997), rather than bovid husbandry on the part of the Toaleans.

All four Toalean assemblages from Leang-Leang are very similar in their salient aspects, suggesting little environmental change between about 7000-8000 BP and 2000 BP. In addition to the common focus on *S. celebensis*, macaques and phalangers both typically constitute a few percent of the identifications, and murids account for 5 to 12%. Where identified, murids of the primary forest (*Lemomys meyeri*, *Paruromys dominator* and *Maxomys hellwaldii*) are the main species. True, the upper levels of Leang Burung 1 Trench A contain a higher proportion of murids (including *R. hoffmanni*) than the other Leang-Leang Holocene assemblages, offering slight evidence of decreased forest cover over time. And the anoa effectively disappeared after the early Holocene, even if Babirusa could still be found close enough to Leang-Leang for its skeletal parts to have occasionally been carried to middle and late Holocene campsites. However, the overall focus is on a diverse mix of ecological generalists that thrive in disturbed forest habitats, and small mammals (especially murids) that require only small forest clumps. This observation suggests that the Leang-Leang environment consisted of a mosaic of copses of primary forest, expanses of secondary forest, and possibly more open habitats between about 7000 and 2000 BP.

The Leang Karassa assemblage excavated by Macknight (see Table 2) is in the main later than any of the Leang-Leang assemblages. It is dominated by ecological generalists that thrive in a disturbed forest mosaic, along with a strong presence of domesticates. The quite high proportion of murids, no longer dominated by primary forest denizens, in particular suggests increasing levels of habitat disturbance. Leang Karassa stands out as a plausible example of the terminal stage in our ideal model outlined in Section 3, involving a focus on small mammals tolerant of disturbed habitats, along with domesticated animals (plus deer). The increase in deer at the evident expense of the Celebes boar may reflect natural increase over time of the introduced species. Van Heekeren's previous excavation, which plumbed the site's older pre-pottery levels, would add *B. babyrussa*, *A. ursinus* and *Strigocuscus celebensis* to the taxa listed in Table 1, but no positively identified anoa (Van Heekeren 1972: 111, 122). These results are consistent with other indications of the virtual demise of the anoa and the Babirusa within the Maros karsts by the middle to late Holocene.

5. OTHER ASSEMBLAGES OF THE LOWLANDS

Van Stein Callenfels (1938) excavated two adjacent sites abutting the south coast, Panganreang Tudea and Batu Ejaya 1 (see Table 3). The top levels at Panganreang Tudea, i.e. Hooijer's (1950: 9) A-B layers, had a mere 13 pot sherds, a bronze fish hook and a stone bead, combined with a late or 'Upper Toalean' assemblage characterised by Maros points and bone points. This assemblage as a whole can be dated between the middle Holocene and the Early Metal Phase. Hooijer's C-D layers can be identified with Van Heekeren's 'Middle Toalean' and 'Lower Toalean' at Panganreang Tudea, covering the period of abundant geometric microliths and the previous period which lacked microliths. These layers would appear to be early Holocene (Van Heekeren 1972: 113-115; Glover 1976).

Table 3. Faunal identifications from lowland sites outside of the Maros karsts.

taxon	PT-AB	PT-CD	BE1-H	BE1-S	BE2	BB	total
Anoa sp.	7	10	1	0	0	86	104
Babyroussa babyrussa	26	12	6	0	0	245	289
Sus celebensis	84	52	7	17	7	265	432
Ailurops ursinus	2	1	1	0	0	3	7
Strigocuscus celebensis	13	15	3	0	2	7	40
Macaca maura	14	2	5	0	0	106	127
Macrogalidia musschenbroekii	0	0	0	0	1	7	8
Soricidae	0	0	0	0	0	1	1
unidentified bat	0	0	0	0	1	0	1
Lemomys meyeri	6	3	1	0	3	0	13
Paruromys dominator	3	5	1	0	8	5	22
Maxomys musschenbroekii	0	0	0	0	0	1	1
Maxomys hellwaldii	0	0	0	0	3	0	3
Taeromys celebensis	1	0	0	0	0	0	1
Taeromys punicans	0	0	1	0	0	3	4
Bunomys heinrichi	0	0	0	0	3	0	3
Rattus foramineus	0	0	0	0	3	0	3
Rattus hoffmanni	0	0	1	0	1	0	2
Rattus xanthurus	1	0	0	0	0	1	2
Rattus tanezumi	0	0	0	1	0	0	1
unidentified murids	0	0	0	0	16	1	17
Cervus timorensis	0	0	0	2	1	0	3
Bos/Bubalus	0	0	0	0	2	0	2
Canis familiaris	0	0	0	0	0	1	1
reptiles	0	0	0	0	2	0	2
total	157	100	27	20	53	732	1089

Note: NISPs, based almost entirely on teeth and jaws except in the cases of BE1-S and BE2 which are based on all identifiable elements. PT-AB = Panganreang Tudea, levels A and B. PT-CD = Panganreang Tudea, levels C and D. BE1-H = Hooijer's identifications, and Musser's rodent identifications, from the excavation at Batu Ejaya 1 by Van Stein Callenfels. BE1-S = the identifications in the red-brown clay unit from the excavation by Mulvaney & Soejono (1970); *Sus celebensis* here includes several '*Sus* sp.' identifications. BE2 = Batu Ejaya 2. BB = Bola Batu. Musser (1987: 73) also reports having identified a *Crocidura rhoditis* specimen from one of Mulvaney & Soejono's excavations at Batu Ejaya.

At Batu Ejaya 1, Van Stein Callenfels (1938) found abundant decorated pottery throughout the levels he excavated, along with artefacts of bronze, and flaked and polished stone (Van Heekeren 1949: 93). He reburied most of the pottery, as Mulvaney & Soejono (1970) discovered during their re-excavation. Mulvaney & Soejono (1970) recovered charcoal, clearly associated with the pottery, in the red-brown clay beneath the levels disturbed by Van Stein Callenfels, and obtained a radiocarbon date of 920 ± 275 BP (ANU-392). This date was provenanced well below two middle Holocene radiocarbon dates, 4430 ± 50 BP (Wk-5464) and 4370 ± 70 BP (Wk-5465), on marine shell from Van Stein Callenfels' trench refill (Flavel 1997). The damage wreaked by Van Stein Callenfels' excavation on the stratigraphy could not account for this dating inversion. It looks very likely that decorated pottery had been buried into older habitation deposits for mortuary or other ritual purposes. In sum, the deposits excavated by Van Stein Callenfels would appear to span the period from about 4500 to 1000 BP, and the same chronology may be applied to the red-brown clay unit beneath his excavation.

Let us see whether the faunal succession established for the Maros karsts would apply to the south coast. When the middle to late Holocene assemblages (Panganreang Tudea layers A-B, and Batu Ejaya 1) are compared to the early Holocene layers C-D at Panganreang Tudea, we should find that the species sensitive to forest disturbance (*Anoa* and *Babyroussa*) decrease in relative frequency, while *S. celebensis* increases. The available data partly conform to expectations (see Table 4). *Anoa* identifications drop from 10% in the early Holocene assemblage, to less than 4% in the middle to late Holocene assemblages. However, the relative proportions of *Babyroussa* (12-17%) and *S. celebensis* (51-54%) hardly vary. If there had been a compensatory trend for the reduced anoa catch after the early Holocene, it would appear to have been the higher culling rates of monkeys in the middle to late Holocene.

The proportions of habitat suitable for *Babyroussa* and the disturbance-tolerant *S. celebensis*, in the vicinity of Panganreang Tudea and Batu Ejaya, probably remained fairly constant throughout much of the Holocene. Murids tell a similar story, as primary forest taxa (*L. meyeri*, *P. dominator* and *Taeromys* spp.) dominate compared to the disturbance-tolerant and disturbance-loving *Rattus* species (see Table 3). Panganreang Tudea and Batu Ejaya lie in a higher (c. 250 m above sea level) and drier location than Leang-Leang, which may explain the relatively reduced impact of hunting and forest clearance by humans. Very interestingly, the tendency for *S. celebensis* to account for approximately half of the identifications, as noted in the Maros Holocene assemblages, also holds on the peninsula's south coast.

The Batu Ejaya 2 shelter, excavated by Ian and Emily Glover in 1969, contained shallow deposits with geometric microliths, pottery and modern materials (including a 'modern' radiocarbon date) all jumbled together (Chapman 1981: 114). The scarcity of evidence of burning on the bone fragments, and their dominance by a wide range of rodents (see Table 3), suggest that a small carnivore (e.g. the brown palm civet, found among the remains) was a primary agent in depositing this assemblage (Simons 1997). The inclusion of deer, domesticates, and four *Rattus* specimens would be consistent with a predominantly late Holocene dating of the assemblage.

The last site to be considered in this section is Bola Batu, excavated to a depth of approximately 1.5 m by Van Heekeren (1949). This limestone shelter lies 191 m above

Table 4. Critical taxa in the four main lowland assemblages outside of Maros.

taxon	Panganreang Tudea layers C-D	Batu Ejaya 1 (Hooijer + Simons)	Panganreang Tudea layers A-B	Bola Batu
	early Holocene	middle to late Holocene		Holocene
Anoa sp.	10.0%	2.1%	4.5%	11.8%
Babyroussa	12.0%	12.8%	16.6%	33.5%
Sus celebensis	52.0%	51.0%	53.5%	36.2%
Macaca maura	2.0%	10.6%	8.9%	14.5%
small animals	24.0%	19.1%	16.6%	4.0%
introduced	0%	2.1%	0%	0.1%

Note: 'Small animals' includes all non-introduced taxa not included in the rows above.

sea level where a low range meets the coastal plain. The faunal set is diverse and very large (see Table 3), especially when we consider that it is based entirely on teeth and jaws. The rich cultural deposits included only slight evidence of late Holocene occupation in the form of eight earthenware sherds, a polished axe fragment, two iron scraps and 14 glazed ceramic sherds, mainly concentrated in the top 20 cm. The artefactual finds thus indicate a predominantly early to middle Holocene antiquity for the cultural deposits, as also suggested by the faunal assemblage's high proportion of *Anoa* of circa 12% (see Table 4). The single identification of a dog (see Table 3) would represent a recent animal, according to Hooijer (1950: 145), despite the lack of information volunteered on the specimen's stratigraphic position. The dominance of primary forest murids (*Paruromys dominator*, *Maxomys musschenbroekii* and *Taeromys punicans*) rather than the disturbance-tolerant *Rattus xanthurus* (see Table 3) points to substantial stands of forest in the vicinity. Monkeys appear proportionally more common than in any other assemblage considered so far (see Table 4).

One feature of the Bola Batu assemblage is the approximately equal occurrence of *Babyroussa* and *S. celebensis* identifications. Although the same observation applies to Leang Burung 2 (see Table 1), this need not imply a Pleistocene component at Bola Batu. As we shall see, a comparable occurrence of *Babyroussa* and *S. celebensis* is also a characteristic of the Lamoncong assemblages in the remote interior of the peninsula. Hence Bola Batu could be seen as geographically transitional between the general coastal pattern, where *S. celebensis* was taken much more often than *Babyroussa* throughout the Holocene, and inland environments where both pigs used to be hunted with equivalent success.

6. THE LAMONCONG SITES

The major excavation of sites in the Lamoncong area was undertaken in 1902 by Paul and Fritz Sarasin (1905a, b). Then, in 1933, Van Stein Callenfels, Noone and Cense excavated Leang Tomatoa Kacicang, a rockshelter north of Cani (Van Heekeren 1972: 109), the label Hooijer (1950) assigned to the assemblage. In July 2003, Bulbeck had the opportunity to inspect the artefactual assemblages excavated by the Sarasin cousins from their four Lamoncong sites and curated at the Museum der Kulturen in Basel, Switzerland. All four sites show evidence of habitation over several millennia but it is possible to place them in the approximate chronological sequence of Leang Ululeba (the earliest), Leang Balisao, Lower Cakondo and Upper Cakondo. This sequence is based on their presence or absence of (a) non-durable organic materials such as bast knots, (b) durable but relatively recent artefacts such as ceramics and iron, and (c) Maros points and backed microliths, and their relative proportions, using the chronology given by Bulbeck et al. (2000: 108) whereby backed lithics but not Maros points continued to be produced after c. 3500 BP. The Tomatoa Kacicang assemblage would fall in the same age bracket as Leang Balisao and Lower Cakondo, based on the information of its site contents gleaned by Bulbeck et al. (2000: 73-75) from the brief published accounts of the excavated materials (Table 5).

Leang Ululeba yielded a typically middle Holocene, preceramic assemblage by the standards of other South Sulawesi Toalean sites, with Maros points predominating over backed lithics (cf. Bulbeck et al. 2000: 95). The only hints of late Holocene occupation are a wood fragment, which is not clearly an artefact, and a polished stone disc which could also be classified as a backed stone artefact as it bears steep bipolar retouch on all of its margins. Leang Balisao, Lower Cakondo, and apparently Tomatoa Kacicang would appear to have been first occupied during the middle Holocene, but occupation then continued until the last millennium CE. This time span is indicated by the range of contents which include Maros points but also much more recent materials such as glazed and high-fired ceramics (or glass in the case of Tomatoa Kacicang) and non-durable organic items. The Upper Cakondo contents would appear to be entirely late Holocene, as there is an abundance of backed lithics but no Maros points, and a full suite of organic finds (Table 5). The approximate chronology of the Lamoncong sites allows us to test our faunal succession model in the remote interior hinterland of South Sulawesi, although it should be noted that the anoa and water-buffalo counts from Tomatoa Kacicang include post-cranial as well as cranial identifications, and so are exaggerated to some degree (Table 6).

Table 5. Cultural contents of the Lamoncong sites in descending chronological order.

identification	Leang Ululeba	Leang Balisao	Tomatoa Kacicang	Lower Cakondo	Upper Cakondo
Maros points	5	2	X	2	0
bone points	2	1	X	1	6
bore tooth artefacts	3	2	—?	1	15
backed stone artefacts	2	1	—?	5	15
polished stone artefacts	1	1	X	0	2
earthenware sherds	0	11	X	11	8
iron artefacts	0	1	X	1	0
glazed ceramic sherds	0	5	(glass)	3	1
wood fragments	1	0	—?	3	1
nut fragments	0	2	—?	4	1
bast knots	0	1	—?	6	3

Note: Counts for the material cultural contents of the sites excavated by the Sarasins are preliminary, and exclude all lithics except for the typologically most distinctive. Only presence/absence data are available for Tomatoa Kacicang.

The steady proportional decrease in anoa identifications over time (allowing for some inflation of the Tomatoa Kacicang count) is in agreement with the pattern observed in the South Sulawesi lowlands. On the other hand, clear evidence is lacking for a switch from hunting Babirusa to culling *S. celebensis*, even though we know the Babirusa was locally extinct by ethnographic times. Arguably, however, the coarseness of our available chronological framework is disguising a switch between these species that did in fact occur over the last millennium or two. When we consider the three assemblages with known late Holocene introductions – domestic animals and deer – these are the same faunal complements that show a proportional increase in Babirusa compared to the Celebes boar. Tomatoa Kacicang particularly stands out in this regard, but Leang Balisao and Lower Cakondo support the same scenario (Table 6). Therefore, the differences between the Leang Ululeba and Upper Cakondo assemblages might reflect middle to late Holocene trends in hunter-gatherer subsistence patterns in the Lamoncong interior, whereas the distinctive features of the other three assemblages could indicate subsistence changes in recent times as an accompaniment to the local adoption of a food-producing economy. In that case, the commensal relationship between middle to late Holocene Toaleans and *S. celebensis*, suggested for the lowland sites, would also have been established in Lamoncong, but specifically with settled farming groups.

The Upper Cakondo fauna diverges from the Ululeba fauna in its higher proportion of the smaller cuscus compared to the Bear Cuscus, its inclusion of bats and squirrels to the same level as monkeys, and its greater number of rodents (Table 6). These differences are all consistent with a transition to smaller forest prey in response to the

Table 6. Faunal identifications from the Lamoncong sites.

identification	Leang Ululeba	Leang Balisao	Tomatoa Kacicang	Lower Cakondo	Upper Cakondo
Anoa sp.	10 (25.0%)	3 (18.8%)	14 (28%)	4 (12.9%)	5 (6.6%)
Babyroussa sp.	4 (10.0%)	1 (6.3%)	—	3 (9.7%)	9 (11.8%)
Sus celebensis	4 (10.0%)	3 (18.8%)	26 (52%)	5 (16.1%)	11 (14.5%)
Macrogalidia (?)	2 (5.0%)	—	—	—	1 (1.3%)
Ailurops ursinus	6 (15.0%)	1 (6.3%)	—	2 (6.5%)	5 (6.6%)
Strigocuscus celebensis	3 (7.5%)	2 (12.5%)	—	2 (6.5%)	15 (19.7%)
Macaca maura	8 (20.0%)	3 (18.8%)	1 (2%)	4 (12.9%)	10 (13.2%)
Scuiridae	—	—	—	—	1 (1.3%)
Megachiroptera	1 (2.5%)	—	—	—	9 (11.8%)
Lemomys meyeri	—	—	—	3 (9.7%)	3 (3.9%)
other murids ('*Rattus*')	1 (2.5%)	—	—	5 (16.1%)	6 (7.9%)
Cervus timorensis	—	2 (12.5%)	—	—	—
Canis familiaris	—	—	3 (6%)	1 (3.2%)	—
Bubalus bubalis	—	1 (6.3%)	5 (10%)	—	—
Gallus gallus	—	—	—	2 (6.5%)	—
Sus scrofa	—	—	1 (2%)	—	—
Python reticulatus	1 (2.5%)	—	—	—	1 (1.3%)
total	40	16	50	31	76

Note: MNIs for all sites except Tomatao Kacicang (NISPs). Identifications based mainly on teeth and jaws. Upper Cakondo includes Sarasin & Sarasin's (1905a) 'small Upper Cakondo shelter'.

toll exacted on medium-sized arboreal mammals up to and including the middle Holocene. Certainly, the differences are hard to attribute to late Holocene improvements in the technology to take arboreal and flying mammals. There is no evidence for blowpipes or bow-and-arrow technology amongst the ethnographically recorded inhabitants of Lamoncong, either as recounted by Sarasin and Sarasin (1905b) or as observed by Bulbeck in his inspection of the Lamoncong ethnographic collection at Basel's Museum der Kulturen. The Sarasins were particularly drawn to Lamoncong to study the locality's 'forest people' or *Toale*', part-time horticulturalists who grew rice and maize, even if they built their shacks in certain limestone shelters other than those excavated by the Sarasins (Sarasin & Sarasin 1905b: 272-274). While the *Toale*' ethnographic collection includes wooden clubs and bamboo lances, consistent with other indications that the *Toale*' maintained access to relatively pristine forests in the highlands surrounding the Lamoncong valley, it also has wooden digging sticks suitable for use in the *Toale*' gardens. The differences in the faunal signature between Upper Cakondo and the three middle to late Holocene sites, especially Tomatoa Kacicang, may be functional – Upper Cakondo may have served purely as a campsite on hunting expeditions, while the other three sites may have accommodated residential families – and/or chronological, if in fact Upper Cakondo had been essentially abandoned once the *Toale*' adopted farming practices.

7. DISCUSSION AND CONCLUSIONS

This article has, for the first time, erected a chronological framework to cover the faunal assemblages reported from rockshelter excavations in the South Sulawesi peninsula. We have divided the assemblages from the Maros karsts into Late Pleistocene, early Holocene, middle Holocene and late Holocene assemblages, based on radiocarbon dates and the artefactual materials. With less confidence we have sorted the assemblages near the south coast into early Holocene and middle to late Holocene assemblages, based on the associated artefacts as much as on the radiocarbon dates. We have suggested that Bola Batu, near the eastern coastal plain, could be a pan-Holocene assemblage. Finally, based on their artefactual contents, we have ordered the Lamoncong assemblages within a chronological framework of middle to late Holocene age.

Among Sulawesi's large mammals, the anoa is highly sensitive to disturbance of its forested habitat, and the lowland and highland sites demonstrate this point in different ways. The anoa has a 12% or lower representation in all lowland assemblages (treating Leang Burung 2 as a whole), whereas its representation lies above 12% in four of the five Lamoncong sets. Further, the frequency of anoa diminished dramatically over time in the lowlands, whereas the same chronological decrease occurred later and perhaps more slowly at Lamoncong. The Leang Burung 2 assemblage (see Table 1) strongly suggests that the arrival of hunters into a region quickly spelled the demise of the local populations of anoa, except those able to take refuge in mountainous, inaccessible habitats visited only occasionally by hunting posses.

The suids Babirusa and *Sus celebensis* also conform to a geographical dichotomy. In the Maros karsts and on the south coast, Babirusa outnumber *S. celebensis* identifications only in the earliest reported assemblage (Level I at Leang Burung 2); otherwise, *S. celebensis* is clearly dominant. Indeed the Holocene faunal assemblages from Maros and the south coast suggest a mutualistic relationship between Toaleans and *S. celebensis*, the only large endemic mammal that thrives on disturbed habitats. In contrast, the two suids show an approximately equal frequency at Bola Batu and in all the Lamoncong assemblages bar those which include domestic fauna.

Our study supports the suggestion that humans were transporting mammals between the Indonesian islands by the middle Holocene, before the appearance of pottery or of those domesticates that can be associated with Austronesian speakers (Groves 1985; cf. Bellwood 1997). Deer and *R. tanezumi* seem to have arrived at Maros by 4000 BP. The distribution of *S. celebensis* and its hybrids in Indonesia and New Guinea (Groves 1985: Fig. 2) would also be best explained in terms of augmenting local hunting grounds prior to the dispersal of domesticated *S. scrofa*. Sulawesi could act as both recipient and donor as it combined open niches (allowing successful introductions) with a relative diversity of endemic forms that could be carried elsewhere. The Leang Balisao assemblage registers the arrival of the deer in Lamoncong by the middle to late Holocene, while the late Holocene Leang Karassa assemblage may reflect local proliferation of deer populations, even at the expense of the Celebes pig. These points could suggest that the deer's successful dispersal substantially depended on clearances wrought by humans in the forests, or on hunters' extirpation of less elusive competitors such as the Babirusa and/or anoa.

Monkeys occur in virtually every assemblage. Their absence from the lower spits of Leang Burung 1 Trench A can be attributed to small sample size (n=39), but their absence from Layer I at Leang Burung 2 may reflect early colonists' focus on easier prey. Monkeys appear to have always been a minor element in Maros (0-6%) but an important element at Bola Batu, the middle to late Holocene south coast sites, and the Lamoncong sites excavated by the Sarasins (9-20%). Other arboreal mammals, notably the phalangers, can occur commonly in early assemblages with few monkeys (Leang Burung 2, Panganreang Tudea Layers C-D) and in later assemblages with many monkeys (the Sarasins' Lamoncong sites). It is difficult to make particular sense of these observations, apart from the obvious inference that hunting arboreal mammals would have required a fair modicum of skill and substantial stands of accessible forest. For instance, there is no obvious match-up between our data and any likely date for the introduction of the blowpipe, a traditional armament employed by South Sulawesi armies (Wolhoff & Abdurrahim 1959: 25), but of limited ethnographic use in Sulawesi for hunting (see Jett 1970; Sarasin & Sarasin 1905b).

Murids occur in every assemblage except the two smallest Lamoncong complements. Murids can account for between 30% and 70% of identifications, as in the upper layers at Leang Burung 2 and at Batu Ejaya 2, although in both cases civets may be largely responsible. A similarly high frequency characterises the Lower Cakondo assemblage, involving *L. meyeri* and possibly other primary forest denizens which the Sarasins lumped under *Rattus*. In those assemblages where we can rely on Musser's expert identifications, non-*Rattus* species appear to predominate over the disturbance-tolerant *Rattus* species, with the possible exception of the late Holocene assemblage from Leang Karassa. The generally low rate of certified *Rattus* specimens may suggest that the commensal relationship struck up with the Celebes pig buffered the Toaleans against descending the food chain too severely, at least until substantial habitat destruction at the hands of transmigrant farmers ultimately handed Toaleans an offer they couldn't refuse: to join the farmers. Lamoncong, inhabited by *Toale'* people who had adopted farming practices and even their language from their culturally dominant Bugis neighbours, whilst retaining various traditional Toalean practices in an adapted form (Sarasin & Sarasin 1905: 272-280), constitutes an ethnographically recorded demonstration of the final gasps of the South Sulawesi faunal succession.

In summary, the empirical data reviewed here suggest a general model for faunal succession with two extreme expressions. 1) The Leang-Leang sequence indicates rapid decline and subsequent extirpation of local anoa and Babirusa; extensive deforestation by the early Holocene reducing arboreal catch (always 6% or less of the identifications), but still supporting forest rats; and the development of a commensal or mutualistic relationship between the Toaleans and *S. celebensis*. The shift away from large mammals of the primary forest had apparently occurred by 30,000 years ago, but the focus on eclectic large mammals and smaller forest animals lasted until the very late Holocene. 2) In contrast to the catastrophic shift from large primary-forest mammals at Maros, the transition in the highland valley (Lamoncong) sequence appears delayed and drawn out. Anoa could evidently take refuge in inaccessible swathes of mountain forest, whereas the Babirusa (less suited to dissected terrain) finally succumbed to extirpation within the peninsula. Arboreal game remained abundant in the valley copses and the forests along the ranges until rampant forest clearance belatedly came to pass, with a concomitant increase in *S. celebensis* predation. The south coast sequence leans towards the Leang-Leang sequence, while Bola Batu more resembles the Sarasins' Lamoncong sites. Deer and domesticated animals may have spread across the peninsula together, both dependent on human alteration of the landscape, even though the means by which indigenous hunter-gatherers could have accessed these new resources would have contrasted markedly.

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