FIELDIANA

Zoology

NEW SERIES, NO. 42

The Contribution of Archaeology to the Zoogeography of Borneo, with the First Record of a Wild Canid of Early Holocene Age

Earl of Cranbrook

A Contribution in Celebration of the Distinguished Scholarship of Robert F. Inger on the Occasion of His Sixty-Fifth Birthday

March 31, 1988
Publication 1385

PUBLISHED BY FIELD MUSEUM OF NATURAL HISTORY

Information for Contributors to Fieldiana

General: *Fieldiana* is primarily a journal for Field Museum staff members and research associates, although manuscripts from nonaffiliated authors may be considered as space permits. The Journal carries a page charge of $65 per printed page or fraction thereof. Contributions from staff, research associates, and invited authors will be considered for publication regardless of ability to pay page charges, but the full charge is mandatory for nonaffiliated authors of unsolicited manuscripts. Payment of at least 50% of page charges qualifies a paper for expedited processing, which reduces the publication time.

Manuscripts should be submitted to Dr. James S. Ashe, Scientific Editor, *Fieldiana*, Field Museum of Natural History, Chicago, Illinois 60605-2496, USA. Three complete copies of the text (including title page and abstract) and of the illustrations should be submitted (one original copy plus two review copies which may be machine copies). No manuscripts will be considered for publication or submitted to reviewers before all materials are complete and in the hands of the Scientific Editor.

Text: Manuscripts must be typewritten double-spaced on standard-weight, 8½- by 11-inch paper with wide margins on all four sides. For papers longer than 100 manuscript pages, authors are requested to submit a "Table of Contents," a "List of Illustrations," and a "List of Tables." In most cases, the text should be preceded by an "Abstract" and should conclude with "Acknowledgments" (if any) and "Literature Cited." All measurements should be in the metric system. The format and style of headings should follow those of recent issues of *Fieldiana*. For more detailed style information, see *The Chicago Manual of Style* (13th ed.), published by The University of Chicago Press, and also recent issues of *Fieldiana*.

In "Literature Cited," authors are encouraged to give journal and book titles in full. Where abbreviations are desirable (e.g., in citation of synonymies), authors *consistently* should follow *Botanico-Periodicum-Huntianum* and *TL-2 Taxonomic Literature* by F. A. Stafleu & R. S. Cowan (1976 *et seq.*) (botanical papers) or *Serial Sources for the Biosis Data Base* (1983) published by the BioSciences Information Service.

References should be typed in the following form:

Croat, T. B. 1978. Flora of Barro Colorado Island. Stanford University Press, Stanford, Calif., 943 pp.

Grubb, P. J., J. R. Lloyd, and T. D. Pennington. 1963. A comparison of montane and lowland rain forest in Ecuador. I. The forest structure, physiognomy, and floristics. Journal of Ecology, **51:** 567–601.

Langdon, E. J. M. 1979. Yagé among the Siona: Cultural patterns in visions, pp. 63–80. *In* Browman, D. L., and R. A. Schwarz, eds., Spirits, Shamans, and Stars. Mouton Publishers, The Hague, Netherlands.

Murra, J. 1946. The historic tribes of Ecuador, pp. 785–821. *In* Steward, J. H., ed., Handbook of South American Indians. Vol. 2, The Andean Civilizations. Bulletin 143, Bureau of American Ethnology, Smithsonian Institution, Washington, D.C.

Stolze, R. G. 1981. Ferns and fern allies of Guatemala. Part II. Polypodiaceae. Fieldiana: Botany, n.s., **6:** 1–522.

Illustrations: Illustrations are referred to in the text as "figures" (not as "plates"). Figures must be accompanied by some indication of scale, normally a reference bar. Statements in figure captions alone, such as "× 0.8," are not acceptable. Captions should be typed double-spaced and consecutively. See recent issues of *Fieldiana* for details of style.

Figures as submitted should, whenever practicable, be 8½ by 11 inches (22 × 28 cm) and may not exceed 11½ by 16½ inches (30 × 42 cm). Illustrations should be mounted on boards in the arrangement you wish to obtain in the printed work. This original set should be suitable for transmission to the printer as follows: Pen and ink drawings may be originals (preferred) or photostats; shaded drawings should be originals, but within the size limitation; and photostats should be high-quality, glossy, black and white prints. All illustrations should be marked on the reverse with author's name, figure number(s), and "top." Original illustrations will be returned to the author upon publication unless otherwise specified. Authors who wish to publish figures that require costly special paper or color reproduction must make prior arrangements with the Scientific Editor.

Page Proofs: *Fieldiana* employs a two-step correction system. Each author will normally receive a copy of the edited manuscript on which deletions, additions, and changes can be made and queries answered. Only one set of page proofs will be sent. All desired corrections of type must be made on the single set of page proofs. Changes in page proofs (as opposed to corrections) are very expensive. Author-generated changes in page proofs can only be made if the author agrees in advance to pay for them.

FIELDIANA

Zoology

NEW SERIES, NO. 42

The Contribution of Archaeology to the Zoogeography of Borneo, with the First Record of a Wild Canid of Early Holocene Age

Earl of Cranbrook

Great Glemham House
Saxmundham
Suffolk, IP17 1LP
England

A Contribution in Celebration of the Distinguished Scholarship of Robert F. Inger on the Occasion of His Sixty-Fifth Birthday

Accepted for publication March 31, 1986
March 31, 1988
Publication 1385

PUBLISHED BY FIELD MUSEUM OF NATURAL HISTORY

ISSN 0015-0754
PRINTED IN THE UNITED STATES OF AMERICA

Table of Contents

List of Illustrations

List of Tables

The Contribution of Archaeology to the Zoogeography of Borneo, with the First Record of a Wild Canid of Early Holocene Age

Abstract

The extant fauna of Borneo lacks several large mammal species that are widespread elsewhere in the Sunda region. Archaeological research in Borneo has already found remains of three of these in late Upper Pleistocene or Holocene contexts: the tiger, *Panthera tigris*; Malay tapir, *Tapirus indicus*; and Javan rhinoceros, *Rhinoceros sondaicus*. Evidence of a fourth, the dhole, *Cuon alpinus*, is now reported from a midden dated about 10,000 B.P. in Agop Sarapad, Madai caves, Sabah. Extinction of these species evidently occurred within the last few thousand years and is attributed to failure to adapt to the environmental consequences of post-glacial climatic changes.

Introduction

In his monograph on the amphibians of Borneo, Robert Inger anticipated that new species would be discovered but that these additions would not materially affect conclusions on the geographical relations of the fauna (Inger, 1966, p. 357). Both predictions have since come true. Inger himself has subsequently described new Bornean taxa (Inger & Frogner, 1979; Inger & Gritis, 1983), and Dring (1983a,b) has added others. Yet the overall picture of amphibian zoogeography in the region remains fundamentally unaltered. The fauna undoubtedly originated from continental Asia and shows little affinity with Celebes, only a short distance to the west, or with the Philippine Islands. There has, however, been a significant local radiation at lower taxonomic levels, recognizable in an assemblage of species confined to the Sundaic region; that is, the islands of the Sunda shelf and the Malay Peninsula south of about 10°N latitude. Species endemic to Borneo (comprising about 40% of the island's amphibian fauna) represent a special group among the Sundaic assemblage. Of the nonendemics, many species (about 80%) also occur in Sumatra, somewhat fewer in Peninsular Malaysia (formerly Malaya), and only about 45% in Java.

Similar patterns characterize the zoogeography of the other terrestrial vertebrate classes. Thus, among the mammals, the fauna has clearly originated from continental Southeast Asia, modified by a significant radiation within the Sunda region. Endemism is high in Borneo, with 37 (29%) of 129 species of land mammals (i.e., excluding bats and marine mammals) currently being recognized as endemics. Of the 92 nonendemic species in Borneo, 87 (95%) also occur in Sumatra, 80 (87%) in Peninsular Malaysia, and only 44 (49%) in Java (data from Medway, 1977a, and Zon, 1979).

Within the Sunda region, anomalous distributions can be recognized, in several cases involving large mammal species which might be expected most easily to cross geographic barriers. In contemporary Borneo, notable absentees are tiger, *Panthera tigris*, at present in Peninsular Malaysia (PM), Sumatra (S), and Java (J); leopard, *Panthera pardus* (PM, ?S, J); wild dog or dhole, *Cuon alpinus* (PM, S, J); Eurasian wild pig, *Sus scrofa* (PM, S); Javan rhinoceros, *Rhinoceros sondaicus* (PM, S, J); Malay tapir, *Tapirus indicus* (PM, S); and serow, *Capricornis sumatraensis* (PM, S). Among smaller mammals, only one giant squirrel of the genus *Ratufa* occurs (i.e., *R. affinis*), the widespread *R. bicolor* (PM, S, J) being absent. Also lacking are the bamboo rat, *Rhizomys sumatrensis* (PM, S), and the brush-tailed porcupine, *Atherurus macrourus* (PM, S). The banteng, *Bos sondaicus,* the only wild cattle in Borneo, is also native in Java, but is absent from Sumatra and Peninsular Malaysia. Like the ferret badger, *Melogale orientalis* (J), *B. sondaicus* occurs in parts of mainland continental Southeast Asia, but only in Java and Borneo on the Sunda shelf. These two distributions, coupled with the occurrence in Borneo of a species of long-nosed ground squirrel, *Dremomys,* and a smooth-tailed treeshrew, *Dendrogale* (genera found elsewhere only on continental Southeast Asia), led Chasen (1940, pp. xi–xv) to propose a limited colonization of the Sunda region by "eastern drift" from the Indochinese region. He also envisaged a "western drift from the continent by way of Sumatra" to explain the absence of the Eurasian wild pig, tiger, and dhole from Borneo.

Archaeological evidence shows that neither postulate is in fact required. It has long been known that the Pleistocene mammal fauna of Java included species now extinct on that island but surviving elsewhere in the Sunda region; for example, siamang, *Hylobates syndactylus*; orangutan, *Pongo pygmaeus*; Malay bear, *Helarctos malayanus*; elephant, *Elephas maximus*; bearded pig, *Sus barbatus*; tapir; and bamboo rat. In Sumatra, banteng remains have been found in cave deposits attributed either to a Middle Pleistocene interglacial or to the early Holocene (data reviewed by Hooijer, 1975, and Vos, 1983). More recently, excavations by the Sarawak Museum in the 1950–1960s and the Sabah Museum in the early 1980s have revealed the former presence in Borneo of four of the large mammals missing from the modern fauna: (1) the tiger, represented at Niah cave, Sarawak (see Harrisson, 1972, and bibliography therein), by a deciduous canine from Neolithic levels (Hooijer, 1963); (2) the tapir, represented at Niah by a dozen pieces ranging in date from late Upper Pleistocene to about 8000 B.P. (Medway, 1960); (3) the Javan rhinoceros represented by a deciduous molar and a fragment of ulna in a midden dated at about 10,000 B.P. (designated "MAD 2" by the excavator) in the Agop Sarapad mouth of Madai caves, Sabah (Bellwood, 1984), and (identified with lessened confidence) by a left ectocuneiform and a fragmentary lateral proximal phalanx from depths at Niah attributable to an early Holocene age (see Cranbrook, 1986, for details of these rhinoceros finds); and (4) the dhole, documented below. The problem in these cases is no longer to elucidate routes or barriers to the colonization of Borneo, but rather to explain local extinctions within the past few thousands of years.

Canid Remains from Agop Sarapad, Madai Caves, Sabah

The excavations were carried out in 1980 in the caves at Madai near Kunak, Sabah, 118°08′E, 4°44′N, by staff of the Sabah Museum in association with Dr. Peter Bellwood (Bellwood, 1984, fig. 1; Bellwood, unpubl. data). Animal remains, including vertebrate teeth and bones, were separately bagged from each layer and later examined by myself in the museum premises at Kota Kinabalu. Notes made at the time have been worked into a general report on animal remains, which has been placed on file in the museum. It is planned to publish an edited version as part of the excavator's final report (Bellwood, unpubl. data). Specimens appearing to be of particular interest (and therefore brought to England for further study) included the two described below. Both derive from the Agop Sarapad mouth (MAD 2), Madai caves, square H1, layer 2, at 5–10 cm. This provenance is firmly within the MAD 2 riverine shell midden, ^{14}C-dated to about 10,000 B.P. (Bellwood, pers. comm.). The specimens are illustrated in Figure 1. Both have been returned to the Sabah Museum, Kota Kinabalu, Malaysia, for safekeeping. A cast

FIG. 1. The dhole calcaneum and canine tooth from Agop Sarapad, Madai caves, Sabah. Scale is in centimeters.

TABLE 1. Measurements of the left calcaneum of selected specimens of canid species.

Item*	Sex	BM(NH) reg. no.	Measurements† (mm) Median length	Maximum length	Maximum depth	Maximum breadth	Minimum breadth (tuber)
Archaeological specimen							
Agop Sarapad, Madai	...	M42838‡	43	45.5	18.3	17.6	7.2
Malaysian pariah-type dog							
("Manggis")	F	71.753	35.5	36.6	15.2	14.3	6.0
Cuon alpinus javanicus	M	1888.2.5.22	41.8	43.9	18.6	16.8	7.4
Cuon alpinus dukhunensis	F	1936.4.8.1	43.7	45.2	19.0	18.8	8.5
Canis familiaris dingo	?	1954.11.15.1	40.8	43.5	17.5	16.4	7.3
Canis familiaris dingo	F	1868.4.14.1	46.2	47.8	19.2	17.3	6.9
Canis lupus	?	1937.2.10.2	49.5	52.2	21.2	22.0	8.6
Canis aureus anthus	?	816c	38	40.8	14.4	15.5	5.6

* All examples are full-grown adults in the collection of the British Museum (Natural History).

† Measurements were taken as follows: median length—from the tendinial groove on the superior face of the tuber calcanei to the inferior facet of the body; maximum length—the greatest length measured by calipers positioned as shown in Figure 2; maximum depth—the greatest distance between the anterior and posterior surfaces measured at the base of the tuber; maximum breadth—the breadth from the median edge of the sustentaculum tali to a point opposite it on the lateral surface on the body of the calcaneum; minimum breadth (tuber)—the mediolateral breadth of the tuber calcanei at its narrowest point.

‡ A cast. The original has been returned to the Sabah Museum.

of the calcaneum has been made by the British Museum (Natural History), where it is held in the Palaeontology Department under the registration number M 42838.

The Specimens

RIGHT LOWER CANINE—Damaged, now consisting only of the root and dentine core of the crown. A very small area of enamel remains on the outer (labial) face at the base of the crown, shiny dark brown in color. This small piece of enamel is adequate to provide an orientation point from which the root can be measured, but is of no value for the specific identification of the tooth.

Measurements are as follows:

Root, length .... 23.3 mm
Root, maximum breadth in anteroposterior (= mesiodistal) plane .... 9.7 mm
Root, maximum breadth in lateral plane .... 6.5 mm

LEFT CALCANEUM—Complete and undamaged. This bone is colored dark brown. It is indisputably attributable to a member of the dog family, Canidae. Among likely species of Asian wild dogs, comparative measurements (table 1) show that this calcaneum is slightly larger in principal dimensions than its homologue in the skeleton of an adult male dhole of the Javan subspecies, *Cuon alpinus javanicus*, but smaller than that of an adult female of the Indian subspecies, *C. a. dukhunensis*. It is distinctly smaller than wolf, *Canis lupus*, and larger than jackal, *Canis aureus* (a member of the African race, *C. aureus anthus*, being the only available adult example). Neither is therefore indicated by the measurements. The discovery of either of these two *Canis* species in Borneo would represent a large extension of known range, historic or prehistoric. Both are thus best excluded from consideration.

There remains the possibility that a type of domestic dog *Canis "familiaris"* is represented. Available for comparison is the skeleton of a female of the primitive Malaysian pariah-type breed of domestic dog, an individual described and pictured by Medway (1977b, plate 3, 'Manggis'), now deposited at the British Museum (Natural History); this is markedly smaller. Examples of Australian dingo in the BM(NH) collections show wide variation in size; measurements of the calcanea of two adults bracket the archaeological specimen.

Examination of a wider selection of calcanea of dholes and dingos does not reveal any nonmetric character that serves to distinguish the species. Features investigated included the relative dimensions of the tuber calcanei, the shape and angle of the sustentaculum tali, the angle of the ventral face of the process at the anterior base of the tuber, and the size and shape of the small facet at the mesioventral corner of the anterior face of the body

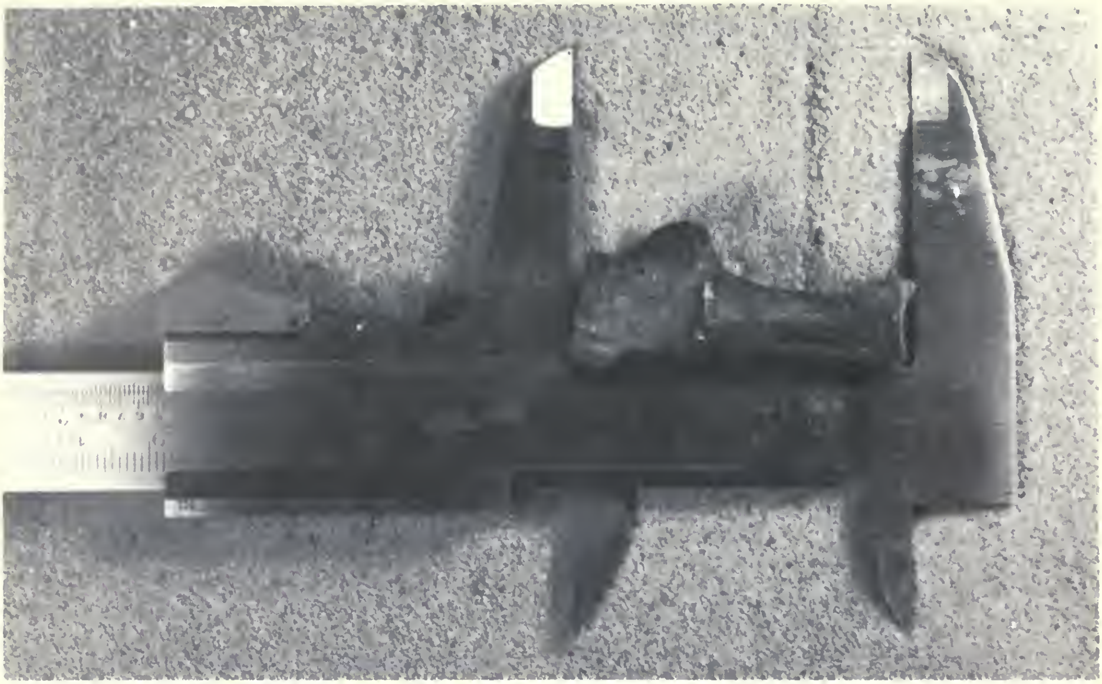

FIG. 2. The calcaneum positioned in calipers to measure maximum length (table 1).

of the calcaneum (terminology following Hughes & Dransfield, 1953). In no case was there any species-specific difference discernible in the samples available. I conclude that, on morphology alone, the specimen could be attributed to a dhole or to a primitive, dingo-like form of domestic dog. Arguments for a more positive identification must be based on nonmorphometric grounds.

Discussion

Identification of the Specimens

On the one hand, the dog was among the first of the mammals to be domesticated. In Europe and the Near East, remains attributed to dogs, rather than wolves, appear in association with Epipaleolithic or Mesolithic cultures of early postglacial age. Dates suggested for the pioneer successes in domestication range from 12,000 B.P. (Davis & Valla, 1978) to 14,000 B.P. (Nobis, 1979).

On the other hand, no such early dates have been established in Southeast Asia. In Borneo, remains of undoubtedly domesticated dogs have been found in archaeological contexts in other caves, but in none have cultural associations indicated an age earlier than Neolithic, at the oldest (Medway, 1977b). In Thailand prehistoric sites have produced domestic dog bones dating back to 3500 B.C. (Higham et al., 1980), a period considerably less ancient than the Agop Sarapad midden.

Relevant evidence is the lack of other signs of the presence of domestic dog at these sites. While examining the bone from Agop Sarapad (and also the much larger quantity from deep levels at Niah), I have looked for the distinctive marks of gnawing by carnivores and found none. These middens originated as the food remains of human cave visitors. If contemporary man had been accompanied by domestic dogs, at least some of the bones must have been gnawed. I conclude that the most plausible identification for the two archaeological specimens is a wild dog, which itself was perhaps the quarry of man. On the grounds of size and zoogeography, the dhole is indicated.

Intriguingly, as for tiger (Gersi, 1975) and tapir (Medway, 1977a), anecdotal accounts exist of the presence of the dhole in Borneo in historic times. Hose (1893, p. 26) included Borneo in the range of the species (under the name *Cyon rutilans*), commenting: "This wild dog must be very rare in Borneo. I have constantly heard native accounts of it, but I have never seen a specimen." Later, recounting a trip to Batu Bukit Song, Sarawak, Hose (1929, p. 144) reported sighting a "pair of wild dogs . . . they had been eating the remains of a young wild pig, but before we had time to get more than a glimpse of them they were away." At no time in the history of zoological collection has a specimen been taken. Hose's record was not admitted by subsequent authors, including E. Banks and F. N. Chasen (see Chasen, 1940, p. 93), both of whom had much field experience in the region.

Post-Pleistocene Extinctions in Borneo

The complete list of 58 mammal species identified in the excavations at Niah, including domestic dog and goat but excluding the Javan rhinoceros (at that time unrecognized), has been published elsewhere (Medway, 1979, table 2). The total from Madai is smaller (Cranbrook, unpubl. ms. deposited at Sabah Museum, Kota Kinabalu). Both lists serve to confirm that the mammal fauna at the threshold of the Holocene era was very similar to that of present-day Borneo.

The deepest levels at Niah yielded remains of one totally vanished mammal, the giant pangolin, *Manis palaeojavanica* (Hooijer, 1960a), but this apparently did not survive into the Holocene era. The early Holocene fauna of Borneo presumably included the mammals already mentioned (tiger, dhole, tapir, and Javan rhinoceros) which have since become locally extinct. Over the same period, other species, which persist in modern Borneo, have undergone metrical changes. Thus, there has been a decline in tooth size among orangutans (Hooijer, 1960b) and monkeys of the genera *Presbytis* (including subgenus *Trachypithecus*) and *Macaca* (Hooijer, 1962). Among two species of giant rats, *Rattus sabanus* and *R. muelleri,* there have been changes both in the size and the relative dimensions of the teeth (Medway, 1964). Larger body size among the prehistoric populations is indicated by the dimensions of limb and foot bones of Sumatran rhinoceroses, *Dicerorhinus sumatrensis* (Cranbrook, 1986), and barking deer, *Muntiacus muntjak* (Medway, 1959).

The same archaeological studies show that man was present throughout the period concerned. Yet, as I have argued elsewhere (Medway, 1979), there are no grounds to suggest that direct or indirect impacts of human activity contributed to evolutionary changes or to the extinction of any species before the advent of the shotgun. Explanations must be sought in natural ecological processes.

Advances in palaeogeographical research have improved our understanding of events in the region during the Cenozoic and subsequently. The antiquity of the Makassar Strait is confirmed, although it is now recognized that Celebes has a complex tectonic origin (Audley-Charles, 1981). During the Pleistocene there were large extensions in the exposure of subaerial land of the Sunda shelf associated with glacial episodes, as summarized by Inger (1966) from earlier sources. It is also known that these were accompanied by climatic changes sufficient, for instance, to cap Mt. Kinabalu with permanent ice (Koopmans & Stauffer, 1967). It seems that present-day conditions in the Sundaic region are atypical of the Quaternary as a whole, with sea level and the upper forest limit on mountains exceptionally high, average temperatures close to maximum Quaternary values, and the climate at or near its wettest (Whitmore, 1981). A change from cooler, drier, and more seasonal conditions apparently took place rather rapidly in the first millenia of the Holocene, accompanied by rising sea levels which reached a maximum of at least 6 m above present shorelines about 5000 B.P. (Haile, 1971).

The cooler and more seasonal climate of Pleistocene glacial periods, including the last, which immediately preceded the Holocene intermission, is presumed to have favored the development of a mosaic of forest broken by open gaps and glades. Under such conditions, the forest-edge facies must have been extensive, with abundant browse accessible to ground-dwelling ungulates. Following the change to a warmer and wetter postglacial climate, the open spaces would have been invaded by closed forest. Mature tropical evergreen rain forest supports a sparse ground and shrub storey vegetation. In the deep shade, plant life is restricted. The main zone of productivity is in the upper canopy, high out of reach of ground-dwelling herbivores. These changes would therefore have degraded the quality of the environment for all nonscansorial phytophagous mammals of the ground or shrub storeys, and for large-bodied browsing or grazing perissodactyls in particular. Indirect consequences would have impinged upon nonscansorial predators of these mammals, again especially the large-bodied carnivores. The affected populations would thus have experienced ecological pressures simultaneously with the final severance of land connections across the Sunda shelf and hence isolation from sources of new genetic inflow.

Nevertheless, Bornean populations of other mammal species have continued from the early postglacial to the present. Among these, the bearded pig, *Sus barbatus*, as far as archaeological material can show, has undergone no morphological change (Medway, 1978). At the same time, the Sumatran rhinoceros and barking-deer have responded to the changing environment by reduction in individual body size, a modification recognized as adaptative to restricted resources. The metrical changes in the teeth of other mammals, as noted above, involving absolute and/or relative dimensions, may also reflect alterations in body size.

The archaeological evidence is inadequate to demonstrate changes in abundance. Populations affected by postglacial alterations in the environment were likely to have declined in response to the diminution of accessible resources. Large mammals might already have been comparatively rare and hence vulnerable to local extinction, even on so big an island as Borneo. Reduced population density among the primary consumers has inevitable repercussions on members of the community at higher trophic levels. It is therefore not unexpected that the mammal species to become extinct in Borneo during the postglacial period included these four obligatory ground-dwellers: two large browsing ungulates (Javan rhinoceros and tapir) and two large predatory carnivores (tiger and dhole).

I would be venturing too far from my own ground if I were to speculate on the likely effects of these environmental changes on amphibian faunas of the terminal Upper Pleistocene of Borneo. This train of thought I hereby offer to Bob Inger, with respect and affection, leaving him to pursue it as far as may be profitable in the light of his own studies of the existing fauna.

Acknowledgments

I am grateful to Dr. Peter Bellwood for supplying radiometric dates, to Dr. Juliet Jewell for providing facilities for this study at the British Museum (Natural History), and to both, with Dr. D. A. Hooijer, for kindly reading and commenting on this text in progressive stages of drafting.

Literature Cited

AUDLEY-CHARLES, M. G. 1981. Geological history of the region of Wallace's line, chap. 4. *In* Whitmore, T. C., ed., Wallace's Line and Plate Tectonics. Clarendon Press, Oxford, England.

BELLWOOD, P. 1984. Archaeological research in the Madai-Baturong region, Sabah. Bulletin of the Indo-Pacific Prehistory Association, **5:** 38–56.

CHASEN, F. N. 1940. A handlist of Malaysian mammals. Bulletin of the Raffles Museum, Singapore, **15:** i–xx, 1–209.

CRANBROOK, EARL OF. 1986. A review of fossil and prehistoric remains of rhinoceroses of Borneo. Sabah Museum and Archives Journal, **1**(1): 50–110.

DAVIS, S. J. M., AND F. R. VALLA. 1978. Evidence for the domestication of the dog 12,000 years ago in the Natufian of Israel. Nature, London, **276:** 608–610.

DRING, J. 1983a. Frogs of the genus *Leptobrachella* (Pelobatidae). Amphibia-Reptilia, **4:** 89–102.

———. 1983b. Some new frogs from Sarawak. Amphibia-Reptilia, **4:** 103–115.

GERSI, D. 1975. Dans le jungle de Bornéo (Kalimantan). Éditions G.P., Paris.

HAILE, N. S. 1971. Quaternary shorelines in West Malaysia and adjacent parts of the Sunda Shelf. Quaternaria, **15:** 333–343.

HARRISSON, T. 1972. The prehistory of Borneo. Asian Perspectives, **13:** 17–45.

HIGHAM, C. F. W., A. KIJNGAM, AND B. J. F. MANLY. 1980. An analysis of prehistoric canid remains from Thailand. Journal of Archaeological Science, **7:** 149–165.

HOOIJER, D. A. 1960a. The giant extinct pangolin (*Manis palaeojavanica* Dubois) from Niah. Sarawak Museum Journal, **9:** 350–355.

———. 1960b. The orang-utan in Niah cave prehistory. Sarawak Museum Journal, **9:** 408–421.

———. 1962. Prehistoric bone: The gibbons and monkeys of Niah great cave. Sarawak Museum Journal, **11:** 428–449.

———. 1963. Further "Hell" mammals from Niah. Sarawak Museum Journal, **11:** 196–200.

———. 1975. Quaternary mammals west and east of Wallace's line. Netherlands Journal of Zoology, **25:** 45–56.

HOSE, C. 1893. A Descriptive Account of the Mammals of Borneo. Edward Abbott, Diss, England.

———. 1929. The Field-Book of a Jungle-Wallah. H. F. & G. Witherby, London.

HUGHES, H. V., AND J. W. DRANSFIELD. 1953. McFadyean's Osteology and Anthropology of the Domesticated Animals, 4th ed. Baillière, Tindall and Cox, London.

INGER, R. F. 1966. The systematics and zoogeography of the Amphibia of Borneo. Fieldiana: Zoology, **52:** 1–402.

INGER, R. F., AND K. J. FROGNER. 1979. New species of narrow-mouthed frogs (genus *Microhyla*) from Borneo. Sarawak Museum Journal, **27:** 311–322.

INGER, R. F., AND P. A. GRITIS. 1983. Variation in Bornean frogs of the *Amalops jerboa* species group, with the description of two new species. Fieldiana: Zoology, n.s., **19:** 1–13.

KOOPMANS, B. N., AND P. H. STAUFFER. 1967. Glacial phenomena on Mt. Kinabalu, Sabah. Borneo Region, Malaysia, Geological Survey Bulletin, **8**: 25–35.

MEDWAY, LORD. 1959. Niah animal bone: II (1954–8). Sarawak Museum Journal, **9**: 151–163.

———. 1960. The Malay tapir in late Quaternary Borneo. Sarawak Museum Journal, **9**: 356–360.

———. 1964. Niah cave bone. VII. Size change in the teeth of two rats, *Rattus sabanus* Thomas and *R. muelleri* Jentink. Sarawak Museum Journal, **11**: 616–623.

———. 1977a. Mammals of Borneo. Monographs of the Malaysian Branch of the Royal Asiatic Society, no. **7**.

———. 1977b. The ancient domestic dogs of Malaysia. Journal of the Malaysian Branch of the Royal Asiatic Society, **50**(1): 14–27.

———. 1978. The wild pig remains from the West Mouth, Niah cave. Sarawak Museum Journal, **25**: 21–39.

———. 1979. The Niah excavations and an assessment of the impact of early man on mammals in Borneo. Asian Perspectives, **20**: 51–69.

NOBIS, G. 1979. Der älteste Haushunde liebte vor 14 000 Jahren. Umschau, **19**: 610.

VOS, J. DE. 1983. The *Pongo* faunas from Java and Sumatra and their significance for biostratigraphical and paleo-ecological interpretations. Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen, Series B, **86**: 417–425.

WHITMORE, T. C. 1981. Palaeoclimate and vegetation history, chap. 5. *In* Whitmore, T. C., ed., Wallace's Line and Plate Tectonics. Clarendon Press, Oxford, England.

ZON, A. P. M. VAN DER. 1979. Mammals of Indonesia. Food and Agriculture Organization of the United Nations Special Report FO/INS/78/061, Bogor, Indonesia.

Field Museum of Natural History
Roosevelt Road at Lake Shore Drive
Chicago, Illinois 60605-2496
Telephone: (312) 922-9410