

23. Poorter, H., Remkes, C. & Lambers, H. *Pl. Physiol.* **94**, 621–627 (1990).
24. Masle, J., Farquhar, G. D. & Gifford, R. M. *Austr. J. Plant Physiol.* **17**, 465–487 (1990).
25. Jarvis, P. & Leverenz, J. W. in *Encyclopaedia of Plant Physiology* Vol. 12D (eds Lange, O. L., Nobel, P. S., Osmond, C. B. & Zeiger, H.) 233–280 (Springer, Berlin, 1983).
26. Medina, E. & Klinge, H. in *Encyclopaedia of Plant Physiology* Vol. 12D (eds Lange, O. L., Nobel, P. S., Osmond, C. B. & Zeiger, H.) 281–304 (Springer, Berlin, 1983).
27. Poorter, H. in *Causes and Consequences of variations in Growth Rate and Productivity of Higher Plants* (eds Lambers, H., Cambridge, M. L., Konings, H. & Pons, T. L.) 49–68 (SPB Academic, The Hague, 1989).
28. Zundel, G., Miekeley, W., Grisi, B. M. & Förstel, H. *Radiat. Envir. Biophys.* **15**, 203–212 (1978).
29. Barnes, C. J. & Allison, G. B. *J. Hydrol.* **100**, 143–176 (1988).
30. Bariac, T., Rambal, S., Jusserand, C. & Berger, A. *Agric. For. Meteor.* **48**, 263–283 (1989).
31. Bariac, T., Jusserand, C. & Mariotti, A. *Geochim. cosmochim. Acta* **54**, 413–424 (1990).
32. Friedli, H., Siegenthaler, U., Rauber, D. & Oeschger, H. *Tellus* **B39**, 80–88 (1987).
33. Tans, P. P. *Tellus* **B32**, 464–469 (1980).
34. Houghton, J. T., Jenkins, G. J. & Ephraums, J. J. *Climate Change: The IPCC Scientific Assessment* (Cambridge University Press, UK, 1990).
35. Levitus, S. *Climatological Atlas of the World Ocean*. (Natn. Oceanic Atmosp. Admin. Prof. Pap. **13**, 1981).
36. Friedman, I. & O'Neil, J. R. in *US geol. Surv. Prof. Paper* 440-KK (1977).
37. O'Neil, J. R. & Adami, L. H. *J. phys. Chem.* **73**, 1553–1558 (1969).
38. Allison, G. B., Colin-Kaczala, C., Filly, A. & Fontes, J. C. H. *J. Hydrol.* **95**, 131–141 (1987).
39. Keeling, C. D. *Geochim. cosmochim. Acta* **24**, 277–298 (1961).
40. Mook, W. G., Koopmans, M., Carter, A. F. & Keeling, C. D. *J. geophys. Res.* **88**, 10915–10933 (1983).

ACKNOWLEDGEMENTS. We thank I. R. Cowan, C. B. Osmond, J. A. Berry, J. R. Evans, J. E. Robertson and S. von Caemmerer for comments, R. Francey, A. Chivas and J. Olley for isotope standards, R. Koster for simulations of $\delta^{18}\text{O}$ of water vapour in relation to precipitation and I. Watterson for humidity fields.

A new species of living bovid from Vietnam

Vu Van Dung, Pham Mong Giao, Nguyen Ngoc Chinh, Do Tuoc, Peter Arcander & John MacKinnon[†]

Forest Inventory and Planning Institute, Ministry of Forestry, Hanoi, Vietnam

* Asian Bureau for Conservation, 18/E Capital Building, 175–191 Lockhart Road, Wanchai, Hong Kong

IN May 1992 a joint survey by the Ministry of Forestry and World Wide Fund for Nature of the Vu Quang Nature Reserve, Ha tinh province, found three sets of long straight horns of a new bovid (Mammalia, Artiodactyla) in hunters' houses¹. None of the specimens had dentition. On four follow-up visits by Vietnamese scientists new specimens were discovered and surveys of forests in neighbouring Nghe an province revealed more localities and some partial specimens. In all, we have examined more than 20 specimens. Three have complete upper skulls and dentitions, two have lower jaws and dentitions. Three complete skins have been collected. The specimens are distinct in appearance, morphology and DNA sequence and cannot be ascribed to any known genus. Only two bovid genera are known from this part of Asia, *Bos* and *Naemorhedus* = *Capricornis*^{2,3}. A new genus and species are therefore described. Such a discovery is of great significance. It has been more than 50 years since any comparable find of a large mammal species has been made; the last being the kouprey *Bos* = *Novibos sauveli*, another Indochinese bovid (Urbain, 1937). Moreover, the bovids (cattle, goats and antelopes) are a mammal family of great value to mankind. Many species have proven or potential value for domestication or cross-breeding. A three-month field study is planned to observe the living animal.

FORMAL DESCRIPTION

Family Bovidae
Subfamily Bovinae
Tribe ? Boselaphini

Genus *Pseudoryx*, gen. nov.

Diagnosis. *Pseudoryx* differs significantly from all described genera in appearance, morphology, cranial and dental features and DNA. The long, smooth, almost straight, slender horns, elongated premolars, large face gland and distinctive colour

pattern are diagnostic.

Description. See under species description.

Etymology. The name reflects the superficial similarity to *Oryx* in having long straight horns slightly recurved in profile, with bold black and white facial markings, while clarifying that the animal is not closely related to *Oryx*.

Type species. *P. nghetinhensis*, sp. nov.

Pseudoryx nghetinhensis sp. nov.

Diagnosis. The only species of the genus. Diagnosis as for genus.

Description. The total body weight of the adult is estimated at about 100 kg. Total length from nose to anus is about 1.5 m. Height at the shoulder is about 80–90 cm. Length from spine to front foot across preserved skin is 96 cm. Tail is short, about 13 cm of bone with fluffy black tassel. Ear length is quite short at about 10 cm. Skull length varies between 32 and 36.5 cm.

The skull is highly bridged in the nasal area. The horns are long, almost straight, smooth, almost parallel in females, and only moderately diverging in males. They are almost circular in cross-section, with horn cores extending close to the tip. Horn length varies from 32 to 52 cm, with a mean (18) = 41 cm. Width between tips varies from 7.5 to 20 cm, with mean (17) = 13.3 cm. Both length and distance between the tips show a bimodal distribution, with inferred males having longer more divergent horns than females. The insertion of the horns is much wider than for goat-antelopes (such as the serow *Naemorhedus sumatraensis*; Fig. 3b), similar to the mountain anoa *Bubalus quarlesi*, but narrow for cattle. Internal width between horns basally varies from 3.0 to 4.0, with a mean (6) = 3.7 cm. The outer width across the horns basally varies from 10 to 12, with a mean (6) = 10.5 cm. The basal 7 cm shows narrow annuli, but

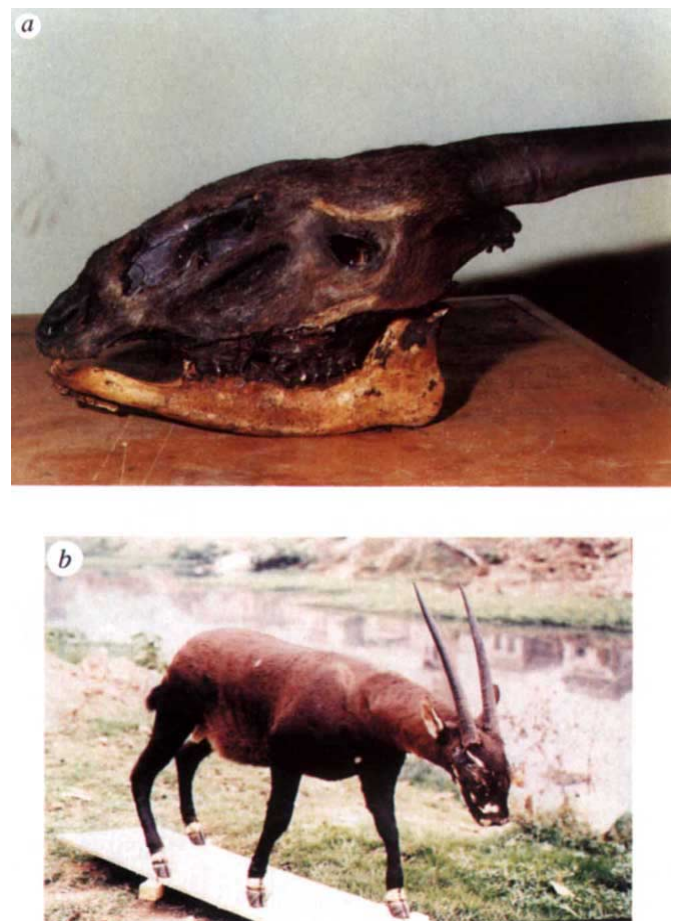


FIG. 1 Photographs of Vu Quang bovid: a, type specimen FIPI/MVQ001; b, stuffed skin of another individual.

[†] To whom correspondence should be addressed.

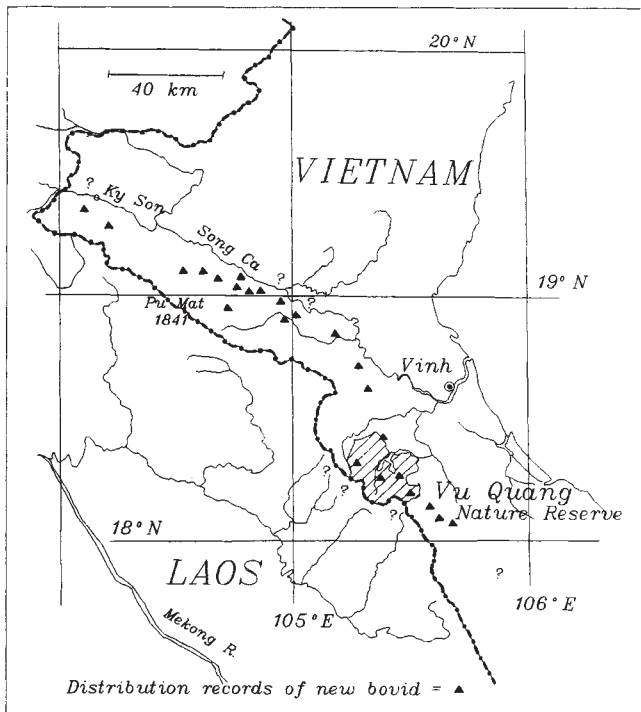
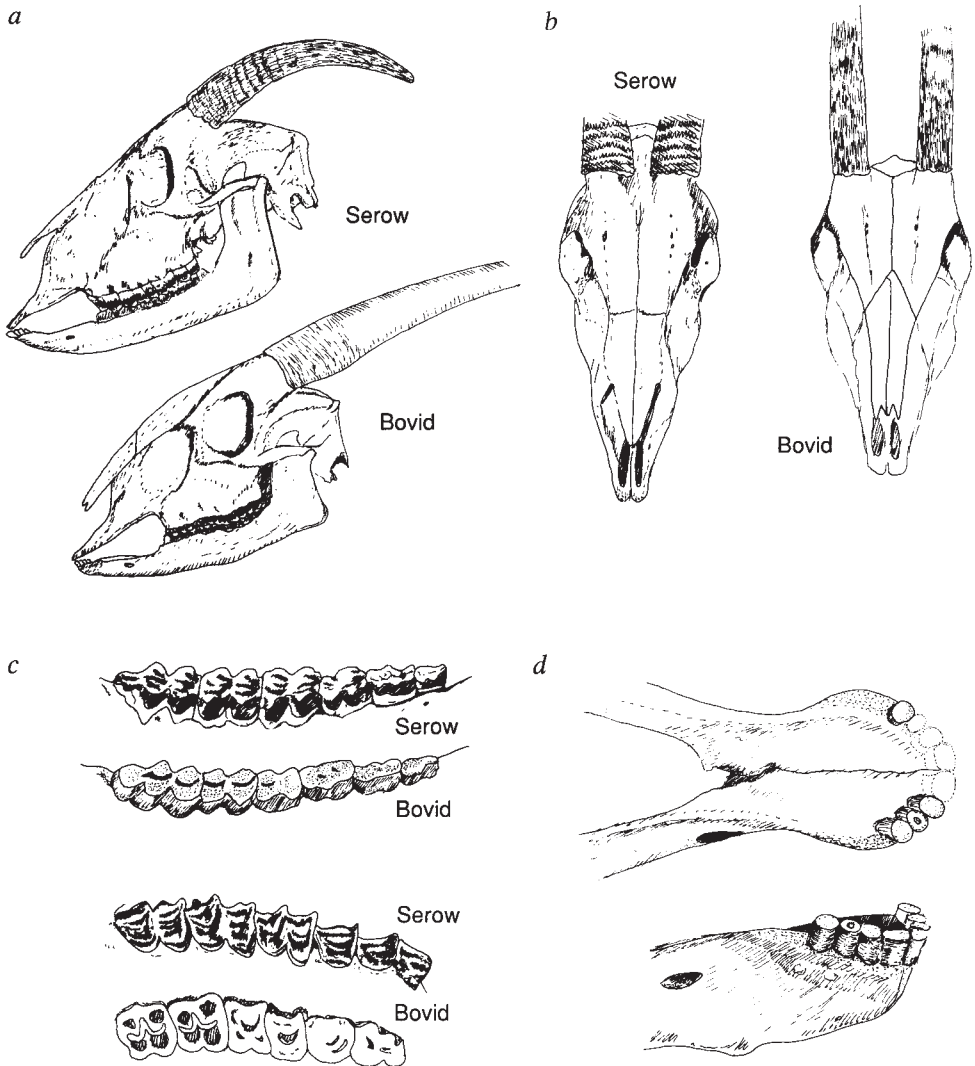


FIG. 2 Distribution of Vu Quang bovid. Definitive records are now known from over 20 localities, all on the forest edge along the cordillera along the Laos-Vietnam border between 104°5'E by 19°25'N and 105°50' by 18°05'N. All specimens are from the Vietnam (wetter) side of the range, but hunters report that the animal does also exist on the Lao side. All definitive records are to the south side of the Song Ca river.

FIG. 3 Cranial details of new bovid. *a*, Full skull (composite reconstruction); *b*, frontal view; and *c*, molar and premolar toothrows of Vu Quang bovid compared with serow; *d*, details of incisor and canine of type specimen of Vu Quang bovid. Serow is the only bovid of comparable size in Southeast Asia.



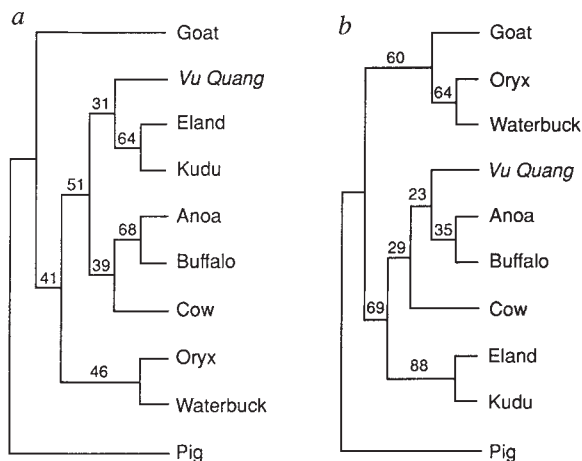


FIG. 4 Phylogenetic relationship of the Vu Quang bovid in relation to representatives of some major bovid groups. Shown is a maximum parsimony bootstrap tree⁵ based on 249-base-pair mitochondrial DNA encoding cytochrome *b*, with the pig (*Sus scrofa*) used as outgroup. Numbers above branches refer to the frequency (in per cent) of finding a group to be monophyletic for 100 bootstrapped samples of the sequences. All substitutions are used in *a* (170 steps, 95 segregating and 66 informative sites). Because of the age of these nodes, transitions in the third codon position are likely to be affected by saturation, and tree *b* shows the results when these are omitted (66 steps, 27 informative sites). In both trees, the Vu Quang bovid clusters with but does not appear especially close to cow (*Bos taurus*), buffalo (*Syncerus caffer*), anoa (*Bubalus depressicornis*), eland (*Tragelaphus oryx*) and kudu (*Tragelaphus imberbis*). The low bootstrap numbers indicate that more sequence data are needed to fully resolve the branching order. But these DNA data show affiliation with the Bovinae as opposed to other bovid groups. DNA extractions, amplifications using the polymerase chain reaction, and sequencing all followed standard procedures^{6,7}. The primers HL14841 and HH15149 (ref. 8) were used for amplifications as well as for sequencing. Note: The sequences from pig, cow and goat (*Capra hircus*) are published⁹; oryx (*Oryx gazella*), waterbuck (*Kobus ellipsiprymnus*), buffalo, kudu and eland sequences were obtained under a joint project between the National Museums of Kenya and the Institute of Population Biology, University of Copenhagen, Denmark; anoa DNA was kindly donated by the Conservation Genetics Group, Institute of Zoology, London, UK; Vu Quang DNA is extracted from a smoke-dried skin sample¹⁰. Sequences are deposited in GenBank under the accession numbers: L13792, anoa; L13793, eland; L13794, kudu; L13795, oryx; L13796, buffalo; L13797, *Pseudoryx*; L13798, waterbuck.

the main shaft is rubbed smooth.

Dental formula is $\begin{matrix} 0 & 0 & 3 & 3 \\ 3 & 1 & 3 & 3 \end{matrix} \times 2 = 32$

Available dentitions of *Pseudoryx* are in late occlusal wear. The lower front teeth appear less spatulate than in other genera (Fig. 3d). The second and third incisors and canine of the type specimen are peglike and almost vertical in alignment rather than splayed forward. The premolars are elongated (Fig. 3e). The proportion of molar and premolar tooth-row length accounted for by the premolars is 44% (lower) and 46% (upper), compared with 39% and 36% for the serow.

The face and general body colour varies from dark brown to rich reddish brown. There is a blackish brown narrow stripe down the middle of the back onto the short tail. Both sexes have whitish-to-buff stripes above and below the eye, and white patterns on the side of the face, chin and throat. All skins show a whitish stripe on the outer rump separating the brown back from blackish legs and show whitish socklet markings with black frontal division. The hair on the upperparts is fine, short (about 2.4 cm) and glossy, whereas on the underparts it is longer (3.5 cm) and more fluffy. The anal area and inner flanks are whitish, as is the scrotum of the male skin. The ear is brown behind and whitish inside, with short hair, except for a tuft of long whitish hair on the upper innerside. The hair pattern results in whorls on the centre of the nose, the sides of the neck and middle of the shoulders. The animal has no dorsal crest of long hair as in serow and nilgai *Boselaphus tragocamelus*.

The hooves are small and dainty with short, blunt toes about 4 cm high and 6 cm long. The 'dew toes' are vestigial calluses, much more reduced than in goat-antelopes or cattle. There are large face glands just in front of the eye as in serows, duikers (*Cephalophini*) and some other bovids.

Etymology. The old Vietnamese province Nghe tinh includes the two new provinces Nghe an and Ha tinh, which precisely define the known distribution of the species.

Holotype. Forest Inventory and Planning Institute (FIPI) Museum, Hanoi. Specimen number FIPI/MVQ001, adult male, skin of head and almost complete skull with lower mandibles, from Vu Quang nature reserve, Vietnam 105°25'E by 18°15'N, collected by FIPI team, April 1992 (see Figs 1 and 3d).

Distribution. Ha tinh and Nghe an provinces, Vietnam (Fig. 2).

Currently known range totals about 4,000 km² and constitutes the only extensive pristine forest in northern Vietnam. Montane forests are dominated by conifers with *Fokienia hodgsoni*, the main species. Lower forests are rich, evergreen, mixed-broad-leaf, dominated by the dipterocarp *Hopea mollissima*. The new bovid appears to use all forest levels in differing seasons, even coming into the secondary lowland forests along large rivers at about 200 m. The highest peaks in the range are over 2,000 m above sea level. From the size of the distribution area and the frequency with which hunters claim to trap the animals, we estimate that a few hundred of the new bovid survive. Following this discovery, the Vietnamese Government has increased the size of the Vu Quang nature reserve from 16,000 ha to 60,000 ha and has plans for another two reserves.

Preliminary DNA analysis indicates that the new species clusters with oxen (Bovinae) rather than other bovids (S. J. O'Brien, personal communication; P. A. Arcander and S. J. O'Brien, manuscript in preparation; also see Fig. 4). The DNA analysis does not yet indicate clearly to which tribe of Bovinae the species belong. The species appears to be a rather deep branch of the subfamily. It may merit creation of a new tribe. It exhibits many anatomical characters listed as primitive for bovids⁴, and our placement in tribe Boselaphini (one tribe of subfamily Bovinae) is provisional and based on morphological features. Only this tribe shows the combination of primitive features of face glands with the pattern of black and white markings on face, neck, feet and rump (c.f. nilgai). □

Received 7 April 1993; accepted 11 May 1993.

- MacKinnon, J. & Vu Van Dung. *Technical Report of MOF/WWF* (1992).
- Corbet, G. B. & Hill, J. E. *The Mammals of the Indomalayan Region* (Oxford Univ. Press, 1992).
- Lekagul, B. & McNeely, J. A. *Mammals of Thailand* (Assoc. Conservation Wildlife, Bangkok, 1977).
- Gentry, A. W. *Mamm. Rev.* **22**, 1–32 (1992).
- Swofford, D. L. *PAUP: Phylogenetic Analysis Using Parsimony* Version 3.0. (Illinois Hist. Surv., Campaign, 1990).
- Innis, M. A., Gelfand, D. H., Sninsky, J. J. & White, T. J. *PCR Protocols* (Academic, San Diego, 1990).
- Sambrook, J., Fritsch, E. F. & Maniatis, T. *Molecular Cloning: A Laboratory Manual* (Cold Spring Harbor Laboratory Press, New York, 1989).
- Kocker, T. D. *et al. Proc. natn. Acad. Sci. U.S.A.* **86**, 6196–6200 (1989).
- Irwin, D. M., Kocker, T. D. & Wilson, A. C. *J. molec. Evol.* **43**, 128–144 (1991).
- Smith, E. F. G., Arcander, P., Fjeldsa, J. & Amir, O. G. *Ibis* **133**, 227–235 (1991).

ACKNOWLEDGEMENTS. We thank A. Gentry, C. Groves, P. Grubb, S. Stuart and G. Corbet for their comments on photos of the specimens and drafts of this paper.