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Borneo yellow muntjac (*Muntiacus atherodes*)
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BORNEO : an Introduction

At almost 750,000 km², Borneo ranks as the world's third largest island. The political division between three nations—Malaysia, Brunei Darussalam and Indonesia—and their contrasting histories, have generated economic and cultural distinctions in human society in different parts of this huge island. Nonetheless, geography, climate, and plant and animal ecology provide a unifying environment to justify the theme of this issue of the Malayan Nature Journal. In these pages, participants from all three nations have presented a remarkable collection of reports on aspects of the natural history of Borneo, or parts of Borneo. Collectively, these papers illustrate the diverse character and fascinating breadth of the subject, and celebrate the endeavours of the community of people and institutions who participate in studies that add to our collective understanding of the diverse and remarkable natural history of Borneo.

The opening contribution draws attention to the Proboscis monkey, the long-nosed colobine endemic to Borneo, frequenting coastal and riparian forest throughout the island. Equally well-known is Borneo's great ape, the Orangutan, whose threatened status has roused international and national support for the rescue and rehabilitation programme at Lamadau, Central Kalimantan. Also generated in Indonesia, in West Kalimantan, the Mastwatch website continues to link observers throughout Borneo in a programme to monitor the phenomenon of mast-flowering and fruiting of dipterocarps, the magnificent giant trees that dominate the lowland and lower montane forest of Borneo. There follows a study of the utilisation of natural resources by an indigenous community of Muslim faith.

Move on to the giant mammals, Asian elephants, at last proven by skilled zooarchaeological detective work to be present in Borneo in the Late Pleistocene era. An archaic group among invertebrates, the Odonata (dragonflies and damselflies) are well represented in Borneo; presented here is an overall review and a linked, first Borneo-wide checklist. The birds of Borneo are perhaps a group more often drawing naturalists to Borneo; several checklists exist and it is more cogent to include, in these pages, an authoritative review of ornithology, an active pursuit throughout the island.

There are two contributions from Brunei based on phototrap images. The first provides previously unknown evidence of colour variation among the Sundaic Horse-tailed squirrel, while the second puts into circulation the first pictures of living Borneo Yellow muntjac, and original evidence of ecological separation of the two species of barking deer in Borneo. On the island Mantanani Besar a study, initiated by the Sabah Society, has investigated the human/bird relationship, and assessed the likelihood of a productive future for the strange, mound-building megapodes. A short essay on the cultural significance of Clouded leopard precedes a careful, well illustrated account of the living legend of Tigers in East and North Kalimantan. In the same area, human ingenuity has invented a mechanical alternative to the blowpipe, the traditional hunting weapon of interior people of Borneo. The second-last features a study of the declining mud crabs in Kuching mangroves, and this issue closes on a report showcasing prey-handling of a venomous Bornean Keeled Pit Viper.

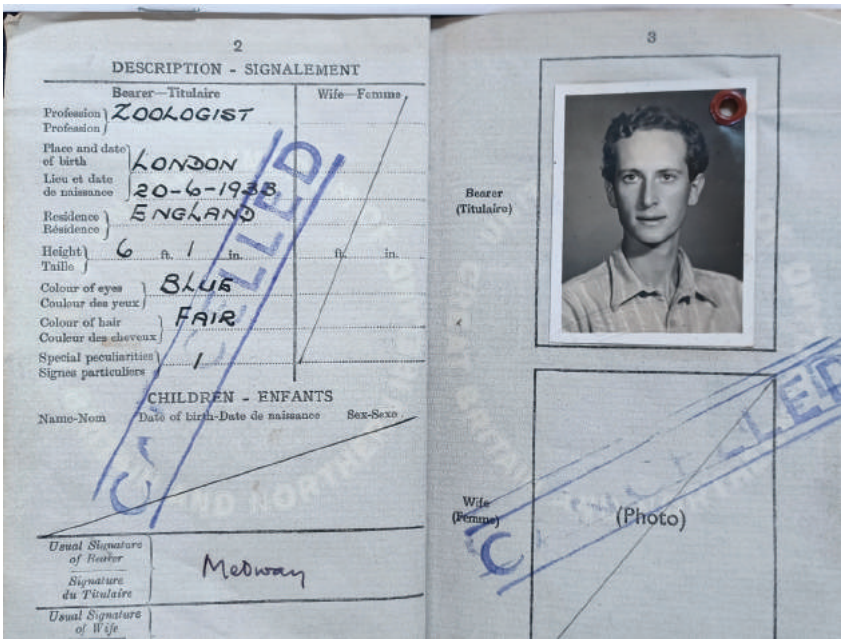
Apologia: lifetime connections with people and places in Borneo

Readers of the Malayan Nature Journal may question my qualification to serve as Guest Editor of this Borneo-themed issue. I hope a few paragraphs can provide satisfactory justification.

Sometimes, in Sarawak, people who half-hear my name, jump to the (wrong) conclusion that I am related to the dynasty of Brooke Rajahs. Dismiss that as the reason why, in March 1956, shortly before graduating at Cambridge, I did not refuse the offer by Tom Harrisson, then Curator of the Sarawak Museum, who offered to give me a job, if I came to Kuching. So, in June 1956, I bought a passage on a cargo steamer of the Blue Funnel Line, from Liverpool to Singapore, where I transhipped to S.S. Rajah Brooke -- and finally arrived at Kuching.

The 'job' was termed 'Technical Assistant to the Curator', and had no fixed duties. The Museum was engaged in a programme of amassing bird skins, funded by the eminent businessman and ornithologist Dato Loke Wan Tho. Young men from rural longhouses were given basic training in skinning and specimen preparation, and sent home with a supply of cartridges, museum labels, cotton wool and preservative. At the Museum, I sorted and identified the resulting skins. This task -- a valuable introduction to the avifauna -- was supplemented by proof-reading B. E. Smythies' new checklist of the birds of Borneo (1957). The text went back and forth (seven times, I remember) between Museum and the Government printer, whose staff were seriously challenged by Latin nomenclature and the arcane rules on the use of italics in zoology. In the same year, I was issued a Sarawak international passport, no. 4553, valid in 'The British Commonwealth and all Foreign Countries'. On this document, I travelled the world for ten years until it expired in February 1967.

Plate 1 - Sarawak International Passport



In 1958, promoted to Archaeological Assistant, I became responsible for the identification of animal remains excavated at Niah caves, and elsewhere in Sarawak and Sabah. As a personal project, the Curator also encouraged me to study the edible-nest swiftlets -- a group of birds with unique adaptations to life in caves. Two years later, my fieldwork on swiftlets became the foundation of a PhD dissertation at the University of Birmingham, U.K. In 1960-1961, a post-doc fellowship with Yayasan Siswa Lokantara (as ahli burung walet) extended my research to Indonesia; Here I found other managed populations of cave swiftlets, and met other scientists prepared to share their experience in the taxonomy and behaviour of these fascinating birds.

In 1961, appointed to the Zoology Department at the University of Malaya, I was well placed to resume research on the animal remains excavated in Malaysian caves, notably at Niah, Sarawak. Discoveries included the foot bones of Malayan tapir, a large mammal now extinct in Borneo, but I failed to find evidence of the past presence of elephant in any Late Pleistocene context.

Most identifiable animal remains in these cave sites consisted of teeth and bones of mammals, encouraging me to study extant Borneo species. In 1965, a grant from U.S. sources funded a round-the-world air ticket. Starting at the B.P. Bishop Museum, Honolulu, and progressing across mainland USA from San Francisco, via Chicago and Washington, D.C., to the Peabody Museum, Yale, and then to museums in London, Paris and Frankfurt, and finally at the India Museum, Calcutta, I managed to see all historic mammal collections from Borneo. During this circumglobal tour, I discovered two undescribed species of small mammal—not in the upland localities they inhabit, but in the museum cabinets where they lay, overlooked: the Grey-bellied pencil-tailed tree-mouse, in the U.S. National Museum, Washington. D.C., USA, and the Black shrew, in the Museum of Comparative Zoology, Cambridge, Mass., USA. The resulting annotated checklist of mammals of Borneo was published by the Malaysian Branch of the Royal Asiatic Society, first in 1965 and, later, as a revised edition, in 1977.

In the 1990s, invited by the Director of Forests and Wildlife, Sarawak, to review the edible birds'-nest industry. I looked for a student-assistant to cooperate in the research. Luckily, Lim Chan Koon, a graduate student at Universiti Malaysia Sarawak (Unimas) was willing to transfer to the topic, He was awarded a Government scholarship to the University of Kent, U.K., and I became external supervisor for his Ph.D. I remembered my 1957 visit to Salai Cave, in the Middle Baram above Long Laput, site of an accessible colony of White-nest swiftlets. We approached YB Kebing Wan, head of the family of hereditary owners of the cave rights, and were pleased by his generous offer to provide facilities for a year's research on site, alongside his relative Usong Wan, as cave manager. This unprecedented opportunity for a dedicated and assiduous student, and for shared learning by myself as supervisor, resulted in a successful graduation by Dr Lim..

In 2001, a grant from Flora and Fauna International helped Dr Lim and myself, with friends from the community of Sarawak birds'-nest cave owners, including George Nawan, to undertake an investigation of birds'-nest operators and island sites in North Kalimantan, and the extensive complex of caves occupied by Black-nest swiftlets in the upper Kayan river, East Kalimantan, managed by a local cooperative. In 2002, our experiences were recounted in a jointly authored book: *Swiftlets of Borneo: builders of edible nests*, produced in a lavishly illustrated edition by Natural History Publications (Borneo) and reissued with revisions in 2014.

In 2009, I was appointed a member of Yayasan Ulin, an Indonesian foundation dedicated to conservation of natural habitat and wildlife in areas unprotected by legislation. I traversed the southern breadth of Borneo by mixed transport modes from Pontianak to Pangkalan Bun, West Kalimantan, across Central Kalimantan, to Banjarmasin and Martapura, South Kalimantan, and later, from Balikpapan to Samarinda and Tenggarong, East Kalimantan, and— later still — from Bandarbaru on the great Mahakam river, by speed boat up the tributary, Sg Belayan, to the oil palm plantations operated by REA Kaltim. The director and staff of REAKon, the conservation arm of this British-owned company, provided valuable insights of the potential for good environmental management on a large commercial plantation.

In 2014, I was invited to participate in the Heart of Borneo initiative, as operated in Brunei Darussalam under Royal patronage and ministerial support. Recipient of a

Merdeka Award in the same year, among other projects, I was able to fund a Sabah graduate of the University of Malaya, for his M Sc research into the Philippine megapodes of the Mantanani archipelago, Kota Belud District, Sabah. In the following years, until the Covid-19 Pandemic closed international travel, I have made at least one visit to a destination in Borneo, and thereby renewed or extended my personal contacts among colleagues who share enthusiasm for all aspects of natural history.

Through the Pandemic years 2020 and 2021, and into 2022, contact has been limited to digital exchanges. As Guest Editor of this Borneo-themed issue of the Malayan Nature Journal, I am supremely grateful to all contributors -- and especially those whom I invited to submit their own stories and discoveries. The subject matter is unlimited. The combination of submissions in this issue indicates the wealth and variety of topics available for research. The published articles demonstrate, emphatically, the assiduity and scrupulous ardour of the diverse community of people whose lives and careers have led them into these fields of research. There is still much more to be discovered. I sincerely hope that this themed issue of MNJ will stimulate further research into the diverse aspects of the natural history of Borneo.

CRANBROOK **11 JUNE 2022**

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Allopatric distribution and ecological separation of Bornean yellow muntjac *Muntiacus atherodes* and Red muntjac *Muntiacus muntjak* in Brunei Darussalam

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Abstract : The Heart of Borneo initiative in Brunei Darussalam led to a Faunal Biodiversity Survey in the Sungei Ingei Conservation Forest and a variety of other localities in the country from 2009-2016. This paper highlights the differences between the two *Muntiacus* species based on camera trap images and establishes that their distribution is allopatric. Our data from camera traps deployed in different habitats have shown conclusively that *Muntiacus atherodes* ranged from secondary forests, lowland forests that include mixed dipterocarp forests, kerangas forests, riverine forests, mineral licks and low hills while *Muntiacus muntjac* was only recorded in the Ulu Temburong National Park and hills in other parts of Temburong and higher hills in Tutong without any instance of both species co-occurring in the same habitat.

Keywords: *Muntiacus atherodes*, *Muntiacus muntjac*, Heart of Borneo, Brunei Darussalam, allopatric distribution, ecological separation, morphological differences

INTRODUCTION

The presence in Borneo of two taxonomically distinct species of barking deer, genus *Muntiacus* Rafinesque 1815, was propounded by Kohlbrugge (1895) based on his collection of the red muntjac and a frontlet with antlers of the yellow muntjac in the Pleihari district. This idea was supported by Lyon (1911), Van Bemmel (1952) and Hill (1960) but based on Davis' observations (1962) on the antlers of the *pleiharicus* type, Medway (1965) united the two into *Muntiacus muntjak pleiharicus* (Kohlbrugge). It was not until Groves and Grubb (1982) carried out an exhaustive study of *Muntiacus* skulls and antlers to establish the occurrence two species on Borneo - the endemic Bornean yellow muntjac *Muntiacus atherodes* and the widespread S-E Asian and Sundaic species, the Red muntjac *Muntiacus muntjak*. It is now generally accepted that these two species are sympatric in Borneo, the Red muntjac being commoner in higher elevation forests and the Yellow muntjac in lower elevations as well as co-occurring in certain places like Dermakot and Danum in lowland Sabah, Barito Ulu, Central Kalimantan (Groves and Grubb 1982, McConkey and Chivers 2004, Payne and Francis 2007, Phillipps and Phillipps 2018, Mattioli 2011,). Phillipps and Phillipps (2018) have summarised the distribution of these species as sympatric with ecological overlap influenced by competitive exclusion.

The use of camera trap technology has revealed an abundance of vital data on elusive mammals in the forests of Borneo, but the proper identification of the species in question depends on the quality of photographs obtained. Researchers who have been unable to distinguish the two species of barking deer from their camera trap data, to avoid misidentification have identified them to genus only (Heydon 1994, McConkey and Chivers 2004, Azlan and Engkamat 2006, Onoguchi & Masubayashi 2006, Bernard *et al* 2013, Mattioli 2011,). The barking deer specimens collected during the 1955-1956

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Usun Apau expedition in Sarawak (Cranbrook 2021) from the Upper Plieran valley at Sut and Buya, Sg. Kejin, Baram, Matalun, and the uplands of Ulu Selio and now housed in the Field Museum, Chicago, were only recorded as *Muntiacus* sp. till much later, after Groves & Grubb's study in 1982, when they were separated as *M. atherodes* and *M. muntjak*.

The World Wildlife Fund-sponsored Heart of Borneo initiative in Brunei Darussalam led to a Sungei Ingei Faunal Biodiversity Survey in the Sungei Ingei Conservation Forest (2009-2012 Phase 1 with the first author as leader) followed by Phase 2 (2013-2016, second author as leader), the aim being to document wildlife: mammals, birds, reptiles, amphibians, freshwater fish, spiders and dragon flies. Mammal surveys continued in several existing conservation areas and other natural habitats in the country until 2020. The present paper reports on the distribution of *M. atherodes* and *M. muntjak* in the country based on the data collected by camera traps in Sungei Ingei Conservation Forest and other habitats in the country, and questions the validity of the accepted sympatric distribution of these two species. Since there have been many instances of misidentifications of *Muntiacus* sp. from camera trap images in Borneo (Phillipps pers comm), morphological differences between the two species based on the data collected in Brunei Darussalam are also supported in this paper with images.

MATERIALS AND METHODS

Field survey methodology

Mammal data collection was carried out using camera traps, sightings and examination of hunters' trophies.

1) Camera traps deployed

Three types were used:

i) The Film Camera traps with an infrared trigger system (Sensor Camera Fieldnote II, Marif Co., Ltd., Yamaguchi, Japan) were first employed in 2007 in the following localities: Ulu Temburong National Park, Bukit Kukub forest and Bang Nalud forest. These were replaced when the Wild-Eye digital flash type model became available. The number of images obtained was limited by the film used.

ii) The digital passive infra-red motion sensitive incandescent flash type (Wild-Eye Remote Camera Trap System by Wildtrack Services: trigger speed 0.3sec, detection angle 60 degrees, detection range 30 ft, interval 10 secs between events) camera trap was used in all habitats as it produced clear and brilliant images both at night and daytime.

iii) Browning Strike Force HD Pro X trail camera was used from 2019 onwards (flash type: red glow IR, picture trigger & recovery speed 0.16s /0.7s; video trigger & recovery speed 0.53s / 2.0s; detection range 90ft; detection angle 41.9 degrees). Images are clear and brilliant, but night images are black and white.

2) Camera trapping effort by locality

The protected forests and other localities where the camera traps were set from 2007-2020 are listed below:

i) Melilas Secondary Forest /home gardens/private lands -11 camera traps 1650 camera trap-nights (2019).

ii) Badas Forest Reserve – 14 camera traps with a trapping effort of 761 trap-nights and a total of 2,169 independent digital images (2019)

iii-v)) Badas peat swamp, Rasau peat swamp forests and Sungai Bisut freshwater swamp –29 camera traps distributed in these threelocalities with a total trapping effort of 2,078 camera-trap days with 2,678 independent digital images (2019 and 2020).

vi) Sungai Topi forests - 13 camera traps, 1,378 camera-trap nights with 1305 independent digital images (2015).

vii) Sungai Ingei Conservation Forest - In a total of 51,202 camera-trap nights over three years, 32,553 digital images were recorded (2009-2012).
viii) Tasek Merimbun Heritage Park- 1709 camera trap images, 7 camera traps (2014-2015)
ix) Bukit Kukub- 18 camera trap images, 60 camera trap-nights (2 film camera traps, 2007)
x) Bang Nalud- 15 camera trap images, 40 camera trap-nights (2 film camera traps, 2007)
xi) Andalau Forest Reserve- 1,682 camera trap images, 844 camera trap-nights (2019).
xii) Mineral licks in Belait District- 8,233 camera trap images, 16,655 camera trap-nights (2013)
xiii) Ulu Temburong National Park (West Ridge) - 206 camera trap images. 150 camera trap-nights (5 film camera traps, 2007)
xiv) Wildlife survey being currently carried out across Temburong (Natasha Mannion, pers comm).

3) Sightings of muntjacs during wildlife surveys
i) Hornbill surveys in the Belalong forests, Ulu Temburong National Park, during the RGS/UBD Belalong Project 1991/1992 (Cranbrook & Edwards 1994) and in 1996/1997 (Charles 2005).
ii) Bukit Tudal wildlife survey (Bennett *et al* 1987)
iii) Bukit Teraja survey, Belait District by the Panaga Natural History Society, (2010)
iv) Bird survey in Anduki Forest Reserve (1989)

4) Examination of Muntjac frontlets from hunter's trophy collection
i) Melilas Longhouse, Belait.
ii) Frontlet souvenir from a hunter in Mount Murud Sarawak.

RESULTS

a) Visual features that distinguish *M. atherodes* from *M. muntjak* as seen in camera trap images.
Identifying characters of Bornean yellow muntjac, *M. atherodes* (Figs.1 2, 4)
From colour images:
The Bornean yellow muntjac, is the smaller of the two (14-18 kg) with a bright yellowish -brown body, a dark forehead between the ears that continues as a dark diffuse dorsal stripe along the dorsal midline and a tail that is dark brown-black above and white below; Males have straight spike-like antlers on thin short pedicels, and lack a basal burr; while females have no antlers. Colour of outer surface of legs is the same as sides of the body; Both sexes lack frontal tufts.
A fawn can be identified by rows of spots or blotches along the dorsal region of the body (Fig. 3).

From black and white images:
Borneo yellow muntjac has a dark forehead with a dark dorsal mid-line, tail colour is much darker than the body while the legs and sides of body are of the same colour.

Characters of Red muntjac, *M. muntjak* (Figs.5, 6)
From colour images:
The Red muntjac, the larger of the two (20-28 kg) has a dark reddish-brown body colour, with dark legs and tail that has the same body colour; The male antler has a small brow tine and an elevated bony rim or burr at the antler base, prominent black-brown frontal tufts that continue as black stripes along the long, furred pedicels, and a bright orange occipital region between the ears. The female has no antlers but has prominent black eyebrows and an orange frontal area between the ears. The image in Fig. 5 shows a male Red muntjac with an antler on the left pedicel but none on the right, probably because it was camera trapped after periodic shedding of that antler.

Differences in the antlers between the males of the two species (Fig 7, 8, 9, 10).
The Borneo yellow muntjac male has a thin, short unbranched antler, without a basal burr. The Red muntjac male has a straight, furred pedicel, with a longer antler, often curved inwards and a single, small tine above the distinctive burr at the antler base.

b) Distribution of *M. atherodes* and *M. muntjak* in Brunei Darusssalam
i) Camera trap records from 14 habitats.
A thorough search for these two species in the camera trap images collected from 14 localities (Materials and Methods Section 2: i-xiv) revealed the presence of Borneo yellow muntjac in 9 localities which were all lowland forests: at Sungei Ingei, Topi, Melilas, Badas, Tasek Merimbun, Andalau, Bang Nalud, Bukit Kukub, and the mineral licks of Ulu Belait .

Red muntjac was recorded in the Ulu Temburong National Park by only a single image of a female that was obtained from a total of 206 images (Fig. 6) and in a wildlife survey currently conducted across Temburong where several images of males were obtained but of low resolution (Natasha Mannion pers comm.) So, we used a high-resolution camera trap image of male taken in Fraser's Hill (1,456m altitude), Selangor, Malaysia for Fig. 5. It is striking to note that neither species was recorded in Badas peat swamp, Rasau peat swamp and Sungai Bisut freshwater swamp based on 2,678 camera trap images.

ii) Records by sightings.
A Bornean yellow muntjac was seen by the first author in Anduki Forest Reserve (1989). Red muntjac was recorded a number of times in the following localities:
i) A male was seen by the first author during hornbill surveys in the East and West Ridges of Belalong forest, Ulu Temburong National Park, at altitudes ranging from 300m to 500m.
ii) During a wildlife survey in Bukit Tudal, Ulu Temburong National Park between 380m and 685m contours (Bennett *et al* 1987),
iii) Hunters from a nearby longhouse reported sightings of Red muntjac males (which they hunt regularly) during a Bukit Teraja survey (about 290m altitude), Belait District by the Panaga Natural History Society (2010).

iii) Information from a hunter's collection of Muntjac frontlets
Melilas Longhouse, Belait District.
A hunter whom we interviewed had collected 19 frontlets, one Borneo yellow muntjac four Red muntjac, eleven Sambar *Rusa unicolor*. and three that could not be identified. The four Red muntjac frontlets were collected in 1993, only from hills - at Bukit Ladan, Bukit Batu Beketam, Bukit Unding and Bukit Khamis. The Bornean yellow muntjac was from a forest near Melilas. The hunter maintained that while the yellow muntjac was available in the lowland forests of Brunei, the Red muntjac could only be found in the hills.

A Red muntjac frontlet from Mount Murud, Sarawak at 1,100m altitude.
A group of four persons from Brunei flew to Bario to ascend Mount Murud in Sarawak. On their way to the base camp with a guide and helpers, a hunter, appeared with a Red muntjac he had shot a little while ago. The frontlet of that animal was prepared and given to Clive Dudley (a member of the team) as a souvenir (with holes for fixing on a wall – Fig. 7) and is now in our collection.

DISCUSSION

Visible distinctions between the two muntjac species in Borneo, outlined above with the help of camera trap and other images, have clarified their separate occurrence in Brunei Darussalam. Remaining obstacles can now be resolved when night camera trap images are taken by recent trail cameras that use 'low glow IR' flash type technology. Earlier records of both species coexisting in Dermakot, Sabah (Phillipps and Phillipps 2018) have been corrected at present to only Bornean yellow muntjac after misidentifications of camera trap images have been recognised (Phillipps and Davies in press).

The camera trap results from 14 localities in Brunei Darussalam have shown the presence of Bornean yellow muntjac in nine localities, in habitats that ranged from secondary forests, lowland mixed dipterocarp forests, kerangas forests, riverine forests, mineral licks and low hills, as in Bukit Patam (227 m) in Sungei Ingei Conservation Forest. Red muntjac was not recorded in the same habitats as Bornean yellow muntjac. Our data showed that the former was only found in the hills of the Ulu Temburong National Park, as well as the hills (e.g. Bukit Patoi) around Batang Duri, Temburong. Further evidence that the Red muntjac is a highland resident came from hunters' sightings in Bukit Teraja (Belait District), from a wildlife survey in Bukit Tudal, Ulu Temburong National Park (Bennett *et al* 1987), from the East and West Ridges of the Belalong Forest in Temburong, the Melilas longhouse hunter's collection of frontlets from the hills in Tutong District, and another hunter's souvenir from Mount Murud in Sarawak.

Both the muntjac species were absent in Badas peat swamp, Rasau peat swamp and Sungai Bisut freshwater swamp, although Sambar and Lesser mousedeer *Tragulus kanchil* were present. Only Bornean yellow muntjac was reported to occur in the Sebangau peat swamp in Central Kalimantan (Husson *et al* 2018).

Our nationwide surveys have not revealed any instance of these two muntjac species occurring together (sympatric) or having overlapping ranges. Our data have given convincing evidence that the Bornean yellow muntjac and the Red muntjac are allopatric in Brunei Darussalam.

Re-examination of the earlier camera trap records in Sabah have now shown that Bornean yellow muntjac is found exclusively in the lowland forests of Dermakot (20-300 m altitude), Sepilok VJR, Kinabatangan WS, Sugut and Trus Sugut Forest Reserves; whereas Red muntjac was found in forested hills (400-500m altitude) of Lingkabau FMU. In Tawau Hills Park, Bornean yellow muntjac occurs in the lowlands, and is replaced by Red muntjac above 800 m altitude (Q. Phillipps pers comm). Although the natural distribution of these two muntjac species in Sabah is allopatric, since it can be affected by altitudinal and logging effects, the situation is termed 'partially sympatric' by Phillips and Davies (in press), with Bornean yellow munjac being common in lowlands and hills while Red muntjac prefer hills and mountains. When there is an altitudinal gradient, with change of vegetation type from foothills upwards, as encountered in the Tawau Hills Park, Sabah, or Gunung Palung National Park, in West Kalimantan (Selwyn 2020), Bornean yellow muntjac dominates at lower elevation, while Red muntjac becomes common at higher altitudes. Heydon (1994) working in Ulu Segama Forest Reserve, Sabah, claimed that Bornean yellow muntjac is mainly a fruit eater while Red muntjac is a browser. This dietic preference may explain the presence of the former being attracted to feed under a fig tree at 900m altitude in the Tawau Hills Park where Red muntjac is normally found.

The allopatric distribution of the muntjacs in Brunei Darussalam has bearing on their conservation and protection in the country. Owing to the effective gun law, illegal hunting of muntjacs is by use of snares and long lines of nets stretched out on the ground in

the forests. Though *M. atherodes* is categorised NT (Not Threatened) by the IUCN Red List and *M. muntjak* as LC (Least concern), their role and importance in forest regeneration as understorey browsers cannot be underestimated. Defaunation of the Lambir forest through hunting of >20% of large mammal fauna (>1kg) and >50% large bird fauna (Harrison 2011) has shown changes in tree population, spatial structure and forest dynamics leading to a decline in local tree diversity over time (Harrison *et al* 2013). The protection of these small deer by Wildlife Law, will have long term implications on the survival of the ancient and diverse forests of Brunei Darussalam.

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Fig. 1. Cropped camera trap image of a male Bornean Yellow Muntjac in Sg. Ingei Conservation Forest. Note straight spike-like antlers, no frontal tufts, dark forehead that continues as a dark diffuse dorsal stripe along ridge of back.

Fig. 2. Camera trap image of a female Bornean yellow muntjac in Sg Ingei Conservation Forest. Females do not have antlers; Note dark forehead between the ears, dark dorsal stripe, body colour tone similar to the colour of the legs.

Fig. 3. Camera trap image of a fawn of Bornean Yellow Muntjac (cropped) in Sg. Ingei Conservation Forest. The fawn can be identified by rows of spots or blotches on the dorsal region.

Fig. 4. Top – Skull of a male Bornean yellow muntjac showing spike-like straight antlers, lacks basal burr and never has a branch or tine.
Below – Skull of a female Bornean yellow muntjac. A female does not have antlers.
(Skulls were prepared by BB Ang)

Fig. 5. Camera trap image of a male Red Muntjac.
Note dark reddish-brown body colour, one long antler with a small tine at the antler base on the left pedicel, dark legs, 2 black facial lines extending up the furred pedicel, bright orange occipital region and prominent frontal tufts; antler on the right pedicel has been probably shed.
(Fraser's Hill, Selangor, Malaysia. Courtesy S. Hogg).

Fig. 6. Camera trap image of a female Red Muntjac from the Ulu Temburong National Park, Brunei Darussalam. Note the reddish-brown body colour, prominent black eyebrows, pale orange-brown occipital region between the ears and dark legs.

Fig. 7. A comparison of a skull of a male (Bornean yellow muntjac above) with that of a frontlet of a male Red muntjac (below)
Top – Skull of a male Bornean yellow muntjac showing spike-like straight antlers from forests near Melilas, Belait District, Brunei Darussalam (skull prepared by BB Ang).
Below – Part of a frontlet of a male Red muntjac showing the main curved antler with a small tine and a burr; holes made for mounting.
(Collected from Mount Murud, Sarawak; Courtesy of Clive Dudley)

Fig. 8. Male Bornean yellow muntjac frontlet with skin from a hunter's collection in Melilas Longhouse, Brunei (collected in 1993).

Fig. 9. Male Red muntjac frontlet without a skin from a hunter's collection in Melilas Longhouse, Brunei
(Collected in 1993).

Fig. 10. Male Red muntjac frontlet with skin from Hj Hamdan's collection (Sarawak Museum) Kuching, Sarawak
(Photograph courtesy of Lord Cranbrook).