Population Estimates of Malay Tapir, *Tapirus indicus*, by Camera Trapping in Krau Wildlife Reserve, Malaysia

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Abstract

The Malay tapir (*Tapirus indicus*) is the only Old World tapir species. Its distribution ranges from Southern Thailand and Myanmar, Peninsular Malaysia and Sumatra. Due to habitat destruction it is believed that the population density has decreased during the past two decades. There have been no specific population density studies of Malay tapir in the past. This study proposes a new method for identifying tapir individuals and estimating the population density of Malay tapir from photographs. The study took place in Krau Wildlife Reserve, Malaysia, consisting of 63.000 ha undisturbed tropical forest. Two units of camera traps were deployed at 13 different salt-licks where tapirs had been recorded. All animal species photographed were recorded and all photographs containing tapirs were analysed and individuals were identified. The results reveal that using necklines is a reliable method for identifying and distinguishing between individual tapirs. The results also suggest that tapirs frequent salt licks relatively often when compared to other species, and that any individual frequently visit salt licks more than 15km apart. The study estimated approximately 45-50 tapirs in Krau Wildlife Reserve.

Keywords: *Tapirus indicus*, Malay tapir, population estimate, camera trapping, Krau Wildlife Reserve, Malaysia

Introduction

Without the benefit of firsthand observations, researchers have traditionally had to rely on indirect evidence such as tracks or scats to confirm the presence of certain species. Recently, automatic camera trapping has been increasingly utilised in surveying a range of elusive wildlife species that are difficult to detect through direct, and even indirect, observation (El Alqamy *et al.*, 2003; Cearley, 2002; Holden *et al.*, 2003; Kawanishi *et al.*, 2002; Lynam, 1999; Sanderson and Trolle, 2005). Although camera traps provide extremely useful "presence-absence" data it does not immediately present population estimates of specific target species and, hence, offer little support in terms of population management of elusive species. However, camera traps *can* provide a method for surveying animal abundance. The combination of automatic camera trapping and capture–recapture statistical modelling has been used to estimate population sizes of many wildlife species (Carbone *et al.*, 2001; Karanth 1995; Karanth and Nichols 1998; Maffei *et al.*, 2005; Noss *et al.*, 2004; O'brien *et al.*, 2003; Silver *et al.*, 2004). Although the methodology has been used successfully in many cases, it remains fraught with possible statistical complications and assumptions about a species' behavioural ecology that are often too simplified (Jennelle *et al.*, 2002). Some of the issues that can bias estimates relate to, for example, the functional relationship between an index and density that is invariant over the desired scope of inference, estimating "effective trapping area" of large mammals, the value of random deployment of cameras when a target species is not homogenously distributed and the need for distinguishing between individuals. The latter may be of less concern in large homogenous populations when trapping frequency and probability of individuals are relatively equal. In other cases, where populations are small and where monopolisation of habitat by certain individuals occur, estimating population size from camera trapping is difficult without, at least, being able to identify individuals.

Several camera trapping studies of tapirs have taken place during the past decade (Holden, 1998; Holden *et al.*, 2003; Kawanishi *et al.*, 2002; Kawanishi *et al.*, 1999; Lynam, 1999; Navarino *et al.*, 2004) but only a few are concerned with estimating population densities of tapirs (Jafferally, 2001; Noss *et al.*, 2003; O'brien *et al.*, 2003). This is partly due to the problem of identifying individual tapirs, which is normally limited to identifying externally induced features such as scars, black and white spots and torn or missing ears. Apart from the latter, many of such features are often temporary in nature and, therefore, less useful over an extended period of time.

The Malay tapir, *Tapirus indicus*, is the only Asian representative of the World's four tapir species. The remaining three species are found in Central and South America. With a recorded weight of up to 540 kg (Lekagul and McNeely, 1977) the Malay tapir is the largest of the tapir species and the only one with a conspicuous black and white colouration. It is known to roam lowland dipterocarp forest, often relatively wet areas along small streams and river (Lekagul and McNeely, 1977; Khan, 1997) although it has also been recorded in sub-montane forest above 1500 m (PERHILTAN/DANCED, 2001). Historically the range extended through Burma and Thailand to Cambodia and Vietnam (Khan, 1997) although there have not been any observation and knowledge of tapirs by local communities and researchers in Cambodia and Vietnam in modern time (personal communication and observation). The former range is now reduced to southern Thailand and Burma (Lekagul and McNeely, 1977; Lynam, 1999), Peninsular Malaysia and Sumatra. The Malay tapir is categorized as "Endangered" on the IUCN red list (IUCN, 2006).

While many camera trap surveys have been undertaken during the past 10 years in Malay tapir range countries (Holden, 1998; Holden *et al.*, 2003; Kawanishi *et al.*, 2002; Kawanishi *et al.*, 1999; Lynam, 1999; Navarino *et al.*, 2004; PERHILITAN/DANCED, 2001) none of them have gone into details of estimating population sizes based on individual identification. Some of them, however, reveal very high capture rates of Malay tapirs in comparison with other large mammal species in West Malaysia such as wild boar (*Sus scrofa*), tiger (*Panthera tigris*), gaur (*Bos gaurus*), sambar deer (*Cervus unicolor*), Asian elephant (*Elephas maximus*) and barking deer (*Muntiacus muntjak*) (Kawanishi *et al.*, 2002; Kawanishi *et al.*, 1999; O'brien *et al.*, 2003). In some cases tapirs are even the most frequently captured species (PERHILITAN/DANCED, 2001; Kawanishi *et al.*, 2002; Kawanishi *et al.*, 1999), which has led to the belief that tapirs are one of the most abundant large mammals in Malaysia with a possible population exceeding 10.000 individuals in Peninsular Malaysia alone.

This study aims at identifying an accurate methodology to identify Malay tapir individuals from camera trap pictures and, subsequently, use these for population estimates and for potential selectivity of salt licks.

Material and Method

Study area

The study took place in Krau Wildlife Reserve, Malaysia, from August 2002 to December, 2006. Krau WR consists of approximately 63.000 ha of undisturbed lowland dipterocarp forest with the slopes of Gunung Benom (2107 m) forming the northern-western border, and Bukit Tapah (870 m) located at the southern end of the reserve adjacent to Bukit Renggit (Fig.1). Approximately 70% of Krau WR consists of lowland dipterocarp forest (Fig. 1). On two occasions tracks of tapirs were found on the slopes of Gunung Benom at an altitude of 1400 m (PERHILITAN/DANCED, 2001).

Methodology

Preliminary studies suggested that tapirs are not homogenously distributed in Krau WR (PERHILITAN/DANCED, 2001) but limited to, primarily, wet areas near small streams, swampy areas and bush. It also suggested that tapirs frequent the area around Jenut

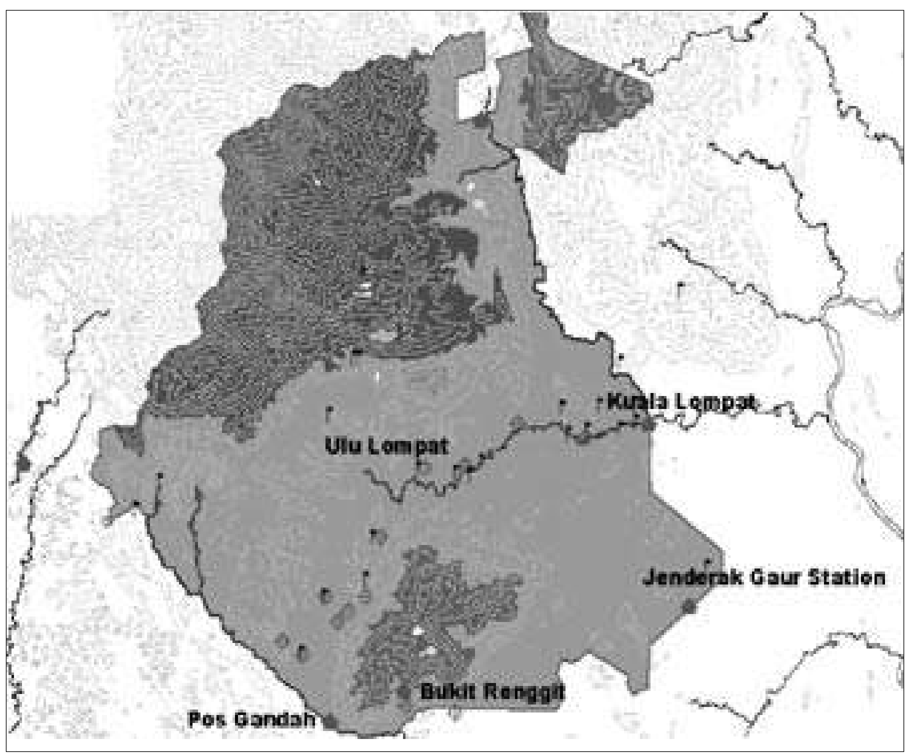


Figure 1. Krau Wildlife Reserve with key DWNP centres, salt licks (flag) and camera trapping sites (⌖). Light green colour illustrates lowland *dipterocarp* forest.

Figure 2. Flank shots of three different tapir individuals photographed at a) Wan Bulan (April, 2004), b) Neram (July, 2004) and c) Wan Bulan (April, 2004). Pictures have been desaturated and outlines have been enhanced using Adobe Photoshop CS2 revealing the necklines unique to each individual. The necklines are permanent features, which makes it useful for identification over a long time period. Necklines on left and right flank are not necessarily symmetric and therefore it is important to utilise two camera traps at each site to ensure "full" identification of an individual.

Bayek (Bayek saltlick) as well as the area around west of Jenderak Gaur Station. From various trips into Ulu Lompat following the Lompat River, which is the main water way of Krau WR, our team recorded occasional presence of tapirs (tracks) although in very scarce numbers.

We deployed camera traps at 13 different sites, all of which were known as salt licks (Fig. 1). This covers the heart of Krau WR and all traps are located in lowland *dipterocarp* forest (Fig. 1). At each site, we deployed two cameras in order to capture both flanks of any animal photographed, which enabled individual identification. We deployed the cameras for 14 days before changing film, and when needed, batteries. Each camera trap consist of a 35 mm automatic camera with autofocus and flash. The camera is triggered by a passive sensor sensitive to movements up to a distance of 10 m. Each camera trap was fitted with 1-2 units of silica gel to keep them as dry as possible. A unit of silica gel was made of empty film cartridges with holes made by a pinup needle. In periods with exceptional amount of precipitation and humidity we recovered the camera traps because films ceased up within two-three days after deployment in spite of fitting the trap with units of silica gel. We utilised Fujichrome Provia 100 at the onset of the study, but due to the high cost of these films, we switched to Kodak Colour 400. Where possible all species were identified and, for tapirs, individual identification was carried out.

In order to estimate the effective sampled area where the population size (N) was estimated, we measured the mean maximum distance covered by all individuals photographed at two or more locations during the survey period as a proxy for home-range diameter (Karanth and Nichols, 2002). We used half the mean maximum distance (w) to buffer each camera trap location (following Silver *et al.*, 2004).

We refrained from using the CAPTURE programme (Rexstad and Burnham, 1991) because camera traps were not deployed randomly. In addition, we did not consider "trapability" normally distributed in relation to trapping site and, therefore, it is a less useful measurement in a scenario where individuals and/or individuals have strong affinity to certain sites.

Individual identification

Tapirs were identified from permanent body marks such as damaged ears and scars as well as on the neck lines (Fig. 2a-c). We did not utilise colour patterns on the hind part of the animal (Navarino *et al.*, 2004) because we found it too unreliable as the patterns change appearance according to the actual position of the hind legs. Prior to using necklines for identifying individuals we compared the patterns with five "known" individuals that were previously caught and fitted with radio-collars. Since these patterns did not change over a 2-year period, we considered them permanent "fingerprints" of a respective individual. Therefore, we assumed that the identification of necklines on Malay tapirs could be employed as a very useful fingerprint as they appear as unique to each individual as the palm lines are in human beings and whisker patterns are in lions (Kissui and Packer, 2004; Pennycuick and Rudnai, 1970). However, these lines can only be significantly observed on a flank-photograph of an individual and within a certain angle. Therefore, it is important that other features (scars, broken ears) are considered at the same time.

Each individual was identified from both left and right flank whenever it was possible. In some cases, flank shots were absent, but still allowed identification of the respective individual because, for example, it was a picture frame from a serious of pictures showing the same individual. In other aspects, a single frame revealing only a glimpse of an ear was enough for identification if this matched a clear picture of a known individual.

Results

A total of 1108 trap nights yielded 665 pictures of various animal species, humans and "ghosts". Out of this, we recorded a total of 14 species of mammals and one bird species (Tab. 1). Malay tapirs were recorded significantly more often (291) than any other animal species ($p<0.05$, t-test matched pairs), followed by barking deer (95) and wild boar (62) (Fig. 3). Although herbivores such as tapir and barking deer were very common at Bayek saltlick sambar deer, *Cervus unicolour*, was only recorded once (December, 2002).

In spite of being the most frequent photographed species, tapirs were only recorded at five different salt licks (Fig. 4) in contrast to barking deer (Fig. 5) and wild pigs that was recorded at nine and six different sites respectively.

All of the five different salt licks where tapirs were recorded were located in the south-western part of Krau WR. Apart from Wan Bulan the remaining four trap sites, where tapirs were recorded, are situated relatively close together (Fig. 5). Barking deer showed much wider distribution in Krau WR and was recorded south of Bukit Renggit to the interior of Krau WR in Ulu Lompat (Fig. 6).

Of the 291 pictures of tapirs 82% could be identified as belonging to only 18 different individuals, whereas 18% did not allow for individual identification. This was primarily due to rear shots and/or unclear pictures. Although many of them could be ascribed to some of the identified individuals with relatively certainty, we chose to treat them as "unidentified", because the time intervals between two, or more, picture frames on which they occurred were too large (>10 minutes). Some individuals (e.g. number 1, 3 and 9) were recorded repeatedly throughout the entire period from 2002 until 2006, whereas others were often recorded more than a year apart.

The largest total number of pictures showing any species was recorded at Bayek saltlick (Fig. 7). We recorded 224 picture frames with either tapir, barking deer or wild boars at Bayek, followed by Wan Bulan (83) and Rumah Tok (39). At the remaining part of saltlicks we recorded less than five pictures of any animal species.

Bayak saltlick also exhibited the highest total number of species recorded at the nine study sites (Fig. 8). Rare species such as tiger, *Panthera tigris*, and leopard, *Panthera pardus*, were recorded only once at Bayek saltlick, whereas Malayan sunbear, *Helarctos*

Table 1. The list of species photographed by camera traps during the survey.

Species		
	English name	**Latin name**
1	Malay tapir	*Tapirus indicus*
2	Tiger	*Panthera tigris jacksonii*
3	Leopard	*Panthera pardus*
4	Sun bear	*Helarctos malayanus*
5	Common Palm civet	*Paradoxurus hermaphrodites*
6	Malay civet	*Viverra tangalunga*
7	Banded palm civet	*Hemigalus derbyanus*
8	Wild boar	*Sus scrofa*
9	Mouse deer	*Tragulus sp.*
10	Barking deer	*Muntjiacus muntjak*
11	Sambar deer	*Cervus unicolour*
12	Water buffalo	*Bubalus babalis*
13	Common porcupine	*Hystrix brachyura*
14	Pig-tailed macaque	*Maccaca nemestrina*
15	Great argus	*Argusianus argus*

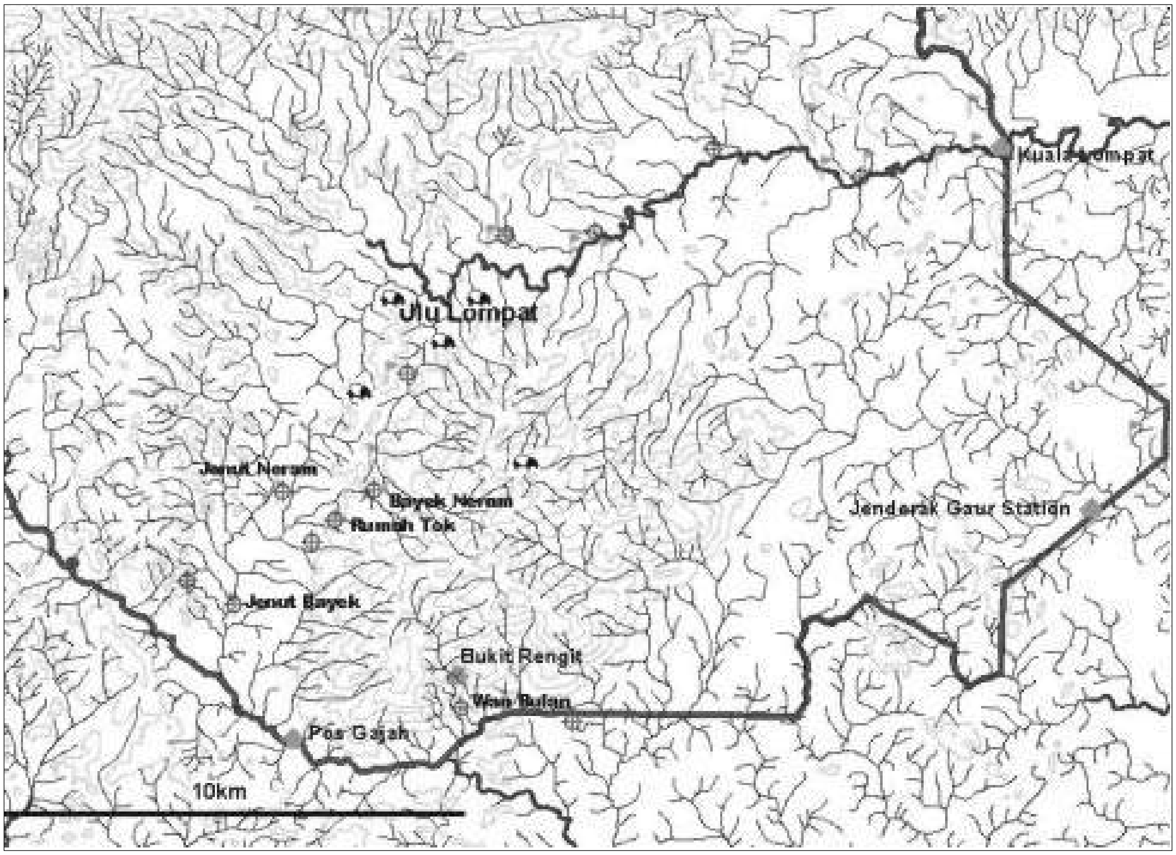


Figure 5. Krau Wildlife Reserve with key DWNP centres, salt licks (green flags) and camera trapping sites (red ⌖). Malay tapirs were recorded at the five salt licks Neram, Bayek, Tok, Bayek-Neram and Wan Bulan.

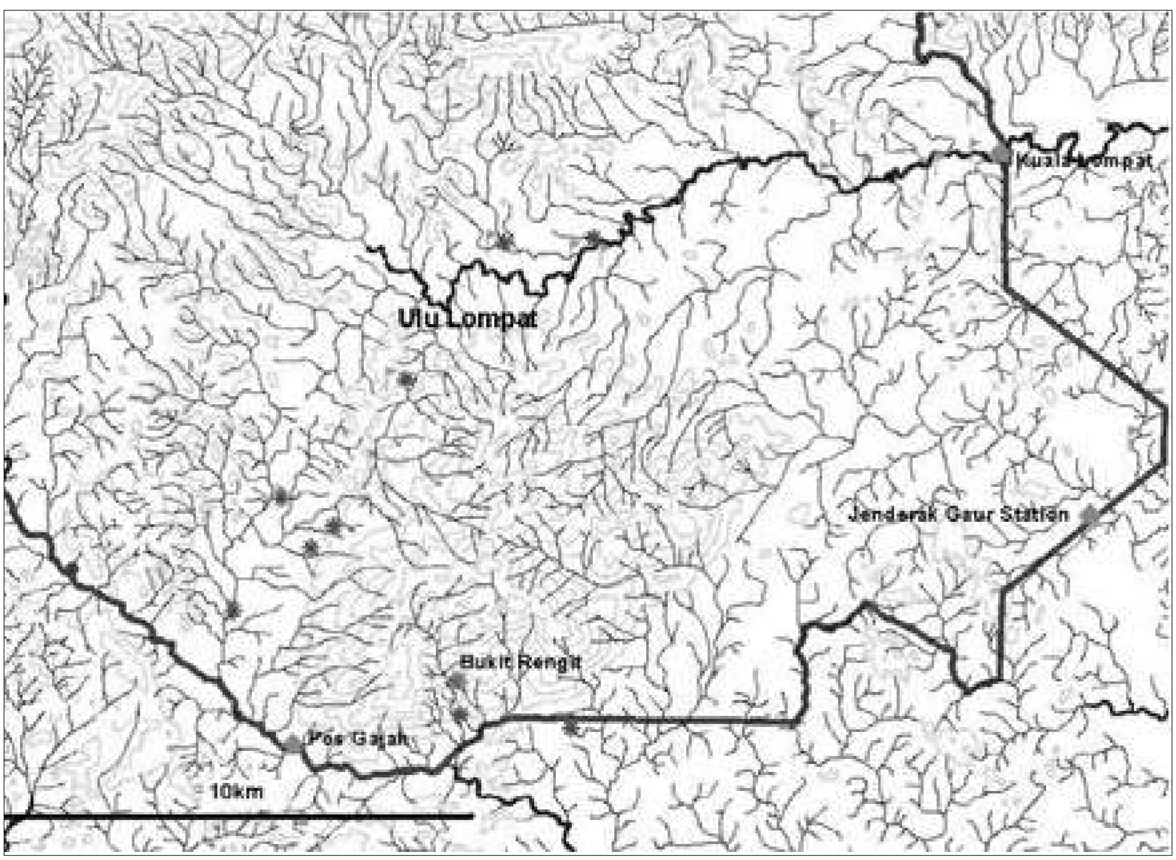


Figure 6. Krau WR with key DWNP sites, salt licks (green flags) and camera trapping sites (✱) where barking deer was recorded.

malayanus, was recorded twice (Neram and Padang Seladang). Six species were recorded at Neram whereas five species were recorded at Wan Bulan and Rumah Tok (Fig. 8).

Of 18 known tapir individuals, 13 visited Bayek saltlick at some point in time. This was the highest number followed by Neram (8) and Wan Bulan (6) (Fig. 9) suggesting that Bayek saltlick is a key area for tapirs in Krau WR.

The accumulated number of newly recorded individuals appeared to reach a saturation point in the beginning of 2006, indicating that no new – or very few - individuals frequent the salt licks (Fig. 10). Similarly, the number of newly recorded individuals at Bayek reached a saturation point at more or less the same time (Fig. 10).

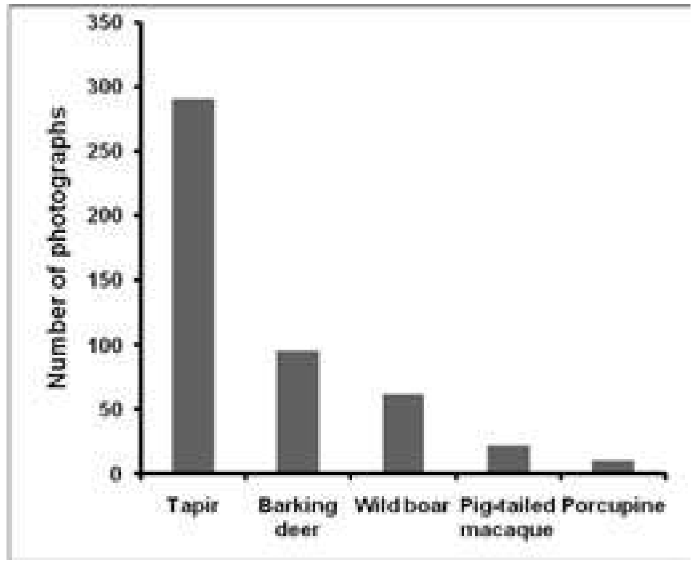


Figure 3. The five most frequently photographed animal species recorded during the study. Tapir was photographed significantly more often than barking deer (p<0.05, Student's t-test, 2-tailed matched pairs). All other species listed were recorded only once (tiger, leopard, banded palm civet, common palm civet, great argus) or twice (sun bear, Malay civet, mouse deer).

Discussion

Few studies have attempted to make population estimates of Malay tapirs from camera trapping. It is partly due to the fact that nobody has previously developed a reliable method allowing for individual identification of Malay tapir individuals and, consequently, population estimates have often relied on "indirect" data (e.g. trapability estimates, frequency capture). This has often resulted in an overly optimistic estimate of populations (Kawanishi et al., 2002) and the belief that tapir may be more abundant than is the case.

Using necklines as means of identification has proven exceptionally useful in this study. Although flank shots of individuals are important for clear identification, a big advantage is that these lines are permanent features of an individual. This study has recorded individuals in 2002 throughout 2006 and in some instances with 1-2 years interval at different sites. Using necklines alone can account for approximately 50% of all individual identifications, whereas additional features such as permanent body scars and ear damages are critical in supporting and reassuring correct identification of individuals on non-flank pictures. As is important for the identification of tigers (Karanth, 1995; Karanth and Nichols, 1998) two cameras are needed for "full" identification of tapirs, because there is no symmetry between the left and right flank necklines.

Previous camera trap studies often captured tapirs in large numbers, often as the second or third most frequent species photographed (Kawanishi et al. 2002; Kawanishi et al., 1999; Holden et al., 2003). These studies have often followed a randomized deployment of cameras and as such it was expected that tapirs would trigger camera traps as frequently when deploying cameras at saltlicks. However, tapirs appeared three times more frequently on photographs than any other species in this study (Fig. 3). This only account for the number of picture frames recorded with tapirs and does not take into consideration the number of individuals in the picture. However, three rolls of 36-frame films reveal a couple of tapirs feeding right in front of the cameras, which accounts for almost 100 "excessi-

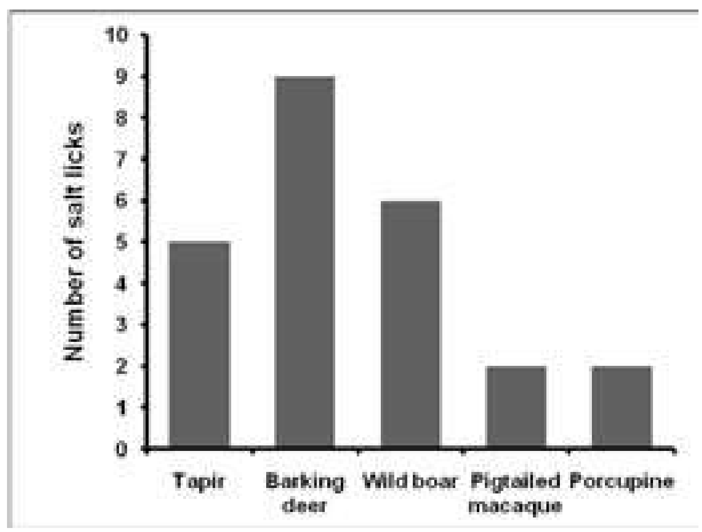


Figure 4. The presence of the five most frequently photographed animal species at various salt licks in Krau WR. Barking deer was recorded at the highest number of salt licks (9) followed by wild boar (6) and tapir (5).

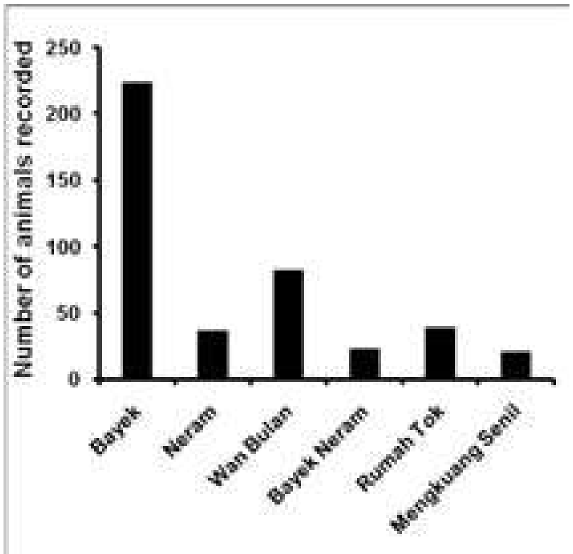


Figure 7. The combined number of tapirs, barking deer and wild boars recorded at the six different salt licks.

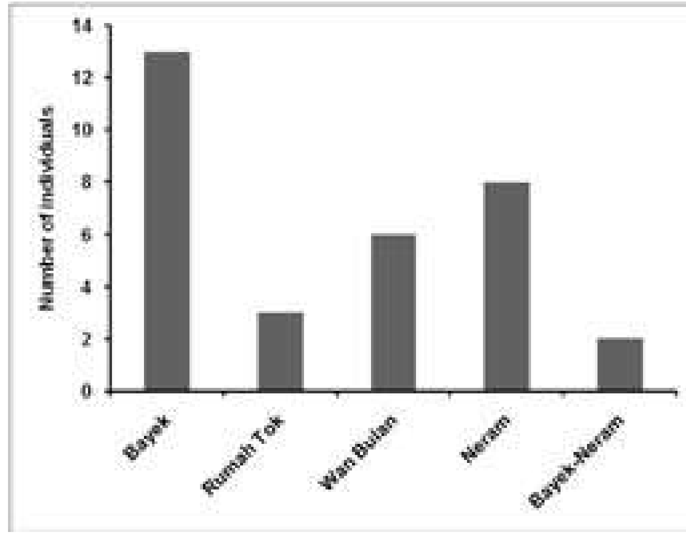


Figure 9. The number of different tapir individuals recorded at five different salt licks in Krau WR.

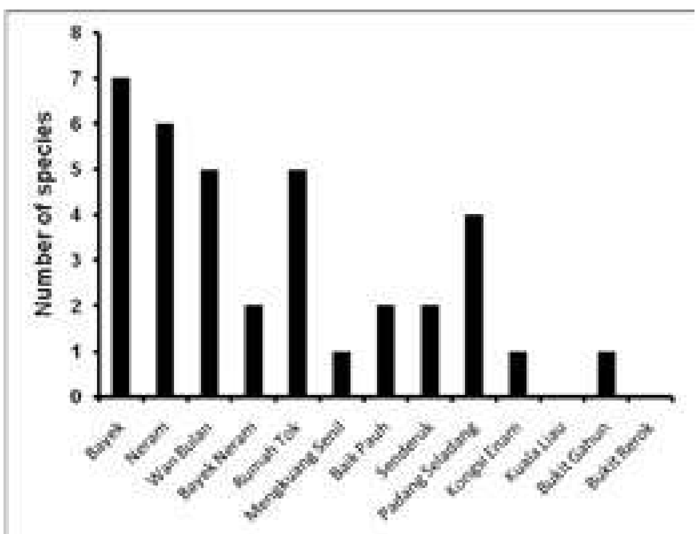


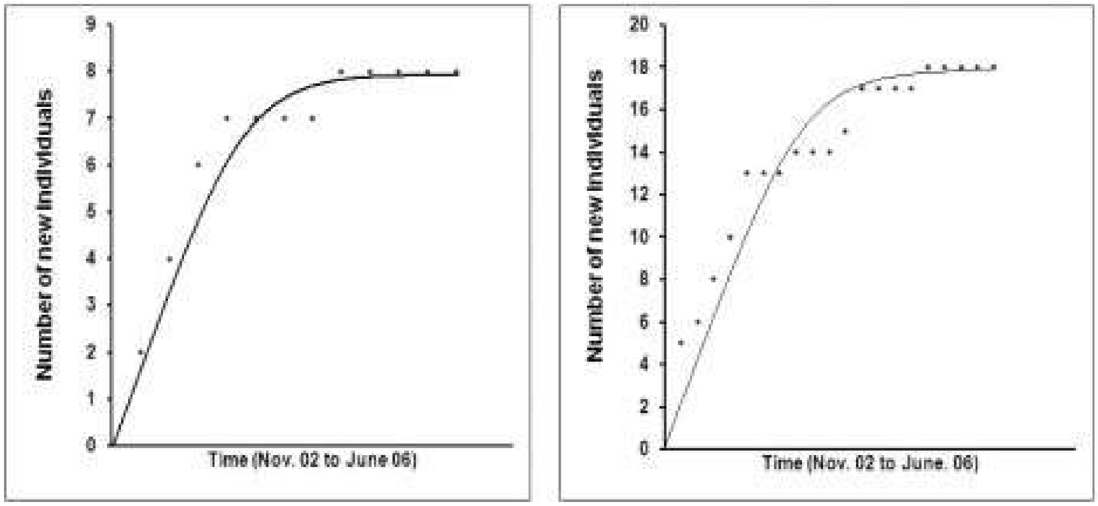
Figure 8. The number of different species recorded at every camera trap site in Krau WR between 2002 and 2006.

ve" pictures. If these individuals are omitted, tapirs are still twice as frequent visitors at the various saltlicks than the second most frequent animal species (barking deer).

This, combined with the results that the same individuals are recorded at different saltlicks, suggests that saltlicks in certain areas are critical for tapirs, and that, once the circumstances are right, they return to the same site repeatedly over an extended period of time. The accumulated number of newly recorded individuals appears to reach a saturation point in 2006 overall as well as in Bayek alone, which indicates that tapirs exhibit relatively permanent home-ranges. Considering that most identified individuals visited a saltlick approximately every 3-4 months it is reasonable to believe that all tapirs in an area will be captured on photograph within a year. Therefore, a population estimate using camera traps can approximate "direct" counting and provide a very accurate population estimate. The main variable that can influence the estimate significantly is the "effective" trapping area covered by the 13 trap sites. Following the procedure described by Silver *et al.* (2004) the 13 trap sites covered an effective area of 484.30 km^2, which constitutes 77% of the entire reserve, or corresponds to an area of equal size as the entire lowland *dipterocarp* forest area. As such, if we assume that the effective trapping area is representative in terms of size, and assuming tapirs are homogenously distributed across the entire reserve extrapolation of this study's data will result in a population estimate of 25-30 individuals. The assumption, however, is unlikely to accept in reality, because tapirs have not (yet) been found above 1600 m and are not homogenously distributed (PERHILITAN/DANCED, 2001). Even if they are found at higher altitudes, they are likely to be occasional visitors rather than "resident" individuals with a permanent home-range at that altitude. The estimate of effective trapping area following Silver *et al.*, (2004) did not seem to provide useful results in this study.

The question of how large an area our camera trapping effectively covered remains? This study revealed a heavy preference by tapirs towards the south-western

Figure 10. The accumulated number of new tapir individuals recorded at Bayek salt lick (left) and in total (right).



corner, with most frequent visits to Bayak and other nearby saltlicks (Neram, Bayak-Neram, Rumah Tok) and this is consistent with the results of the survey undertaken in 2001 (PERHILITAN/DANCED). The 2001 survey covered the entire Krau WR at all elevations and revealed two primary tapir areas, Bayek, and the area around Jenderak Gaur station. Considering that the two primary sites are of similar topographic composition and size, it could be assumed that the Jenderak area contains a similar number of tapirs (18±2) as we recorded in the Bayek basin. This suggests there are approximately 35-40 individuals within the two primary tapir areas alone. In addition, our study recorded tapir tracks – albeit very few – in Ulu Lompat, as well as in areas north of Lompat, which suggests, with reasonable certainty, that Krau WR contains individuals other than the "resident" individuals at Bayek and Jenderak areas. This, however, does not exclude the possibility that the few individuals recorded in Ulu Lompat can be some of the individuals recorded in Bayek as well, and further studies are needed to cast light on this issue. Considering they are not from the Bayek or Jenderak area, it is realistic to assume that the tapir population in Krau WR reaches 45-50 animals.

Bayek saltlick appeared to be the most attractive of all the salt licks. However, since the number of trap nights (<75) at Bayek were higher than, for example, that of Padang Seladang (>25) in Ulu Lompat, it could indicate that the bias towards Bayek, in relation to the number of pictures captured, is caused by the higher number of trap nights. Whilst this provides part of the explanation for the significant difference in number of species, total number of animal visits and total number of individual visits between Bayek and trap sites in Ulu Lompat (Fig. 7-8), it cannot explain the higher number of visits to Bayek in comparison with, for example, Neram, Wan Bulan and Rumah Tok because the number of trap nights at these sites were equal to Bayek.

This study reveals that tapirs appear to roam within relatively confined home-ranges up to, at least, four years. It also shows that tapirs are very frequent visitors to certain saltlicks and, consequently, population estimates of tapirs by camera trapping must make use of a combination of randomised grid deployment and more target specific trapping at salt licks. There are, however, many individuals that are recorded over a wider area, for example, individual No. 9 (male) was recorded at four different salt licks 11 km apart. Our data did not provide enough information to suggest that males distribute significantly more than females. There are certain trends that point into that direction, which will be the focus in the continuation of the study.

The results of this study suggest that tapirs exhibit habitat preference in Krau WR and that the area around Bayek contains advantageous resources. It also indicates that tapirs can co-exist in relatively small areas provided there are sufficient resources available. It is uncertain, however, what exactly makes the area attractive to tapirs. To answer some of these questions additional studies are being carried out on the microhabitat in Bayek area, which will be compared to that of Jenderak area and other areas in Krau WR.

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