CONTRIBUTIONS

Vocal behaviour and communication of the Malayan tapir (*Tapirus indicus*)

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Abstact

The purpose of this study was to investigate the vocal repertoire of the Malayan tapir (*Tapirus indicus*), and to describe the observed calls by physical parameters and appearance in spectrogram. Vocalizations from five animals at Sungai Dusun Wildlife Conservation Centre were recorded for 14 days, prior to morning feeding. Four distinct call types were observed, two of which were categorised as whistling-type calls, the other two call types were categorised as non-whistling-type calls. Two other whistling-type calls were observed, but it was not possible to determine whether they were different, or if their differences were due to individual differences between the animals. The effects of distance on the number of high order harmonics were studied, and showed that the higher harmonics of the whistling-type calls would be severely dampened within 50m. This, and the fact that the majority of the recorded calls were whistling-type calls with higher harmonic rather than non-whistling-type calls without harmonics, supports the hypothesis that Malayan tapirs originally were adapted to life in the open, rather than life in forests.

Introduction

Zooarchaeological evidences of Malayan tapir, *Tapirus indicus*, suggest that the species, along with Sumatran and Javan rhinoceroses, *Rhinoceros sondaicus*, roamed semi-open woodland in Southern China to the Indonesian island of Java and possibly the great plains of Sundaland (Corlett, 2010; Cranbrook, 2010, 1986; Cranbrook and Piper, 2009, 2007; Louys and Meijaard, 2010). The massive de-glaciations during the upper Pleistocene resulted in rising seawater that eventually isolated Peninsular Malaysia from Borneo, Sumatra and Java (Cranbrook, 2010; Cranbrook and Piper, 2009) forcing ungulate species into rainforest habitat. The late Quaternary concentration of extinctions, however, was not seen in Southeast Asia, where the fossil record shows losses of genera and species of large mammals extending over a long period (Cranbrook and Piper, 2011). Instead, selective pressures for evolutionary adaptation appears to have given rise to regional radiations, the emergence of new species and the local divergence of prospecies (Cranbrook and Piper, 2011). The surviving species of large ungulates e.g. Malayan tapirs, Javan rhinoceros, *Rhinoceros sondaicus*, Sumatran rhinoceros, *Dicerorhinus sumatrensis* and gaur, *Bos gaurus* likely had to adapt to rainforest habitat within a relatively short period of time and in some places with greater success than others.

Fossil evidences of Malayan tapirs, Javan rhinoceros, Rhinoceros sondaicus, and gaur, Bos gaurus, from caves on Borneo suggest the three species were present on Borneo until upper Holocene (Cranbrook, 2010, 1986; Cranbrook and Piper, 2009, 2007). Whereas hunting contributed to their extinction (Cranbrook, 2010; Cranbrook and Piper, 2009) the causes that lead to the Bornean extinction of these charismatic species remain unknown. Malayan tapir and other large ungulates may have been better adapted to semi-open woodland or savannahs that dominated Southeast Asia during the Pleistocene until the lower Holocene and if so, some physiological and behavioural traits may provide evidence of this.

Vocal characteristics can be used to assess evolutionary adaptation, systematic relationships among individuals of a species and to reconstruct their phylogeny (Barker et al., 2008; Daren et al., 2008; Geissman, 2002; Wiley and Richards, 1978). Animals use vocalization as a way of identification and communication and is common amongst social animals such as horses, primates and whales. Vocal communication, however, is also observed in species that are considered "solitary", such as the Sumatran rhino, *Dicerorhinus sumatrensis* (Penny, 1987), a close relative to the Malayan tapir. The Malayan tapir belongs to the order of Perissodactyla along with horses

and rhinos and since vocalization amongst horses and rhinos is used as a mean of communication (Lemasson et al., 2009; Budde and Klump, 2002; Metrione et al., 2007; Policht et al., 2008), and recognition (Proops et al., 2008), it is possibly important to the Malayan tapir as well. In 1965 Hunsaker and Hahn studied general vocalization in captive Lowland tapirs (*Tapirus terrestris*), but no further studies on tapir vocalization were conducted, probably due to the difficulties of studying shy, nocturnal and highly illusive animals in a dense tropical forest (Traeholt, 2008). With a well-developed sense of hearing, but poor eyesight (The New Encyclopaedia of Mammals, 2001; Grzimek's Encyclopaedia, 2003) vocal communication is likely very important for tapirs, yet the vocal behaviour and communication in Malayan tapirs is not well-understood. The purpose of this study is to describe calls used in vocal communication in Malayan tapirs (*T. indicus*) by means of physical parameters and appearances in spectrograms and to review how it associates with rainforest habitat. The possibilities for individual differences in these parameters will also be investigated, along with differences in vocal behaviour between the test animals.

Methods

The study took place in Sungai Dusun Wildlife Conservation Centre, Malaysia (SDWC). The SDWC has three enclosures at ¼Ha, 4Ha and 40Ha, respectively. Each enclosure is built around natural forest habitat.

4Ha enclosure: This enclosure is square with a clearing of approximately 1000m2 with a few palms, bushes and trees. The rest of the enclosure is dense tropical forest.

40Ha enclosure: This enclosure is semi-circular with a path next to the fence leading into the 4Ha enclosure. The habitat consists of dense tropical forest.

SDWC held six Malayan tapirs; One 1-year old male alone in the stable, one adult male in the ¼ Ha enclosure (designated as '¼Ha in the rest of the report), an adult male ('Junior') and adult female ('Pradong') in the 4Ha enclosure and an adult male ('Boy') with an adult female ('Mala') in the 40Ha enclosure.

Most vocalizations were recorded prior to feeding time when the tapirs in the 4 and 40Ha enclosures vocalized most actively. No recordings was made after nightfall, because it was impossible to distinguish between individual vocalises.

Recording methods

Calls were recorded with a Marantz PMD671 recorder and an omnidirectional Sennheiser ME60 microphone. Recordings took place for 14 days, between 07:00 and 10:00 in the morning before feeding. Individual tapirs were identified along with distances between the recorder and the animals. Recordings were made 1-50m from the study animals, at different positions:

40Ha: 0-46m in a straight line from the gate with the animal visible within 15m from the gate at all times. This recording site was covered by tree canopies, and had some background noise primarily from insects.

4Ha: 1-2m from a marking stick placed on the inside of the enclosure.There was considerable background noise primarily from insects, but no canopy cover.

Calls were described by their duration, frequency range and the number and shape of harmonics. All measurements and readings were done manually in Batsound – Sound Analysis v. 4.01©.

Results

The calls were categorized into six different call types. Four whistling-type sounds: whistle, whine, squeal 1, squeal 2 and two non-harmonic sounds: burp and hiccup. These six types were distinguished with respect to appearance in the spectrogram (Figure 1), along with frequencies and duration (Table 1). A seventh type of call was also observed; a composite call (different whistling-type calls ending in one of the two non-harmonic calls), but there was not sufficient data for measurements.

The whistle is a harmonic whistling sound that has a stable, well defined f_{min} throughout its duration, and a somewhat stable f_{max}. The whine starts out as a harmonic whistling-sound and then turns into a downward sweep. F_{max} for this type of call shows a declining trend from the beginning to the end of the call. Both whistle and whine are easily distinguished from the other six types of calls by their appearance in the spectrogram.

Squeal 1 and squeal 2 are very similar in appearance; they both start out as harmonic and then turn into a downward sweep. There is a great variation in the appearance of these two calls with a graduation from calls beginning with an upward sweep turning into a downward sweep, to calls with a short stable f_{max} turning into a downward sweep. The two calls differ significantly (Welsh variance-weighted ANOVA) from each other in duration, and f_{max} (See Table 1 for values of f_{max}, f_{min}, f_{Emax} and duration). Neither F_{min} nor f_{Emax} for the two squeal-type calls are significantly different from each other.

Several higher order harmonics were observed for the whistling-sounds; for the whistle up to eight harmonics were observed (1st harmonic and 7 higher orders), for whine up to eight harmonics, squeal 1 up to five harmonics and for squeal 2 up to six harmonics were observed.

The two types of non-harmonic calls had a larger variation in their f_{max} than the whistling sounds. F_{min}, f_{Emax} and durations for these two types of calls can

Table 1. F_{max}, F_{min} and F_{Emax} of the 1st harmonic are shown in kHz and duration shown in seconds for the six call-types; whistle, whine, squeal 1, squeal 2, burp and hiccup. All shown with ±1SD. The sample sizes (n) for the different call-types in the particular comparisons for the different call types are shown to the right of the compared parameter.

Type	F_{max} (kHz)	n	F_{min} (kHz)	n	F_{Emax} (kHz)	n	Duration (s)	n
Whistle	3.0 ±0.4	59	2.0 ±0.3	59	2.2 ±0.4	59	0.48 ±0.11	59
Whine	2.9 ±0.2	53	0.5 ±0.2	52	2.2 ±0.4	53	0.70 ±0.16	53
Squeal 1	3.9 ±0.2	12	0.5 ±0.2	8	3.1 ±0.9	14	0.29 ±0.07	14
Squeal 2	3.2 ±0.2	50	0.8 ±0.5	33	2.7 ±0.4	50	0.46 ±0.07	50
Burp	2.4 ±0.5	3	0.8 ±0.1	3	1.6 ±0.2	3	0.58 ±0.21	3
Hiccup	5.7 ±2.6	10	0.6 ±0.6	11	1.1 ±0.5	14	0.34 ±0.11	14

be seen in Table 1. The burp-type call is seen as a somewhat long, flat and dense call with frequencies that do not fluctuate with the duration of the call, as it is seen with the whine, squeal 1 and squeal 2. The hiccup is composed of two well defined narrow vertical parts, with the two parts separated.

According to the Dunnett's T3 multiple comparison, the burp-type calls are significantly lower than hiccup and Squeal 1 concerning f_{max}. The hiccup-type calls were not significantly different from any of the whistling sounds concerning f_{max}. Burp-type calls were significantly lower than the whistle-type calls regarding f_{min}. F_{min} for both non-harmonic calls were significantly lower than whistle-type calls ($p<0.0001$) With respect to f_{Emax}, burp and hiccup did not differ from each other, but they were both significantly lower than the four whistling sounds ($p<0.0001$).

A comparison of the four parameters (f_{max}, f_{min} f_{Emax} and duration) for whistle-type calls produced by the two females 'Mala' and 'Pradong' showed that f_{Emax} was significantly different between these two individuals (*Welch's* $p=0.0337$).

The number of harmonics were also counted at different distances for the three whistling-types. These data showed that the average number of harmonics for 'Whistle' declined significantly from 6 ±1 harmonics at distances of 11-15m to 1 ±0 harmonics at distances of 46-50m (*One-way ANOVA* $p=0.0004$), no data were available for 0-5m and 21-45m. Squeal 1 showed no significant decline in average number of harmonics at distances of 6-10m and 16-20m (*One-way ANOVA* $p=0.8546$). Squeal 2 showed a decline in the number of harmonics between distances of 6-10m and 16-20m, but not between 11-15m and any of the two (*Welsh's* $p= 0.0114$).

Several observations of behaviour were made; 'Mala' was observed repeating the whine-type calls repeatedly for up to 60min, stopping only when she got fed. She would remain 10-15m from the gate, pacing in the area where she would normally be fed.'¼Ha' was observed one morning facing the back of the ¼ Ha enclosure and into the 4Ha enclosure, producing whistling-type calls. Facing the back of his enclosure meant that he was turned perpendicular to the usual calling direction. The two individuals in the 4Ha enclosure, 'Pradong' and 'Junior', had not appeared yet, and it seemed as if he was calling for them rather than for food. '¼Ha' and 'Junior' would often touch each other through the fence in the morning when 'Junior' appeared, as if to greet each other.

Discussion

Prior to morning feeding six different signals were recorded and described by the maximum frequency of the 1st harmonic (f_{max}), the minimum frequency of the 1st harmonic (f_{min}), the frequency with the highest energy in the 1st harmonic (f_{Emax}) and the duration of the 1st harmonic. The six different calls were; whistle, whine, squeal 1, squeal 2, burp and hiccup. Another type of call, the composite call, was also recorded, but there was not enough data to measure all four parameters.

The comparisons of appearance and the four parameters show that whistle, whine, burp and hiccup are clearly different types of calls. The duration for whistle is shorter than whine and burp, but this might not be a meaningful measurement. An estimate of the duration in the spectrogram suggests that the duration should be around 1.0s, rather than 0.48s. It seems that there is a bigger gab between the maximum energy and the average energy in this call type, than there is in the other call types, thus making the measuring method inadequate for this call type. The method was used because it was considered the best general method and seemed to be accurate with respect to the other five signal types. Of 30 whistle-type calls, 'Mala' and 'Pradong' produced almost half of the calls each (only a few were produced by '¼Ha and 'Junior').

An individual comparison of the four parameters for whistle-type calls coming from 'Mala' and 'Pradong' showed significant difference between 'Mala' and 'Pradong' for f_{Emax}, but not in any of the other three parameters. This suggests individual difference in this type of call, although the main sound components (f_{min}, f_{max} and duration) are similar i.e. there is a difference

in "pronunciation". Unfortunately, the sample sizes in the parameter comparison for the whistle-type signals were small i.e. 'Mala' = 10 calls, and 'Pradong' = 8 calls, respectively.

All identified 'whines' were produced by 'Mala'. Considering the circumstances during which she was whining, it appeared as if she was calling for food rather than directing it at other tapirs. This type of call could be some kind of begging/calling for food, and it is important to study if this kind of call is used by other adult individuals in other situations, or if used by young tapirs still suckling, thus begging for food or attention.

Although very similar in appearance, squeal 1 and squeal 2 had significantly different f_{max} and durations, suggesting that these are indeed different types of calls. The squeals do not differ significantly at f_{min}, but since "whistle" does, they are easy to distinguish from "whistle". Squeal 1 and squeal 2 are not different in f_{Emax} either. 'Pradong' was responsible for 90% of the 10 squeal 1-type signals, and 'Mala' was responsible for the last 10%. 'Mala' was responsible for 89% of 47 squeal 2-type signals and 'Pradong' was responsible for 4% and this suggests that the differences in f_{max} and duration between squeal 1 and squeal 2 are an expression of individual differences rather than differences between signal types. Unfortunately the sample sizes for squeal 1 were small (12 f_{max} signals, 14 duration records and 10 for comparison of distribution between the five recorded individuals), whereas the sample sizes for squeal 2 were 50 signals for both f_{max} and duration, and 47 for comparison of distribution between individuals squealing making it a more meaningful sample size.

The f_{Emax} of both non-harmonic calls (burp and hiccup) are significantly lower than the four whistling-type signals. The f_{max}-value is the only parameter that is significantly different between the two non-harmonic calls, despite the large variance in f_{max} for the hiccup. Despite the small sample size for "burp calls" the different spectrograms appearances implies that the two non-whistling-type calls are different from each other.

Whereas composite-calls were recorded there was not enough data to describe these call-types. All recordings were made in the morning just before feeding, and three composite calls were recorded, which suggests that the Malayan tapir make use of additional call-types than were recorded in this study.

Hunsaker& Hahn (1965) conducted at study on vocalization of South American tapirs (*Tapirus terrestris*) in San Diego Zoo and recorded four different signal types. One of these was defined as a "sliding squeal". This call type had a F_{Emax} (dominant frequency in Hunsaker& Hahn) and duration quite similar to the squeal 2-type signal recorded in this study. Hunsaker& Hahn (1965) also described a non-harmonic call, which they called "species specific clicks". This signal appears in the spectrogram similar to the "hiccup" in this study; with two narrow vertical lines, slightly apart (Hunsaker& Hahn, 1965). Frequency range and duration is also similar to the hiccup-type call described in this paper. This indicates that these two call-types could be similar for the two species, perhaps sharing vocal evolution as suggested in gibbons and birds (Konrad and Geismann, 2006; Podos et al, 2004). Unfortunately, Hunsaker& Hahn (2006) did not describe the measuring method in their paper, and it is uncertain if it corresponds to the measuring methods used in this study. Consequently, it is not possible to conclude that similarities and differences in the calls between Malayan and South American tapirs are due to different sampling methodologies or because they are closely related species.

Comparisons of the number of higher order harmonics (including 1st) at different distances for the whistle-type calls and squeal 2 show that there is a significant reduction in the number of higher harmonics over distances of approximately 20m. At 45-50m only the 1st harmonic would be visible in most calls, and it would be distorted in some calls (the distorted calls were not used in measurements of the four parameters). There was not sufficient data to compare parameters for the non-harmonic calls at different distances with the whistling-type calls or compare calls recorded with or without obstacles in the form of trees and bushes. However, since sound of low frequency travel further than sound of high frequency in air and are damped less by physical obstructions, low frequency calls are expected to be less effected than the whistling-

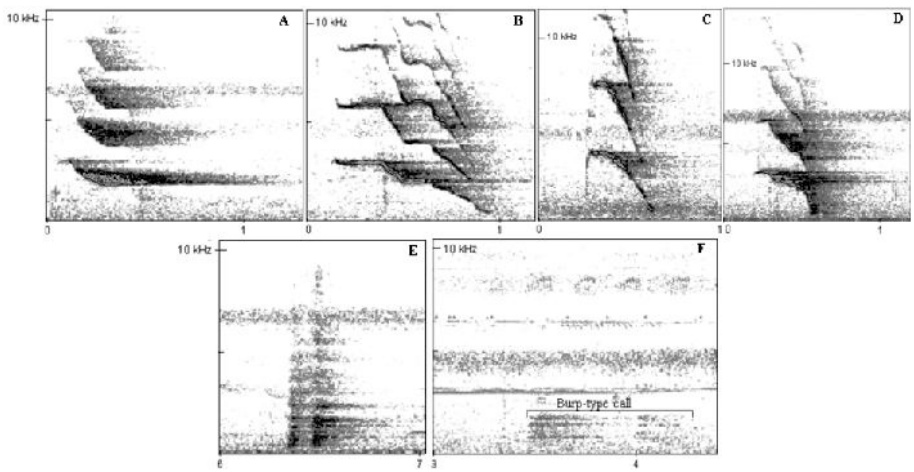

Figure 1 A: whistle, B: Whine, C: Squeal 1, D Squeal 2, E: Hiccup and F: Burp. Spectrograms are taken fromBatSound ©, Hanning window FFT size 1024, with time (seconds) on the x-axis and frequency (kHz) on the y-axis (note that the different spectrograms have different scales).

type calls and, hence, more effective in tropical rainforest habitats. If low frequency vocalisation is indeed more effective in a forest environment, it is interesting that out of 336 categorized calls 85% are high frequency whistling-type calls. This could indicate that vocalisation is not sufficiently important for the survival of Malay tapirs to affect evolutionary fitness, or Malay tapirs are still in the evolutionary process of adapting to rainforest habitat. The Malay tapir's tendency to use high-frequency vocalisation may be a rudiment from its original adaptation to semi-open deciduous forest habitat that dominated Sundaland until 10.000 years ago (Corlett, 2010; Cranbrook, 2010, 1986; Cranbrook and Piper, 2009, 2007). In an open habitat the high frequency sounds do not have the same draw backs as in forested habitat.

There is also the possibility that tapirs only use vocalization for short-distances communication, in which case, the distortion of the calls will not be significant. Tapirs are considered solitary and the evolution of "social communication" is unlikely to take place. There are incidents, however, were adults accompany each other during mating season, and it is likely that these individuals use vocalization to communicate with each other. 'Pradong' and 'Junior' were often seen more than 50m apart in the 10 acre enclosure and the male in the ¼ acre enclosure was observed calling in a direction towards the 10 acre enclosure before 'Pradong' and 'Junior' showed up for their morning feed. The male in the ¼ acre enclosure and 'Junior' would often greet each other through the fence in the morning. 'Mala' and 'Boy' (in the 100 acres) also spent time apart and together, with 'Boy' only occasionally showing up for morning feeding. This is, of course, not a natural environment, with 'Pradong' and 'Junior', and 'Mala' and 'Boy' confined to enclosures with supplementary feeding, but the 100 acre enclosure makes it possible for the animals to exhibit a large part of their natural behaviour, including avoiding each other.

This study reveals that Malay tapir utilizes at least four different and distinct call-types in their vocal repertoire - whistle, whine, burp and hiccup – with a few more types of call undetermined. Whether the differences between squeal 1 and squeal 2 is due to individual differences between animals or whether they are in fact two different call-types cannot be determined in this study.

Distances of 50m had a dramatic effect on the number of higher harmonics in the whistling-type calls, indicating that these types of calls might not be well suited for life in the tropical forest. Whereas this study aimed at describing the vocalization of Malay tapirs, the limited samples size and study duration made it impossible to capture the entire scope of vocalization and communication in the Malayan tapirs. Data from more individuals under different circumstances, for example at aggressive encounters, mating or between mother and young, is necessary in order two fully describe the vocal communication and behaviour of the Malayan tapir.

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Displacement of the Malayan Tapir (*Tapirus indicus*) in Peninsular Malaysia from 2006 to 2010

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Introduction

Peninsular Malaysia is the centre of the Malayan Tapir's, *Tapirus indicus*, distribution range. Tapirs are found in every forest type, including peat swamps up to lower montane forest (Holden et al., 2003; Kawanishi et al., 2002; Novarino et al., 2004; Traeholt and Sanusi, 2009; Williams, 1979). The Department of Wildlife and National Parks' (DWNP) wildlife inventories have recorded signs of tapirs in lowland areas and up to 1430m near Gunung Tahan, 1,720m at Gunung Benom in Krau Wildlife Reserve and 1730m at Gunung Bintang Hijau. Tapirs were recorded in forest fringes as well as logged disturbed forest, and occasionally passing through rubber and oil palm plantations. William and Petrides (1980) reported that tapirs were found in all states of Peninsular Malaysia, and although its current distribution range, according to states, remains similar, its effective range has been reduced to primarily the main range, Belum forest complex (including Ulu Muda), greater Taman Negara forest complex, Pahang peat swamp forest and Endau-Rompin forest complex (DWNP, 2009).

The first report on displaced Malayan tapir in Peninsular Malaysia was published in 1991 (Zainal Zahari *et al*., 2001) and to date, this remains the only study on large mammal displacement in Peninsular Malaysia. It reviews displacement of Asian elephant (*Elephas maximus*), Sumatran rhinoceros (*Dicerorhinus sumatrensis*) and Malayan tapir (*Tapirus indicus*) suggesting that the trend of displacement of large mammals in Peninsular Malaysia follows a standard pattern; an initial increase followed by a slight decrease that reflects the possible effect of management intervention (Zainal Zahari *et al*., 2001). The study also reiterated that the displacement is related to home range size, the largest being that of the Asian elephant (*E. maximus*), followed by the Sumatran rhinoceros (*D. sumatrensis*) and, subsequently, the Malayan tapir (*T. indicus*). The estimated home range of the Malayan tapir is 13 km^2 (Williams, 1979, 1978).

Loss of habitat through forest clearing for agricultural purposes and illegal hunting are considered the main reasons for declining populations of large