

Preliminary Study on the Vocal Behavior of Mountain Hawk-eagle *Nisaetus nipalensis* in Taiwan

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Abstract

Vocalizations are one type of communication that has been widely studied in avian species. There were relatively few studies conducted on the vocalizations of raptor species. Most of these studies were focused on nocturnal species, whereas diurnal species was little known on their vocalizations. Mountain hawk eagle *Nisaetus nipalensis* is a large predator that distributed across from Taiwan, China, South-East Asian, Bhutan and India. Vocalizations of mountain hawk eagles had been described in some studies, but none of these studies provided a comprehensive outcome for later research to follow. This causes some difficulties on further studies of mountain hawk eagle. This study was

conducted in the mountain region of South-Eastern Taiwan from 2006-2010. The result reveals that mountain hawk eagles produced seven types of vocalizations based on the context and structure. Some vocalizations were also only occurred during the breeding season or can be heard near the nest. It is aimed that this study can provide systematic and comprehensive results on the vocalizations of mountain hawk eagle and the preliminary understanding of vocal behavior in terms of seasonal and geographical changes.

Key Words : Mountain Hawk-eagles; *Nisaetus nipalensis*; vocalization; raptor; Taiwan.

Introduction

Vocalizations are on one type of the communication that widely used in avian species. Most of studies conducted in the past have mainly focused on passerine species, whereas relatively fewer studies have focused on vocalizations of raptors. The previous studies of raptors included basic description of vocalizations (Thorstrom *et. al.* 1997) ; individual, sex and species identification (Odom and Mennill 2010,

Rasmussen 2012) ; responses of vocal behavior, seasonal changes and related factors (Penteriani 2001, Clark and Anderson 1997, Ramanujam 2000, McGarigal and Fraser 1985) and monitoring for population, individual and nest location (Mosher and Fuller 1996, Mosher *et. al.* 1990, McClaren *et. al.* 2003, Holschuh and Otter 2005, Navarro 2005, Grava *et. al.* 2008, Nagy 2012, Penteriani *et. al.* 2000) . Among these published studies, majority of work focused on nocturnal species. There were very few studies on diurnal species. Hence, the knowledge and understanding of vocalizations of diurnal species remained largely unknown.

Mountain hawk eagle (*Nisaetus nipalensis*) is a large diurnal raptors where mainly live in the forest. It currently distributed through China, Taiwan, south-east Asian countries, Bhutan and India (Ferguson-Lee and Christie 2001) . Two studies used to describe the vocalization of mountain hawk eagle and its context during the vocal behavior, but there is no measuring data or sonogram provided (Morioka *et. al.* 1995, Ferguson-Lee and Christie 2001) . Another two studies provided some sonogram of mountain hawk eagle, but no actual measurement or quantified data in the studies neither (Rasmussen and Anderton 2004,

Kabaya and Matsuda 1996) . None of these studies had systematic and comprehensive presentation and description on vocalizations of mountain hawk eagles. Consequently, it is difficult for later researcher to conduct the further study based on these finding. For example, Gjershaug *et al.* (2008) suggested that *N. n kelaarti* as an independent species, *n. kelaarti* based on their findings on the difference of morphological features and vocalizations. It is thought that vocal data provided by Gjershaug *et al.* (2008) did not quantize and was non-systematic, and thus weakened their results and suggestions (BirdLife International 2012) . Status of *n. kelaarti* still remained unclear. Hence, it should be the first step to establish possible vocal repertoire with proper quantized data on the mountain hawk eagles before the further questions can be addressed and figure out.

It is hoped that a complete and systematic result of vocalizations on mountain hawk eagle can be presented in this studies. Moreover, whether vocal behavior of mountain hawk eagles has seasonal or geographical difference were also analyzed in this study.

Methods

The study site is located at southern part of Central Mountain in Taiwan (Fig. 1). This area included Pingtung and Taitung County and the total area accounted for 63801.8 km². Percentage of forest area in these two counties is about 52.9 and 79 percent, respectively (Construction and Planning Agency 1992, 1998) .

Line transect survey was conducted between January 2006 and December 2008 in Taitung county. Each survey lasted at least two days per month. Vocal and non-vocal behavior was recording in each survey day started from 06:00h to 16:59h.

Apart from trail survey, two nests were found and observed at upstream region of Ta-Tzu stream between March and June 2007, and upstream of Fun-Shan stream between March and May 2010. A blind tent was set 30-70m away from the nest. Each nest was observed at least seven days a month and observation started from 05.00h to 18.59h each day. All vocalizations, vocal behavior and context of behavior were recorded through the observation inside the blind tent.

The type and numbers of calls were recorded through the observer. Same type of calls continuously produced and the silent interval was less than 30 seconds were counted as one call event. If different types of calls

were produced continuously within 30 second interval, all calls were counted as single call event. However, the detail of call type was noted in the records.

All vocalizations of mountain hawk eagles were recorded using digital recorder (Sony M-10, Sony Inc) and digital camcorder (DCR-HC90, Sony Inc.). All video data will be transformed into uncompressed video and extracted audio tracks. All extracted audio tracks were saved as wave form. Four call parameters were selected and analyzed including start frequency, peak frequency, duration and frequency range of the note. All sound files were analyzed by sound analysis software (Raven Pro 1.4, Cornell University).

Results

The call types of Mountain hawk-eagle

Seven types of call were recorded according to the call structure and the context when the call was heard or recorded. Five types of calls were successfully collected samples, whereas the other two types of calls were only heard and documented by one of the authors.

- Flying call (N=117) is the most common call heard during the study.

Each set of flying call was consisted of two different notes. The

frequency of the first note is relatively lower than the second note. Each flying call contained various numbers of sets. Generally, two- or three-set flying call were the most common calls recorded during the study period. It accounted for more than 75% of recorded samples (88/117). There is no particular season to give flying calls in mountain hawk eagle. Several occasions were found when mountain hawk eagles produced this type of call. For example, the male produced flying call while bring the food back to the nests. Sometimes, the male also produced it when it gave the food to the adult females. It is noted that adult individuals also produced flying call when they were mobbed by other birds such as Eurasian Jay (*Garrulus glandarius*).

- Nest calls contained several single repeat call notes, which can be up to 16 notes within a single call. However, it is also found that sometimes the female also produce another kind of nest call, which was consisted of two short notes as set in the call. Nest calls were often heard during the breeding season, particular when the adult female stay close to the nest. There is no data recorded outside of the breeding season.
- Food-begging call is similar to nest call, mainly contained a single note

with repeat numbers within a call. However, the frequency is higher than adult nest call. The structure of the call changed when chicks gradually grew up. The note started to have more variety in the call. Chicks normally produced this type of call when the adult brought back food, but it could start to produce this kind of call a couple minutes before adults return to nest.

- The structure of trill is a long rapid modulated call. It was normally recorded this kind of call along with flying call, but it was sometimes also recorded without accompany other types of calls. This kind of call usually recorded before pre-breeding season and when the researchers have attempted to get close to their nest. It is also noted that the author once recorded trill when both adults hunted Formosan macaques.
- Single note call: The structure of single note call is similar to the first note of flying call, but has longer duration. Most of single note calls were either produced independently or combined with other types of calls such as flying call, nest call and trills. Single note call produced when mountain hawk eagles fly. No calls were recorded when mountain hawk eagles were in other position. This type of call only

recorded during breeding season between March and June. It is noted that it is more often to be found in May.

- Alarm call: This type of call was always produced along with flying call. Adults usually produced flying call followed by one to two notes of alarm calls. The sound of alarm call sounded like " hge-hge- ". None of alarm calls were able to record as it happened pretty quickly. Observers only found these calls in two occasions. It was first found when adults flew close to the blind tent where observers stayed in 2007. The observer also found this kind of vocalizations during a banding procedure in 2010.
- High-pitch short note: This type of calls was not found in the wild individuals of this study. It only founds in the captive individual, which was raised by human-being. The exact function of this call was still not clear.

Transect survey throughout a year

A total of 174 days line transect survey was conducted in Taitung within a year. The average survey days per month was 14.5 days (3.5 to 24.5, SD= 5.53). Eighty three times of vocal events were recorded. Among

the 83 vocal events, 32 events were unable to clarify the type of calls due to the long distance between the observer and the targeted individual. The rest of 51 vocal events have clearly records on the types of vocalizations.

Other than single distinct type of calls were recorded in these vocal events, it was common to find mountain hawk eagles produced more than one types of calls within a single call event. The combination included flying calls plus thrill calls, flying calls plus nest calls and thrill, flying calls plus single note call and nest calls plus thrill calls. Among these combinations, flying calls plus thrills were the most common call combinations within the call events. Of the 51 clear vocal events, flying calls were the most common vocalizations (n=19), followed by flying calls plus thrill calls and thrill calls alone. Nearly 80% of recorded vocal events (40/51) was involved with flying calls during the line transect survey.

The number of vocalizations made by mountain hawk eagles was different within the same day (Fig 3). The peak time that mountain hawk eagles produced their vocalizations was 10.00h to 14.00h. There is little vocalizations can be heard in the early morning or late afternoon. The average call rate based on the number of call events and number of

survey days is 0.48 times/day. The call rate increased to 0.7 times/day during breeding season (March to June). It seems that mountain hawk eagles decreased their call rate started from the end of breeding season until the pre-breeding season (May to September).

Among the verified vocal events, twenty six events were maintained visual contacts. Most of the occasions when mountain hawk-eagles produced calls were involved with flying-related behavior. The behavior included cycling around, flying down and other types of flying behavior. It is noted that mountain hawk eagles produced flying call plus thrill call combination when they performed mating behavior (n=6).

Observation in breeding season of Mountain hawk-eagle

A total 51.5 days of nest observation in 2007, 2009 and 2010, with 525 times of mountain hawk eagles sound were recorded. The average call rate is 10.29 times per day. Five types of calls and eleven types of call combination within a single call event were observed during the breeding season.

The majority of the call made by the chick was food-begging call. There were a small proportion of flying call (n=7) and single long note call

(n=1) recorded during the observation. It is not these two types of calls were only recorded after 67 days old.

Call rate showed monthly change between adults and the chick. In the beginning of the breeding season, the adult has lower calling rate. It increased in April and May (7.7 and 7.86 times /day, respectively) , and then decreased in June (5 times / day). On contrast, the chick has a positive tendency to increase its calling rate with its age. In the first month after hatching, the chick only produced about 0.18 time per day. It increased to 1.4 times per day in April and 4.6 times per day in May, respectively. In the late of rearing period, the call rate of mountain hawk eagle chick increased to 8.3 times / day, which is even higher than adults. The variation of call rate made by mountain hawk eagles was also found in the time of a day during breeding season (Fig. 4). Adults usually produced their call most frequently during 0900h, which is accounted for 12.77% of total recorded calls. The second most frequent time period that adults produced their calls was 1500h. There were very few calls recorded in the early morning and late afternoon. The chick had similar calling pattern as adults, which produced calls most frequently at 0900h and 1500h.

Discussion

Studies on mountain hawk eagles often focused on flying calls. This type of calls is probably the most common vocalizations found in mountain hawk eagles, and results showed that flying calls were the only type of vocalizations documented through the whole year. The result here also suggested that mountain hawk eagles in Taiwan also produced at least another five types of vocalizations in adults and chicks during breeding season and non-breeding season. It is noted that a captive mountain hawk eagle also produced one type of vocalizations, which is never heard from wild individuals. This type of vocalization has very high-frequency with short duration. Consequently, it may not be able to transmit in long distance. As most of vocalizations collected from wild individuals were at least 30 m away, it is possible that observers may not be able to record such high-pitch calls even if wild mountain hawk eagles produced.

Most of individuals produce flying calls during their flight. One adult female in this study has found that 30% of her flying calls were produced while she stayed inside the nest or where is close to her nest. Moreover, the observer witnessed that eight times Eurasian Jays mobbed the adult

female when this female stayed and produced flying calls. It is noted that the mountain hawk eagles produced longer flying calls at such occasion. The longest call event can last more than 40 minutes. It is also found that adult males often produced flying calls before or after passing food to adult females, who is also responded to the adult male by using flying calls. A study on Ornate Hawk-eagle (*Spizeatus ornatus*) suggested that adult males tended to produce vocalizations when they flew close to their nest (Klein *et.al.* 1988). The result of this study suggested that although most of flying calls were made while mountain hawk eagles were flying, they can also produced flying calls when they in the still position. It is not clear whether the function of flying call was used to defense their territory or communication with its group member. The precise function of flying calls needed further studies to determine.

Flying calls often produced along with other types of vocalizations such as trill and alarm calls. It is not clear why mountain hawk eagle produced this series of call combination as those calls were actually produced alone in many occasions. It is neither unclear whether such combination brings different kind of functions as what it produced independently. Studies on non-human primates found several instances

that some primate species do use call combination to refer the meanings that differed from calls that produced independently (Crockford and Boesch, 2005; Arnold and Zuberbühler, 2008; Ouattara *et. al.*, 2009a). Studies also found that Campbell's monkeys (*Cercopithecus campbelli campbelli*) also used call combination to enhance the meaning of the later type of call in the call combination to other group members (Ouattara *et. al.*, 2009a; Ouattara *et. al.*, 2009b). Our results could not clarify whether the call combination found in this study is same with any cases found in primate species. Further studies needed to conduct to determine whether mountain hawk eagles is able to organize their calls to express different meaning or enhance the meaning as found in the primates.

Nest calls were only documented during the breeding season. None of adult males produced this type of vocalizations. It is possible that nest calls were only produced by adult females. It may need more observation to confirm this suggestion. If this is true, it may then use this vocalization to monitor the number of breeding pairs in the breeding season. Trill calls or other call combination were often observed when mountain hawk eagles in a strong emotion state including mating display, hunting together with pair member or when mountain hawk eagles encountered

researchers. Further experiments were needed to determine the function of these calls.

Food begging calls made by chicks had very identical structure in the first few weeks after hatching. Call structure later started to have more variations and multiple notes also occurred in a single call. One or two weeks before the chick left the nest, flying calls were also recorded. Such development suggested vocal repertoire of mountain hawk eagle may start to develop before the chick left the nest. This kind of development has been found in other non-passerine species including cranes (Klenova *et al.*, 2007) and falcon (Kemp, 1975). The question remained is whether all vocalizations were genetic determined or acquired from later social context. Further playback experiments may help in clarifying this question.

All alarm calls recorded in this study was almost followed by the flying calls. This type of call was mainly due to researcher's approaching the blind. It is suggested that population of mountain hawk eagles in southern Taiwan has suffered with high level of hunting pressure (Sun, 2005). This was resulted from the demanding of mountain hawk eagles feathers from aboriginal culture and the need of chicks for falconry eagles market in Taiwan (Sun, 2007). Consequently, adult mountain hawk eagles

during the breeding season has expressed alter behavior or even attacking behavior to humans who approached the nest (Sun, 2007; 2010). Thus, alarm calls were frequently expressed during the breeding season.

Previous work indicated tha Mountain hawk eagles in Taiwan produced calls when they encountered with Formosan macaques, Taiwan blue magpie (*Urocissa caerulea*), and Himalayan tree magpie (*Dendrocitta formosae*) (Tsai, 2007). However, there is no detailed information regarding the type of calls. It has found that female mountain hawk eagles tried to expel yellow-throated marten(*Martes flavigula chryospila*) , Eurasian jay and crested serpent eagle (*Spilornis cheela*) in our study.

Daily and monthly variation between the call types

There are more records of vocal behavior nearby nest site than that at transect in breeding period, regardless of call rate 、 the basic call types, and call combination. It may imply that the calling frequency, and numbers of call types has the special variation. Vocal behavior would be more active around the core area that close to nest site than that in the edge of the home range.

Throughout the year, overall call rate has the trend that is relatively higher in period of November-April in transect survey, this timing conform to the pre- to mid-term of breeding period of mountain hawk-eagles. The call rate of the flying call or the call combination of flying call/trill increased to the peak in November-December in transect survey, and accompanied by the wavy flight/ porpoising as courtship display. Tsai (2007) reported that mountain hawk eagles were perform courtship display, such as gliding together, porpoising, and aerial talon-grappling from December to January, and this result roughly conforms with our study. Generally speaking, call rates have tendency to lower from May to September, and this period exactly corresponds to fledgling stage.

Results from observation in breeding season show that call frequency gradually rising from April, and achieve the highest in June (14 occasion/day) . Most of the records are contributed by the youngs. Call rate of young mountain hawk eagles gradually increased after fledgling in Ta-Tzu stream in late May (n=25) , mainly the food begging call (n=20) , followed by newly-developed flying call, and flying call/food begging call combinations (n=5) .

From the results of transect survey throughout year, it demonstrates that daily call number of mountain hawk eagle peaked at 10-14 h, and lower at twilight, forming a single-hump shape. From results of breeding period observation it showed that call number achieved peak in 9 o'clock, then gradually decreased until a small peak occurred at 15. It slightly forms a double-hump shape, and this pattern is quite close to the result of activity pattern by radio telemetry (Sun 2007) .

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Table 1: Measurements of each type of vocalizations made by mountain hawk eagles

Call type		Measurement									
		Start Frequency		End Frequency		Peak frequency		Duration		Range	
Flying call	Call 1 first note	1879.14	286.50	2360.77	263.50			0.16	0.09	481.63	175.81
	Call 1 second note	2799.48	296.30	3178.23	254.56			0.17	0.08	378.75	107.38
	Call 2 first note	1948.60	313.12	2411.21	301.11			0.06	0.04	462.61	122.95
	Call 2 second note	2905.78	383.92	3217.44	294.42			0.08	0.04	311.66	131.73
	Call 3 first note	1874.89	206.54	2357.21	227.64			0.07	0.04	482.33	103.84
	Call 3 second note	2830.09	268.40	3131.59	250.46			0.08	0.06	301.50	88.93
Nest call		2601.70	23.41	2472.25	116.18	2725.48	19.70	0.12	0.02	253.23	120.56
Food-begging call	type 1	3203.16	506.82	3187.49	561.51	3511.06	539.15	0.19	0.09	307.90	187.61
	type 2	3853.65	385.89	3863.57	352.84	4239.09	306.09	0.17	0.02	385.44	147.66

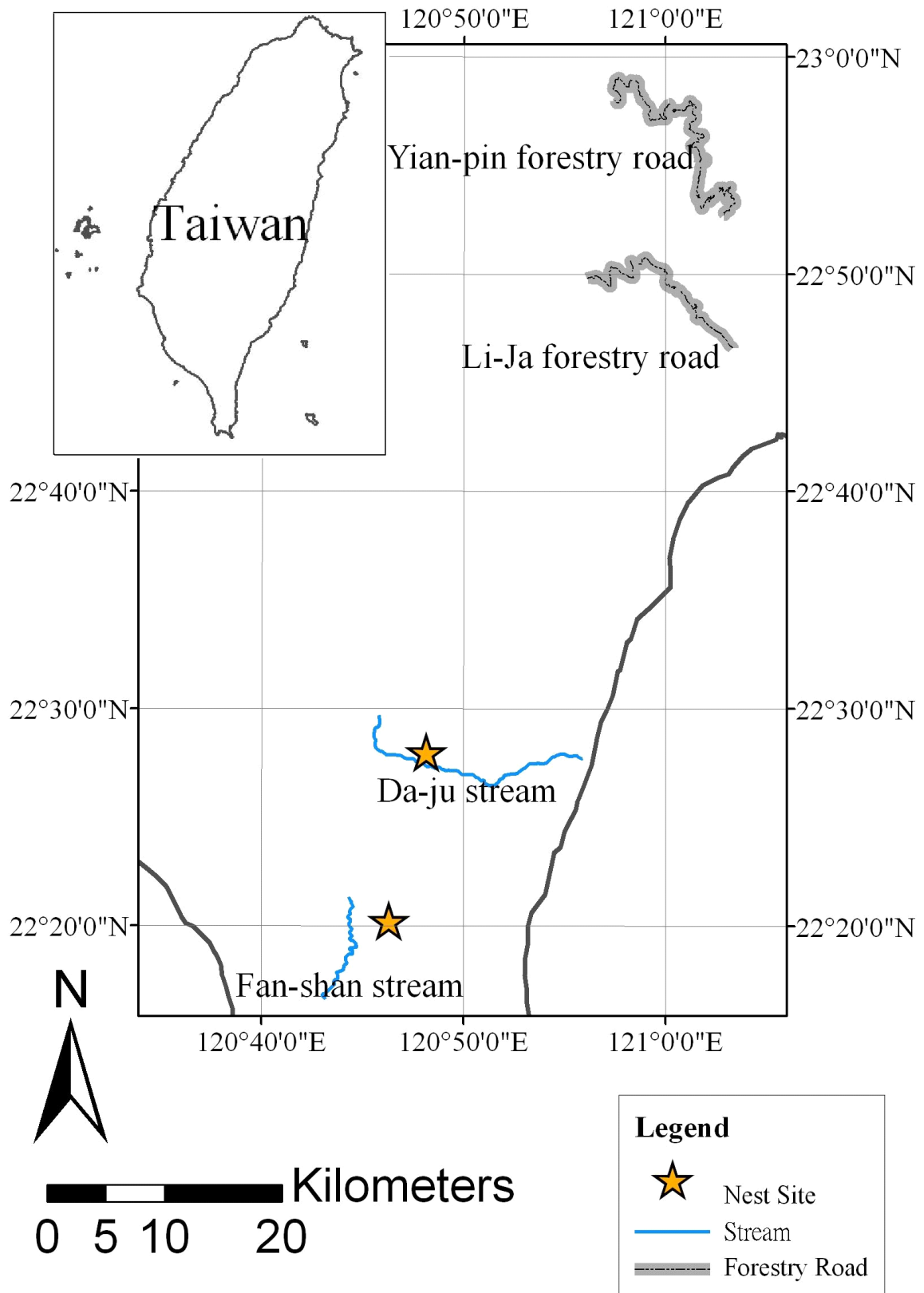


Figure 1. Study area.



Figure 2. A female mountain hawk-eagle with her chick which expressing the food begging behavior.

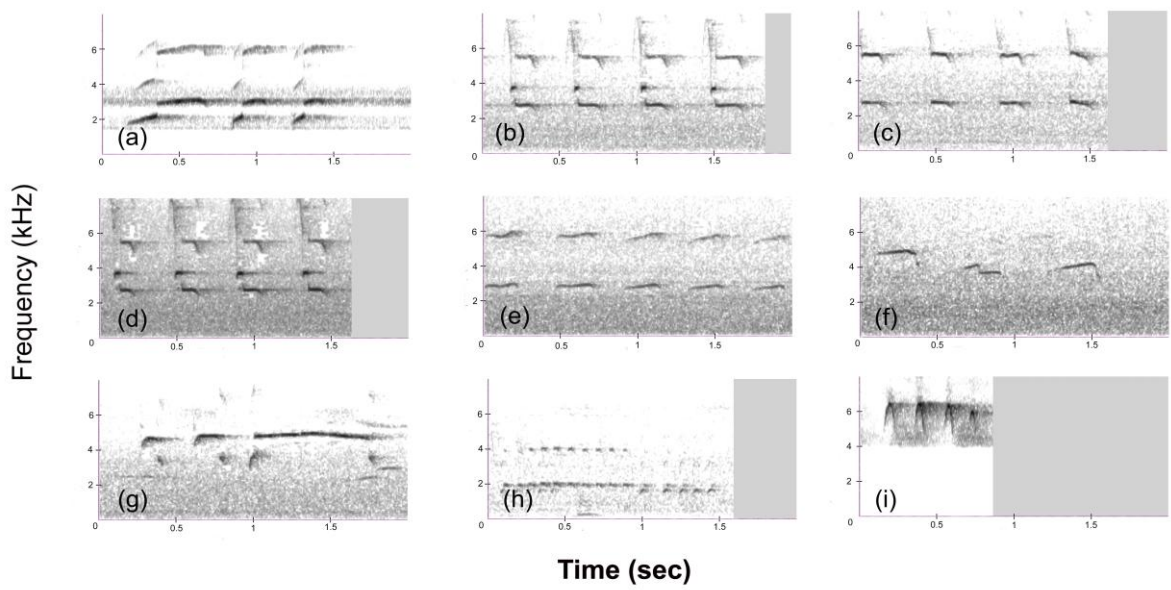


Figure 3. Sonograms of the call types of Mountain hawk-eagle: (a) flying call, (b) nest call type 1, (c) nest call type 2, (d) nest call type 3, (e) food begging call type 1, (f) food begging call type 2, (g) food begging call type 3, (h) trill, (i) high-pitch short note.

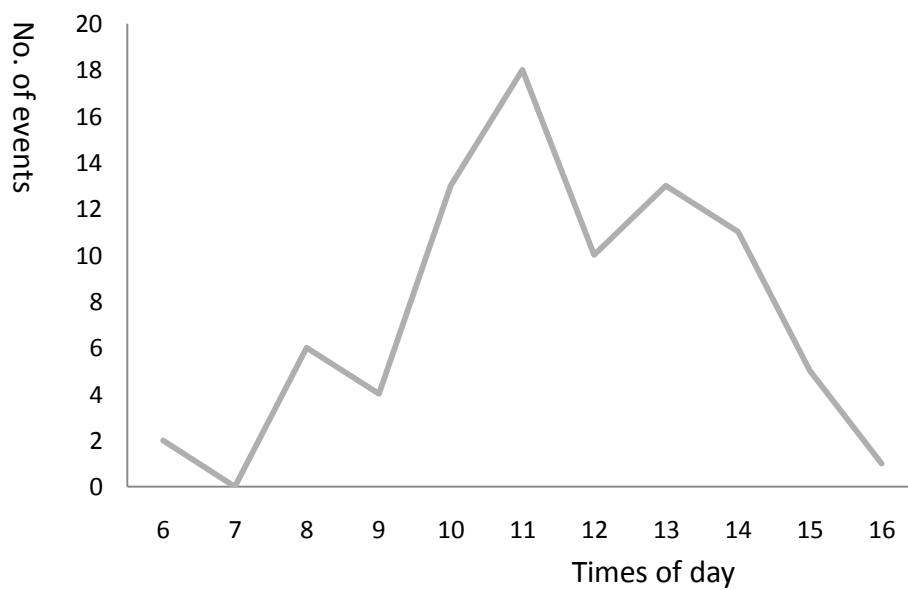


Figure 4. The daily variation of number of vocal event given by Mountain hawk-eagle throughout year transect survey (n=83).

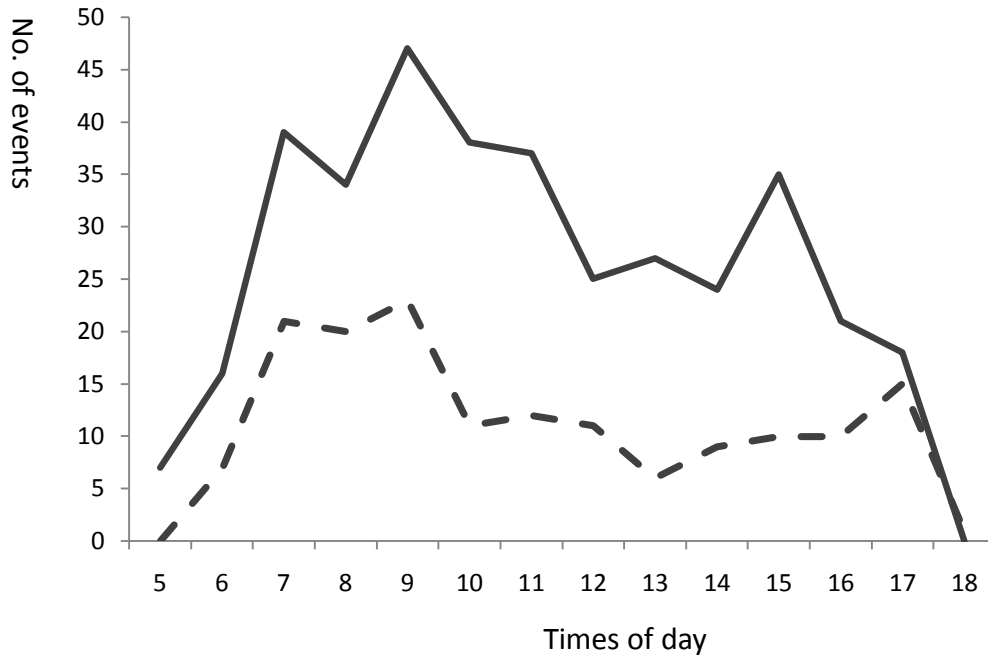


Figure 5. Daily variation of number of vocal event of Mountain hawk-eagle in the observation of breeding season(n=525). The solid line represents the number of calling event of adult Mountain hawk-eagles, the dashed line represents the number of calling event of the youngs.