Russian J. Theriol. 10(2): 59–64

Nest box utility for arboreal small mammals in Vietnam's tropical forest

Ami Kato, Tatsuo Oshida, Son Truong Nguyen, Nghia Xuan Nguyen, Hao Van Luon, Tue Van Ha, Bich Quang Truong, Hideki Endo & Dang Xuan Nguyen

ABSTRACT. To test nest box utility in a Southeast Asian tropical forest, we set 30 wooden nest boxes on trees in the Cuc Phuong National Park, Vietnam for a year. During the rainy season, we checked each nest box each month in the daytime. We expected that arboreal rodents might be more likely to use the nest boxes as shelter from the heavy rain. During dry season, we additionally checked each nest box every two months. We expected that nest boxes would be used as a shelter from the rain by small arboreal mammals, such as rats and flying squirrels in the rainy season more than in the dry season. During the rainy season, we found ants, bees, and birds mainly nested the nest boxes for reproduction: bees in April; ants from May to August; and birds from April to June. From the late rainy season to the dry season, arboreal small mammals mainly used nest boxes: rats from August to February and flying squirrel in December. Nest resource competition between birds and rodents may be minimal since they use cavities in different seasons. Also, unlike our expectation, it was preliminary suggested that arboreal small rodents would use more frequently nest box in the dry season than in the rainy season.

KEY WORDS: flying squirrel, rat, rainy season, dry season, competition, nest resource, nest material.

Ami Kato, Laboratory of Wildlife Ecology, Obihiro University of Agriculture and Veterinary Medicine, Obihiro 080-8555, Japan; Tatsuo Oshida** [oshidata@obihiro.ac.jp], Laboratory of Wildlife Biology, Obihiro University of Agriculture and Veterinary Medicine, Obihiro 080-8555, Japan; Son Truong Nguyen, Nghia Xuan Nguyen, Tue Van Ha and Dang Xuan Nguyen, Institute of Ecology and Biological Resources, Vietnamese Academy of Science and Technology, Hanoi, Vietnam; Hao Van Luon and Bich Quang Truong, Cuc Phuong National Park, Nho Quan, Ninh Binh, Vietnam; Hideki Endo, The University Museum, The University of Tokyo, Tokyo 113-0033, Japan.*

Использование дуплянок для исследования мелких древесных млекопитающих в тропическом лесу Вьетнама

А. Като, Т. Ошида, С.Ч. Нгуен, Н.С. Нгуен, Х.В. Люон, Т.В. Ха, Б.К. Чунг, Х. Эндо, Д.С. Нгуен

РЕЗЮМЕ. Для анализа пригодности гнездовых дуплянок в тропическом лесу Юго-Восточной Азии, в течение года проводили наблюдения за 30 деревянными дуплянками, установленными на деревьях в национальном парке Кукфын, Вьетнам. В течение дождливого сезона дуплянки проверяли каждый месяц, в дневное время. Ожидалось, что арбореальные грызуны могли бы использовать дуплянки как убежища от проливного дождя. В течение сухого сезона дуплянки проверяли каждые два месяца. Ожидалось, что дуплянки будут использоваться мелкими древесными млекопитающими, в частности, крысами и летягами, как убежище от дождя, в дождливый сезон чаще, чем в сухой сезон. В течение дождливого сезона дуплянки использовались муравьями, пчелами и птицами, главным образом, для воспроизводства: пчелами — в апреле; муравьями — с мая до августа; птицами — с апреля до июня. С конца дождливого сезона до сухого сезона дуплянки в основном использовались мелкими древесными млекопитающими: крысами — с августа до февраля, летягами — в декабре. Гнездовая конкуренция между птицами и грызунами, вероятно, минимальна, так как они используют дупла в разные сезоны года. Кроме того, в отличие от ранее предположенного, арбореальные грызуны использовали дуплянки в сухой сезон чаще, чем в дождливый сезон.

КЛЮЧЕВЫЕ СЛОВА: летяга, крыса, дождливый сезон, сухой сезон, конкуренция, гнездование, гнездовой материал гнезда.

* Present address: Kiyosato Educational Experiment Project, Hokuto 407-0301, Japan

** Correspondence author: Tatsuo Oshida

Introduction

Tree cavities in forest ecosystems are a vital resource, providing sites for nesting, roosting, foraging, and reproduction for many vertebrates (e.g., Fokidis & Risch, 2005). Arboreal rodents living in sub-boreal and temperate zones mainly use tree cavities for nests: for instance, northern flying squirrel *Glaucomys sabrinus* (Carey *et al*., 1997; Cotton & Parker, 2000; Bakker & Hastings, 2002), southern flying squirrel *G. volans* (Wells-Gosling, 1985; Fokidis & Risch, 2005), Siberian flying squirrel *Pteromys volans* (Hanski *et al*., 2000a; Airapetyants & Fokin, 2004; Kadoya *et al*., 2011), Allen's squirrel *Sciurus alleni* (Best, 1995), gray squirrel *S. carolinensis* (Koprowski, 1996), and Arizona gray squirrel *S. arizonensis* (Best & Riedel, 1995). Although there are many arboreal rodent species in tropical regions (Corbet & Hill, 1992; Wilson & Reeder, 2005), little known about how they use nest cavities. It was reported that gray-cheeked flying squirrel *Hylopetes lepidus* and smoky flying squirrel *Pteromyscus pulverulentus* use tree cavities for nests in Malaysia (Muul & Liat, 1974). Boyle *et al*. (2008) suggested that, worldwide, cavity density appears to increase from the poles to the tropics. Therefore, tree cavities may be a useful resource for arboreal mammals in tropical forests.

It is difficult to observe and track small arboreal rodents in dense tropical forests, because most species are nocturnal and cautious.Nest boxes are useful tools for investigating arboreal small mammals. These boxes are often used in ecological studies of rodents in the Holarctic region, such as southern flying squirrel (Raymond & Layne, 1988; Layne & Raymond, 1994; Taulman & Smith, 2004), Siberian flying squirrel (Hanski *et al*., 2000b) and small Japanese field mouse *Apodemus argenteus* (Shibata & Kawamichi, 2009). In Asian tropical forests, nest boxes may be used by arboreal mammals. These nest boxes may also be used by cavity-nesting birds such as lorikeets, parakeets, robins and shamas (Ali, 1979) and cavity-nesting insects such as honeybees (Seeley & Seeley, 1982; Dyer & Seeley, 1991) and ants (Tanaka *et al*., 2010). In fact, artificial nest boxes are used by the great hornbill (*Buceros bicornis*) and the rhinoceros hornbill (*Buceros rhinoceros*) in Thailand (Pasuwan *et al*., 2011). There may be competition between such birds and insects and arboreal small mammals for nest boxes. In the present study, to know whether wooden nest boxes are useful tool in ecological research of arboreal small rodents in tropical forest, we observed the use of them placed in a tropical forest in Vietnam.

Study site

This study was conducted in the Cuc Phuong National Park, Ninh Binh Province, Vietnam (20°14′ – 20°24′N, 105°29′ – 105°44′E; Fig. 1). This natural forest has an area of 22,220 ha. It is characterized with natural broad-leaved evergreen tropical forests (Djaja

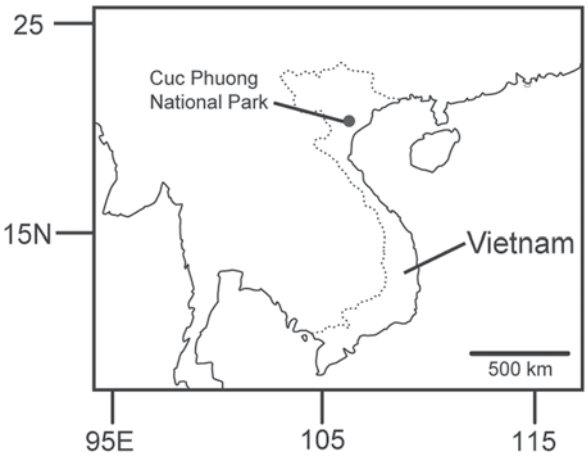

Figure 1. Location of the Cuc Phuong National Park, Vietnam.

et al., 2004). In this forest, we chose a 2.0 ha area dominated by *Dimerocarpus brenieri*, *Saraca dives* and *Hydnocarpus* sp. as our study site. During our study period, average temperatures and rainfalls in the rainy season (from late April to August 2006) were about 26.7°C and 2966 mm per month, respectively; those in the dry season (from September 2006 to early April 2007) were about 21.0°C and 323 mm per month, respectively. In this area, many small mammal species are recorded such as *Ratufa bicolor*, *Dremomys rufigenis*, *Bandicota indica*, *Mus caroli*, *Niviventer fulvescens*, *Rhizomys pruinosis* and *Hystrix branchyura* (Lunde & Nguyen, 2001).

Methods

We built wooden nest boxes with inner dimensions of 160×160×210 mm. This size was based on the head and body lengths of the Indomalayan niviventer *Niviventer fulvescens* and the particoloured flying squirrel *Hylopetes alboniger*, which are 130–170 mm and 175–225 mm, respectively (Francis, 2008). These are common arboreal rodents in the Indochina Peninsula. According to a case study of the southern flying squirrel (Fokidis & Risch, 2005), nest entrance diameter is 4 cm. This diameter is large enough for *Hylopetes* and *Niviventer* rodents to enter. In early April 2006, we attached 30 nest boxes to 30 randomly selected trees. Nest boxes were placed at heights of 4–6 m above the ground. We did not identify tree species and take bearings of nest box locations. Distances between the two nearest nest boxes were around 20–30 m. During the rainy season (from late April to late August 2006), we checked each nest box each month in the daytime. We expected that arboreal rodents might be more likely to use the nest boxes as shelter from the heavy rain. During dry season (from late December 2006 to early April 2007), we checked each nest box every two months. When we check so frequently nest boxes, arboreal

Table 1. Animals, their remains, and tooth marks found in nest boxes placed in Cuc Phuong National Park, Vietnam.

Nest box number	Rainy season					Dry season		
	2006					2006	2007	
	late April	May	June	July	August	December	February	early April
1	DL	DL	DL	DL	DL	–	–	–
2	–	OA	–	A	–	–	–	–
3	R(F)	OA	OA	A	DL	A	A	A, OA
4	DL	DL	DL	B(N)	B(N)	FS, DL	–	OA
5	–	DL	DL	B(N)	B(N)	DL, OA	–	B(N)
6	–	–	–	R(F)	–	OA	OA	B(N)
7	–	–	–	–	OA*	–	–	B(N)
8	–	–	B(N)	B(N), OA	B(N)	–	–	R(T), DL
9	A	A	FL, R(T)	FL	FL	DL, OA	OA	–
10	A	A	OA	OA	FL, R(T)	–	DL	OA
11	A	–	–	OA	OA	DL	R(F)	B(N)
12	–	B(N, I)	B(N)	B(N)	B(N), OA	R(F, H)	R(F), DL	DL
13	–	A	DL, OA	DL, A, OA	OA	R(F, H)	R(F), OA	–
14	–	–	–	OA	–	R(F), DL	–	OA
15	Be	–	B(I, N)	B(N)	B(N)	–	R(F), OA	–
16	–	DL	DL, OA	DL, OA	DL, A	DL	R(F)	DL, A
17	–	–	DL	DL	–	R(F)	R(F)	–
18	–	DL, A	DL	DL, A, OA	DL	R(F, Br)	R(F)	B(E, N)
19	–	–	–	A	–	R(F, Br)	–	–
20	DL	–	–	–	–	–	–	–
21	OA	A	A	A	FL	–	–	A, OA
22	–	–	–	R(T)	R(T)	–	R(F)	Be
23	A	–	A	A	A	R(F, Br)	OA	R(T), Be
24	A	A	A	A	A	A	–	–
25	OA	B(N, I)	B(N), OA	B(N), OA	B(N)	–	–	B(I, N)
26	–	DL, OA	DL, A	DL	A	–	–	Be
27	A	A	B(I, N), OA	B(N)	B(N)	–	–	DL, Be
28	–	–	OA	OA	OA	–	–	A
29	OA	–	–	–	–	–	–	Be, OA
30	A	A	–	OA	OA	–	R(F)	A

Designations: A — ants; OA — other arthropods; B(E) — bird's egg; B(I) — bird nestling; B(N) — bird nest; Be — bees; DL — dry leaves; FL — fresh leaves; FS — flying squirrel; R(Br) — bark pieces collected by rats; R(F) — rat feces; R(H) — rat hairs; R(T) — rat teeth marks. Asterisk indicates the nest box consumed by termites.

rodents may not use or discard nest box. Therefore, we made an enough interval (at least one month) between successive observations. We recorded presence of rodents and their nest materials. We also recorded use by potential competitors: birds and arthropods (ants and bees). We did not remove anything from the nest boxes. After the rainy season, we removed all nest boxes to repair, replacing them in November 2006.

Results

From May to July 2006, vertebrates gradually filled nest boxes with dry leaves (Tab. 1, Fig. 2). From December 2006 to early April 2007, we also found a few dry leaves in nest boxes (Tab. 1, Fig. 2). They seemed to be occasionally brought by wind, but not collected by any vertebrates. From May to June 2006 and in April

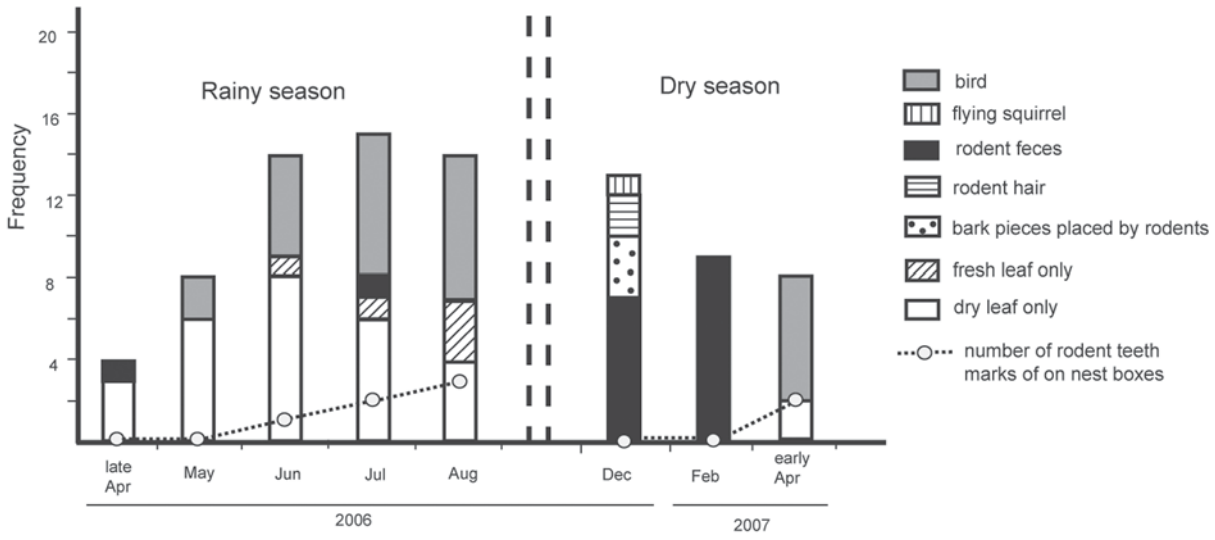

Figure 2. Number of nest boxes used by vertebrates in the Cuc Phuong National Park, Vietnam. Use indicated by presence of animals and their remains found in nest boxes and rodent teeth marks on nest box walls.

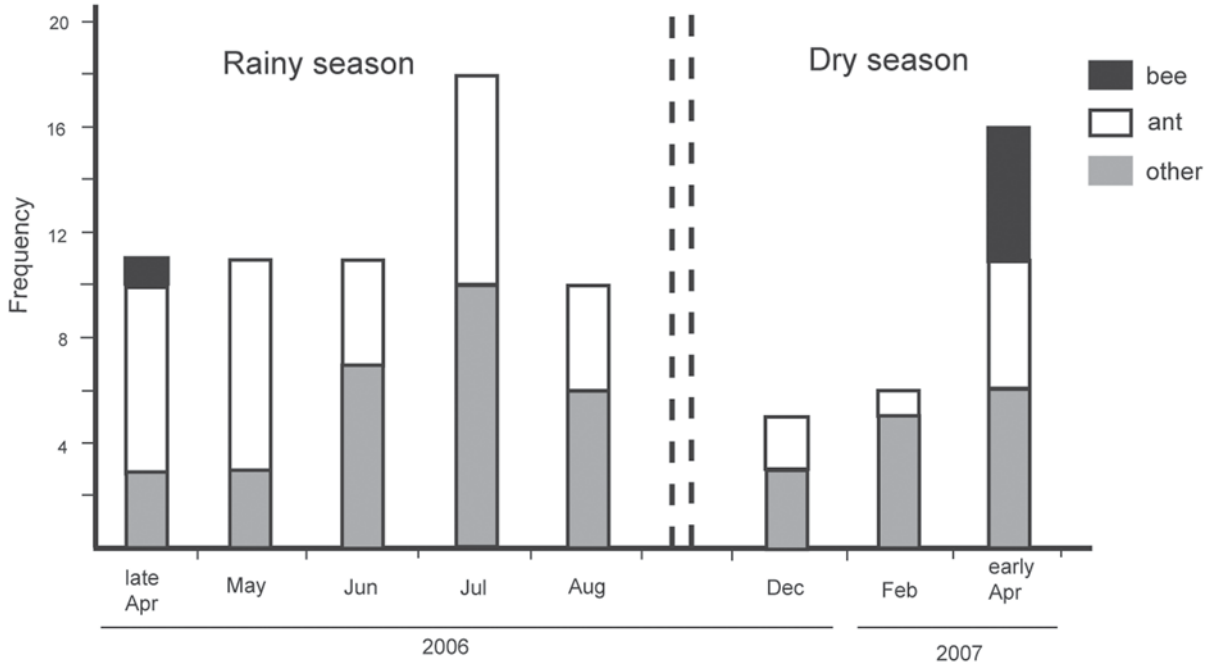

Figure 3. Number of nest boxes used by arthropods in the Cuc Phuong National Park, Vietnam.

2007, the bird, *Copsychus* sp., used nest boxes for reproduction (Tab. 1, Fig. 2). This bird nested in nest boxes occupied with dry leaves. Seven nest boxes and five ones were used by this bird species in the rainy season and in the dry season, respectively. From June to August 2006, vertebrates filled three nest boxes with fresh leaves (Tab. 1, Fig. 2). During the same time period, we found rodent teeth marks on the inner walls of nest boxes. In April and July 2006 and December 2006 to February 2007, we found rodent feces (Tab. 1, Fig. 2). In December 2006, a flying squirrel (*Hylopetes* sp.) nested in one box (Tab. 1, Fig. 2). The nest was composed of dry leaves of *Bauhinia*. Unfortunately, as the flying squirrel run away when we approached to the nest box, we were not able to identify this individual to species. Nest box utility of vertebrates between rainy and dry seasons based on bird individuals or bird nests and rodent individuals or rodent remains (feces and hairs) was significantly different from each other (χ^2 = 11.089, df = 1, P < 0.0001).

We found many arthropods (ants, bees, spiders, centipedes, Stenopelmatidae crickets and termites) in

the nest boxes (Tab. 1, Fig. 3). It was difficult for us to identify each arthropod species, because we avoided collecting animals inside the protected Cuc Phuong National Park. Ants (*Polyrhachis* sp.) used nest boxes year-round (Fig. 3), but cared for eggs in May and August. Bees only used nest boxes in April (Fig. 3). Although the other insects and spiders were found in the nest boxes (Tab. 1, Fig. 3), it was not clear whether they were nesting. Also, nest box utility of arthropods between rainy and dry seasons based on the use of bees and ants was significantly different from each other (χ^2 = 9.989, df = 1, $P < 0.001$). Termites consumed one nest box in August (Tab. 1).

Discussion

During both the rainy and dry seasons, *Polyrhachis* ants frequently used nest boxes. They laid eggs in rainy season, showing that this might be their reproductive season. Bees only used nest boxes in April. We never found both ants or bees and vertebrates together in a nest box. Therefore, in the tropical forest in Vietnam, *Polyrhachis* ants and bees could complete with cavity-nesting vertebrates for cavity resources. *Copsychus* birds nested in the boxes in May and June 2006 and April 2007. These birds nest in tree cavities (e.g., Komdeur, 1996; Siddique, 2008). We found that the nest materials were dry leaves. Therefore, this bird probably collected the dry leaves in nest boxes from May to June 2006. Presence of dry leaves in a nest box may signal *Copsychus* reproductive condition. From June to August 2006, the number of nest boxes occupied with fresh leaves slightly increased. At the same time, rodent teeth marks on the walls of nest boxes also slightly increased. In Japan, the small Japanese field mouse *Apodemus argenteus,* which is semi-arboreal, puts fresh and dry leaves in nest boxes (Ando, 2005). The fresh leaves found in the nest boxes in our study may have been gathered by arboreal rats, such as *Niviventer*. Unfortunately, we did not observe the rodents using the nest boxes. In December 2006 and February 2007, rodent feces were frequently found in nest boxes, but we could not identify the species. Since these signs of rodent activity increased in the late rainy season and in dry season, we may suppose that rodents use cavity resources in colder seasons. At the end of December 2006, we found a flying squirrel (*Hylopetes* sp.) nesting in a nest box. This is the first record of a flying squirrel using a nest box in the tropical forests of Vietnam. Nest boxes may be useful tools for investigation of flying squirrels in tropical Southeast Asia. Although arboreal rodents seem to compete to ants and bees over cavity resources, they broadly divided nest resources by season. During the rainy season, ants, bees and birds mainly used the nest boxes for reproduction: bees in April; ants from May to August; birds from April to June. From the late rainy season through the dry season, arboreal small mammals used the nest boxes: rats from August to February and flying squirrel in December. In Louisiana, USA, the nest boxes were most frequently used by birds from spring to early summer and by arboreal mammals from late autumn to winter (McComb & Noble, 1981). Even in the temperate forests of Louisiana, seasonal differences of nest box use may benefit both birds and arboreal rodents. In South Carolina, USA, southern flying squirrels (*Glaucomys volans*) were less likely to use nest boxes during the summer season (Fokidis & Risch, 2005). Therefore, the season in which nest boxes are installed is probably important for studies of arboreal mammals. Nest box surveys of arboreal rodents in Vietnam's tropical forest should focus on the dry season. To concrete the conjecture, study on nest box utility by arboreal mammals in the other tropical forests in Southeast Asia is needed.

ACKNOWLEDGEMENTS. We are grateful to Cara Lin Bridgman for her critical reading of the manuscript. We thank Canh Le Xuan and Dang Van Hoang for their supports. We also thank Mitsuhiro Iwasa, Yasuo Konno and Hisashi Yanagawa for their critical suggestions. This study was partly supported by the JSPS core-to-core program HOPE.

References

Airapetyants A.E. & Fokin I.M. 2004. Biology of European flying squirrel *Pteromys volans* L. (Rodentia: Pteromyidae) in the North-West of Russia // Russian Journal of Theriology. Vol.2 (for 2003). No.2. P.105–113.

Ali S. 1979. The Book of Indian Birds. Eleventh Edition. Oxford: Oxford University Press. 187 p.

Ando M. 2005. Improvement of nest box investigation techniques for study of arboreal rodents // Honyurui Kagaku [Mammalian Science]. Vol.45. No.2. P.165–176 [in Japanese with English abstract].

Bakker J.V. & Hastings K. 2002. Den trees used by northern flying squirrel (*Glaucomys sabrinus*) in southeastern Alaska // Canadian Journal of Zoology. Vol.80. No.9. P.1623–1633.

Best T.L. 1995. *Sciurus alleni* // Mammalian Species.Vol.501. P.1–4.

Best T.L. & Riedel S. 1995. *Sciurus arizonensis* // Mammalian Species. Vol.496. P.1–5.

Boyle W.A., Ganong C.N., Clark D.B. & Hast M.A. 2008. Density, distribution, and attributes of tree cavities in an old-growth tropical rain forest // Biotropica. Vol.40. No.2. P.241–245.

Carey A.B., Wilson T.M., Maguire C.C. & Biswell B.L. 1997. Dens of northern flying squirrels in the Pacific Northwest // Journal of Wildlife Management. Vol.61. No.3. P.684–699.

Corbet G.B. & Hill J.E. 1992. The Mammals of the Indomalayan Region: a Systematic Review. Oxford: Oxford University Press. 488 p.

Cotton C.L. & Parker K.L. 2000. Winter habitat and nest trees used by northern flying squirrels in subboreal forests // Journal of Mammalogy. Vol.81. No.4. P.1071–1086.

Djaja D.S., Nguyen T.H., Phan K.L., Nguyen M.C., Le K.B., Tran D.D., Jacinto R., Marian R.K., Nguyen T.T.H. & Truong Q.B. 2004. Seed plants of Cuc Phuong National Park, Vietnam: a documented checklist. Hanoi: Agriculture Publishing House. 760 p.

Dyer F.C. & Seeley T.D. 1991. Nesting behavior and the evolution of worker tempo in four honey bee species // Ecology. Vol.72. No.1. P.156–170.

Fokidis H.B. & Risch T.S. 2005. The use of nest boxes to sample arboreal vertebrates // Southeastern Naturalist. Vol.4. No.3. P.447–458.

Francis C.M. 2008. A Guide to the Mammals of Southeast Asia. Princeton: Princeton University Press. 392 p.

Hanski I.K., Mönkkönen M., Reunanen P. & Stevens P. 2000a. Ecology of the Siberian flying squirrel (*Pteromys volans*) in Finland // Goldingay R.L. & Scheibe J.S. (eds.). Biology of Gliding Mammals. Fürth: Filander Verlag. P.67–86.

Hanski I.K., Stevens P.C., Ihalempiä P. & Selonen V. 2000b. Home-range size, movements, and nest-size use in the Siberian flying squirrel, *Pteromys volans* // Journal of Mammalogy. Vol.81. No.3. P.798–803.

Kadoya N., Iguchi K., Matsui M., Okahira T., Kato A., Oshida T. & Hayashi Y. 2011. A preliminary survey on nest cavity use by Siberian flying squirrels, *Pteromys volans orii*, in forests of Hokkaido Island, Japan // Russian Journal of Theriology. Vol.9 (for 2010). No.1. P.27–32.

Komdeur J. 1996. Breeding of the Seychelles magpie robin *Copsychus sechellarum* and implications for its conservation // Ibis. Vol.138. No.3. P.485–498.

Koprowski J.L. 1996. Natal philopatry, communal nesting, and kinship in fox squirrels and gray squirrels // Journal of Mammalogy. Vol.77. No.4. P.1006–1016.

Layne J.N. & Raymond M.A. 1994. Communal nesting of southern flying squirrels in Florida // Journal of Mammalogy. Vol.75. No.1. P.110–120.

Lunde D. & Nguyen T.S. 2001. An Identification Guide to the Rodents of Vietnam. New York: American Museum of Natural History. 80 p.

McComb W.C & Noble R.E. 1981. Nest-box and natural cavity use in three mid-south forest habitats // Journal of Wildlife Management. Vol.45. No.1. P.93–101.

Muul I. & Liat L.B. 1974. Reproductive frequency in Malaysian flying squirrels, *Hylopetes* and *Pteromyscus* // Journal of Mammalogy. Vol.55. No.2. P.393–400.

Pasuwan C., Pattanakiat S., Navanugraha C., Chimchome V., Madsri S., Rattanarngsikul P., Thiensongrusamee P., Boonsriroj T. & Poonswad P. 2011. An assessment on artificial nest construction for hornbills in Budo Su-Ngai Padi National Park, Thailand // Raffles Bulletin of Zoology, Supplement. Vol.24. P.85–93.

Raymond M.A.V. & Layne J.N. 1988. Aspects of reproduction in the southern flying squirrel in Florida // Acta Theriologica. Vol.33. P.505–518.

Seeley T.D. & Seeley R.H. 1982. Colony defense strategies of the honeybees in Thailand // Ecological Monograph. Vol.52. No.1. P.43–63.

Shibata F. & Kawamichi T. 2009. Female-biased sex allocation of offspring by an *Apodemus* mouse in an unstable environment // Behavioral Ecology and Sociobiology. Vol.63. No.9. P.1307–1317.

Siddique Y.H. 2008. Breeding behavior of *Copsychus saularis* in Indian-sub-Continent: a personal experience // International Journal of Zoological Researches. Vol.4. No.2. P.135–137.

Tanaka H.O., Yamane S. & Itioka T. 2010. Within-tree distribution of nest sites and foraging areas of ants on canopy trees in a tropical rainforest in Borneo // Population Ecology. Vol.52. No.1. P.147–157.

Taulman J.F. & Smith K.G. 2004. Home range and habitat selection of southern flying squirrels in fragmented forests // Mammalian Biology. Vol.69. No.1. P.11–27.

Wells-Gosling N. 1985. Flying Squirrels: Gliding in the Dark. Washington: Smithsonian Institute Press. 128 p.

Wilson D.E. & Reeder D.M. (eds.). 2005. Mammal Species of the World: a Taxonomic and Geographic References. Vols. 1–2. Third Edition. Baltimore: Johns Hopkins University Press. 2142 p.