

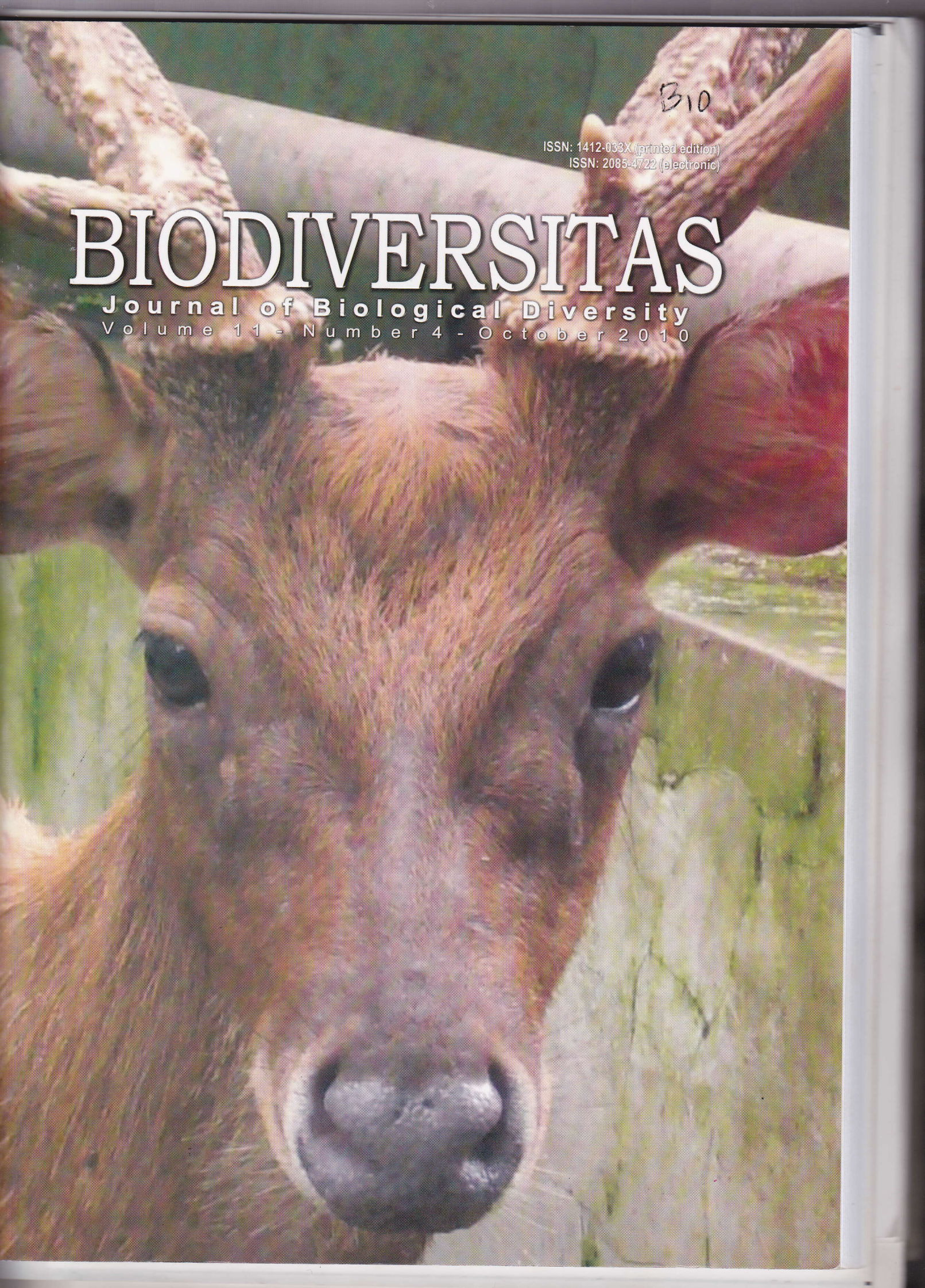
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Front cover:

Cervus unicolor
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Recognition of seasonal effect on captive Sumatran Sambar deer reproductive cyclicity and sexual behaviors

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ABSTRACT

Putranto HD, Soetrisno E, Nurmeiliasari, Zueni A, Gibson B (2011) Recognition of seasonal effect on captive Sumatran Sambar deer reproductive cyclicity and sexual behaviors. *Biodiversitas* 12: 200-203. The objective of this study was to identify seasonal effect on reproductive cyclicity of a captive female Sumatran sambar deer by monitoring its visual estrus manifestations and visual sexual behaviors in buck during female natural estrus in ex situ habitat. A pair of six years of age Sumatran sambar deer was used in this study. Daily observation of visual estrus manifestations of doe and visual sexual behaviors of buck was conducted using focal-animal sampling by two animal keepers during 0800 to 1700 h from June-July 2009 (dry season) to August-September 2009 (rainy season). Doe visual estrus manifestations include apparent reddening and swelling of the external genitalia, loss of appetite and a natural tendency of the doe to approach the buck. There was no significant effect of season on doe visual estrus manifestations and buck sexual behaviors ($p > 0.05$), except for loss of appetite and fighting behavior, respectively. Estrus was observed monthly and result of the cycle was 25.00 ± 5.22 days. It is possible to assess non-invasively estrous cycle of Sumatran sambar deer by the observation of visual estrus manifestations and there was less of seasonal effect on doe-buck sexual behaviors during female natural estrus in ex situ habitat.

Key words: estrous cycle, sambar deer, seasonal effect, sexual behavior.

INTRODUCTION

Indonesia is a habitat for eight sub-species of *Cervus timorensis*, two sub-species of *Cervus unicolor*, and *Axis axis* (Semiadi and Nugraha 2004; Garsetiasih and Takandjandji 2006). *C. unicolor* which is known as sambar deer, inhabits some areas in Asia and Australia. Moreover, a sub-species of sambar deer (*Cervus unicolor* Equinus) is an endemic deer populated in Bengkulu province, particularly in Kerinci Seblat National Park (TNKS), Sumatra island of Indonesia. Sumatran sambar deer inhabit TNKS, that a total of 22.73 % of TNKS territorial area are located in Bengkulu province (Putranto et al. 2008, 2010; Soetrisno et al. 2009).

In Oceania, Asia and Europe Union countries, deer has been domesticated (Gordon 2004), and venison becomes an alternative of natural protein resources for the society. Unfortunately, the demand of venison in Indonesia nowadays is fully supplied by poacher hunt, even though deer is classified into Lower Risk/Least Concern by 2007 IUCN The Red List of Threatened Species (IUCN 2007), then Vulnerable by 2010 (IUCN 2010). As a result, deer in situ population in Indonesia decreased gradually due to poaching and over hunting (Takandjandji and Garsetiasih 2002; Garsetiasih and Takandjandji 2006; Soetrisno et al. 2009; Putranto et al. 2010).

Recently, the population of sambar deer in their habitat is not recorded. Furthermore, captivity program or intensive domestication of sambar deer in Indonesia is not as popular as in other countries such as Australia, Malaysia and Thailand (Semiadi et al. 2005), while the venison consumption among native Indonesian society is common (Mukhtar and Suita 2002; Semiadi 2002). In fact, there is only one captive sambar deer preservation recorded, that is located in East Kalimantan province (Muchsinin et al. 2002).

In order to improve the Sumatran sambar deer population in situ and ex situ, it requires the breeding performance and reproductive physiology information of sambar deers. There are limited scientific references on the reproductive physiology and endocrinology of sambar deer (Soetrisno et al. 2009; Putranto et al. 2010). In the last five decades, there have been seven reports on general management and biology of sambar deer (Van Mourik and Schurig 1985; Semiadi et al. 1993; Semiadi et al. 1994; Ahmed and Sarker 2002; Muchsinin et al. 2002; Semiadi et al. 2005; Putranto et al. 2010). However, there is only a report on its breeding record (Awal et al. 1992).

Sambar deers reach sexual maturity at 8 months of age and its life span which is up to 11 years in the wild (Jacoebe and Wiryosuhanto 1994). In general, deer breeding occurs from October to January with peak activity in November. Does are in heat for 24 hours every 28 days for 2 to 3 consecutive cycles. Single fawn is born every 2 to 3 years

after a gestation of 7 months, and the peak of fawn drop in May or June (Craven and Hygnstrom 1994).

Characteristically, Sumatran sambar deer (*C. unicolor*) is categorized as a ruminant species with specific behavior and different to other ruminants. Sambar deer has a very sensitive hearing capability as well as a sensitive sense of smelling and high speed movement (running and jumping) (Putranto et al. 2010). However, does an intensive management system at ex-situ habitat can diminish sambar deer natural behavior especially their breeding behaviors? It would be a chance for scientist and conservationist for a further exploration.

Season has a great impact on animal reproduction. In a temperate zone, white-tailed deer (*Odocoileus virginianus*) is a breeding season deer (Li et al. 2001). However, in a tropical zone breeding may take place any time of the year. Indonesia which is dry and rainy season periods in tropical zone it may affect the endemic mammals production performances and reproduction status such as Sumatran sambar deer. Therefore, there is an urgent need to discover the Indonesian tropic seasonal effect on sambar deer reproduction status and sexual behavior to support the conservation program.

The purpose of the present study was to identify the seasonal effect (dry and rainy season) on reproductive cyclicity of individual female Sumatran sambar deer by monitoring the visual estrus manifestations and visual sexual behaviors in buck during female natural estrus in their ex situ habitat.

MATERIALS AND METHODS

Material

A pair of sambar deer (*Cervus unicolor* Equinus) were monitored, a doe named Mimi (No. 1, approximately six years of age at the beginning of this study) and a buck named Ujang (No. 2, six years of age) housed at Commercial Zone and Animal Laboratory, Department of Animal Science, Faculty of Agriculture, University of Bengkulu, Indonesia. The deers live together and have free access to the natural photoperiod in an outdoor paddock (5 x 6 m) during the daytime, and they are isolated in individual indoor chambers at night (2 x 3 m). They are sexually mature based on their individual ages during this study was conducted. Doe No.1 was parous before the present study began. They were fed a cut and carry diet consisting of grass, legume, and concentrate daily with proportion of 12 : 2 : 3, respectively. Drinking water was available ad libitum.

Procedures

Generally in Indonesia, from August to March is classified into rainy season and from April to July is classified into dry season (BMKG 2009). Furthermore, in this study the period of June-July 2009 represented dry season while the period of August-September 2009 represented rainy season.

Daily observation of visual estrus manifestations of individual doe and visual sexual behaviors in buck during

female natural estrus was conducted using focal-animal sampling to determine frequent of bout of every manifestation and behavior (She-Jin et al. 2007) by two animal keepers where no specific observation time during 0800 to 1700 h from June to September 2009 (four months). Observations were made outside the paddock from a site of path where the sambar deers were not disturbed.

Doe visual estrus manifestations included apparent reddening and swelling of the external genitalia, loss of appetite and a natural tendency of the doe to approach the buck (Villamor 1985). Each estrus manifestation was scored as one (1) for the presence of the estrus indicators and zero (0) for the absence of the estrus indicators. They were recorded daily during two months of dry and rainy seasons.

Sexual behaviors of the buck were categorized as either actions or states, by using all-occurrence recording method (Webster and Matthews 2006). Sexual behavior included vocalization, flehmen, penile erection (excluding copulation), chasing, mounting, copulation and fighting (Putranto et al. 2005, 2007). The sexual behavior in this study has been used for other male mammals (Schmidt et al. 1988, 1993; Brown et al. 2001) except for fighting behavior.

Data analysis

All data are shown as the mean \pm standard error of the mean (SEM). Paired-sample t-test subsequently conducted for each behavior to determine whether the sambar deer's behavior was influenced by the season (dry and rainy season or not) (She-Jin et al. 2007). The rainy season defined as the month with average rainfall over 100 mm during ten consecutive days. In contrast, the dry season defined as the month with average rainfall below 100 mm during ten consecutive days. Estrous cycle length was calculated as the number of days from the first appearance of apparent reddening and swelling of the external genitalia of one cycle to the appearance of apparent reddening and swelling of the external genitalia in the following cycle (Putranto et al. 2010). Total daily estrus manifestations and sexual behavior scores were expressed as monthly frequency.

RESULTS AND DISCUSSION

In order to preserve sambar deer population in Bengkulu province required a well managed domestication system. Ex-situ conservation located at University of Bengkulu with the deer collection and individual rooms would be a good example for a managed domestication system. The domestication program by conducting an intensive management such as cut and carry system feeding, a monitored sexual activities, a continuously health examination and disease prevention including well provided drugs and additive supplements (vitamins) will ensure a daily basic welfare needed for a healthy live of sambar deer. For a long term objectives, these efforts will avoid the preserved species from extinction.

Sumatran sambar deer is classified as a native ruminant of Bengkulu province, Sumatra – Indonesia. It is well known that in female ruminant, the easiest way to detect the reproductive status is through visual estrus manifestation such as apparent reddening and swelling of the external genitalia (Villamor 1985; Putranto et al. 2010). Individual estrus of a doe was observed monthly throughout this study period. The total average of estrus length and estrous cycle was 2.00 ± 0.41 days (range = 1 – 3 days, $n = 8$) and 25.00 ± 5.22 days (range = 18 – 37 days, $n = 4$), respectively (Table 1). Estrus length of doe in this study was last for 24 to 72 hours every 25 days in 4 consecutive cycles. It is agree to a previous study that generally doe is in heat for 24 hours every 28 days for 2 to 3 consecutive cycles (Craven and Hygnstrom 1994), 24 to 48 hours every 20 days in timor deer (Garsetiasih and Takandjandji 2006) and 20 to 25 hours every 17 – 18 days in calamian deer (Villamor 1985).

There were four visual estrus manifestations in this study such as the apparent reddening, swelling of external genitalia, lost of appetite and natural tendency of the doe to approach the buck (Table 2). The apparent reddening and swelling of external genitalia were appeared monthly in dry and rainy season, and the mean and range of those visual estrus manifestations are shown in Table 2. However, season has no effect on the apparent reddening, swelling of the external genitalia and natural tendency of the doe to approach the buck ($p > 0.05$). Doe significantly lost of appetite during dry season (June – July 2009) than rainy season (August – September 2009) ($t = 0.035$, $p < 0.05$). It can be assumed that these signs can be used as indicators for doe reproductive status of Sumatran sambar deer in this study.

Table 1. Individual mean (\pm SEM) length of estrus and estrous cycle in female Sumatran sambar deer.

Month ^{a)}	Estrus length (days)	Estrous cycle (days)
June	2	25
July	2	37
August	2	20
September	2	18
Average	2	25

Note: ^{a)} Months in the year of 2009.

Table 2. Individual mean (\pm SEM) frequency of visual estrus manifestations appearances in female Sumatran sambar deer.

Month ^{a)}	Estrus manifestation appearances			
	A ^{b)}	B ^{c)}	C ^{d)}	D ^{e)}
June-July (dry)	2.0 ^{ns}	2.0 ^{ns}	4.5 ^a	7.5 ^{ns}
August-September (rainy)	2.0 ^{ns}	2.0 ^{ns}	0.0 ^b	0.0 ^{ns}

Note: ^{a)} Month in the year of 2009, ^{b)} Apparent reddening (number of days per bi-monthly), ^{c)} Swelling of external genitalia (number of days per bi-monthly), ^{d)} Loss of appetite (times per bi-monthly during female natural estrus), ^{e)} Natural tendency to approach the buck (times per bi-monthly during female natural estrus), ^{ns} Means in a vertical line differ non-significantly from each other when analyzed by t-test ($p > 0.05$), ^{a,b} Means in a vertical line differ significantly from each other when analyzed by t-test ($p < 0.05$).

Table 3. Individual mean (\pm SEM) frequency of visual sexual behavior appearances in male Sumatran sambar deer.

Month ^{a)}	Sexual behavior appearances (times in bi-monthly)						
	E ^{b)}	F ^{c)}	G ^{d)}	H ^{e)}	I ^{f)}	J ^{g)}	K ^{h)}
June-July (dry)	1.5 ^{ns}	0.0 ^{ns}	0.0 ^{ns}	49.0 ^{ns}	0.0 ^{ns}	0.5 ^{ns}	11.0 ^a
August-September (rainy)	7.0 ^{ns}	16.5 ^{ns}	4.0 ^{ns}	111.5 ^{ns}	2.0 ^{ns}	2.0 ^{ns}	46.0 ^b

Note: ^{a)} Month in the year of 2009, ^{b)} Buck vocalization, ^{c)} Flehmen, ^{d)} Penile erection, ^{e)} Buck chase the doe, ^{f)} Buck mount the doe, ^{g)} Copulation, ^{h)} Buck fighting, ^{ns} Means in a vertical line differ non-significantly from each other when analyzed by t-test ($p > 0.05$), ^{a,b} Means in a vertical line differ significantly from each other when analyzed by t-test ($p < 0.05$).

One important character of tropical deer is that they can breed throughout the year or polyestrous (Craven and Hygnstrom 1994; Semiadi et al. 2005). The findings of this study indicated that breeding of Sumatran sambar deer may take place any time of the year. A seasonal factor has a non-significant effect on doe estrus manifestations except for its loss of appetite. According to previous report (BMKG 2009), the average of daily temperature and humidity during dry season in Bengkulu were 26.3°C and 87%, respectively. Dry-humid condition during dry season influences doe feed consumption. Physiologically during heat-stress, body will reduce feed intake and increase water intake.

A natural tendency of does in approaching to the buck is an indicator for sexual receptivity that accompanies estrus (Villamor 1985). In this study, doe approached the buck in the same day as her visual estrus manifestation (apparent reddening and swelling of the external genitalia) which appeared on date 18-19 June and 26-27 July 2009. The natural tendency to approach the buck which was more frequent in dry season than in rainy season. In contrast, we observed that during rainy season, buck was less aggressive in fighting and had fewer libidos (no penile erection and mounting activity) than in dry season.

The mean and range of visual buck sexual behaviors in dry and rainy seasons are shown in Table 3. A Seasonal factor has no effect on vocalization, flehmen, penile erection, chasing, mounting and copulation ($p > 0.05$). However, the seasonal factor has a significant effect on fighting behavior with the value of t was 0.036 ($p < 0.05$). Another mammal such as felids (Putranto et al. 2007), their vocalization and flehmen are probably sexually receptiveness sign. During rainy season, buck vocalization and flehmen were first noticeable and dominant sexual activity in this study. The previous report stated that vocalization and flehmen are visually easy to be seen and detectable breeding behaviors in mammal species (Putranto et al. 2007a; 2008).

During breeding season, the buck aggressiveness increase (Craven and Hygnstorm 1994), and the result showed the increasing buck sexual activities can be seen during rainy season. Those sexual behaviors seem stimulated buck libido as seen by the increasing frequency of buck chasing and fighting activities. In this phase, doe did not show any natural tendency to approach the buck.

Furthermore, the buck was sexually active which is recorded by his mounting activity, penile erection, and finally by copulation. The main breeding activities such as mount, penile erection and copulation are typically to be appear in September.

Another Indonesian deer species, known as timor deers (*C. timorensis*) can deliver one or twin offspring in a year (Garsetiasih and Takandjandji 2006). During 2006 to 2009, a pair of Sumatran sambar deer in this study have not been successful in a breeding season as number of offspring produced is $n = 1$ level. In East Kalimantan preservation, sambar deer conception rate was 30.9% and classified as low (Semiadi et al. 2005). There were 4 copulations recorded during this study. However, the pregnancy of doe in this study until the study accomplished in September 2009, is still unclear.

CONCLUSIONS

It can be concluded that it was possible to assess non-invasively estrous cycle of Sumatran sambar deer by the observation of visual estrus manifestations and there was less of seasonal effect on doe-buck sexual behaviors during female natural estrus in their ex situ habitat.

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REFERENCES

- Ahmed S, Sarker NJ (2002) Food consumption of sambar deer (*Cervus unicolor* Kerr) in captivity. *Saudi J Biol Sci* 9(1): 81-83.
- Awal A, Sarker NJ, Husain KZ (1992) Breeding records of sambar deer (*Cervus unicolor*) in captivity. *Bangladesh J Zool* 20: 285-290.
- BMKG (2009) Bengkulu weather forecast. Badan Meteorologi Klimatologi dan Geofisik Bengkulu, Indonesia. [Indonesian]
- Brown JL, Graham LH, Wielebnowski N, Swanson WF, Wildt DE, Howard JG (2001) Understanding the basic reproductive biology of wild felids by monitoring of faecal steroids. *J Reprod Fertil* 57 (suppl): 71-82.
- Craven SR, Hygnstrom SE (1994) Deer. In: *Prevention and control of wildlife damage*. USDA, USA.
- Garsetiasih R, Takandjandji M (2006) Deer conservation model. In: *Forest resources conservation and rehabilitation expose*. Padang, Indonesia. [Indonesian]
- Gordon I (2004) *Controlled reproduction in horses, deer and camelids*. CAB International, UK.
- IUCN (2007) IUCN red list of threatened species. www.iucnredlist.org/search/details.php/15955/summ.
- IUCN (2010) IUCN red list of threatened species. Version 2010.3. www.iucnredlist.org
- Jacob TN, Wiryosubanto SD (1994) *Deer farming management*. Kanisius, Indonesia. [Indonesian]
- Li C, Jiang Z, Jiang G, Fang J (2001) Seasonal changes of reproductive behavior and fecal steroid concentrations in Pere David's deer. *Hormon Behav* 40: 518-525.
- Muchsinin M, Semiadi G, Dradjat A, Farida WR (2002) Developing sambar deer as new domesticated animal in East Kalimantan. In: *Ungulate bioecology and conservation*. Bogor, Indonesia. [Indonesian]
- Mukhtar AS, Suita E (2002) Market demand for venison in Jakarta restaurants. *PS Ilmu Hayati IPB*, Bogor. [Indonesian]
- Putranto HD, Kusuda S, Doi O (2005) The compatibility between musth and estrus in the reproductive cycle of Asiatic elephants by noninvasive measurement. In: *Indonesian student meeting*. Nagoya University, Japan, 1-2 September 2005.
- Putranto HD, Kusuda S, Ito T, Terada M, Inagaki K, Doi O (2007) Reproductive cyclicity based on fecal steroid hormones and behaviors in Sumatran tigers, *Panthera tigris sumatrae*. *Jpn J Zoo Wildlife Med* 12(2): 111-115.
- Putranto HD, Soetrisno E, Nurmeiliasari (2008) Reproductive physiology of sambar deer (*Cervus unicolor* Equinus), Bengkulu endemic ruminant. *LPPM Universitas Bengkulu*, Indonesia. [Indonesian]
- Putranto HD, Soetrisno E, Nurmeiliasari (2010) Monthly live weight gain and estrous cycle estimation of domesticated female sambar deer. In: Widiyono (ed) *Revitalisasi program studi dan peningkatan peran perguruan tinggi ilmu-ilmu pertanian*. Universitas Bengkulu. Bengkulu, 23-25 May 2010. [Indonesian]
- Semiadi G (2002) Tropical and non-tropical deer farming potency. *Ps Ilmu Hayati IPB*, Bogor. [Indonesian]
- Semiadi G, Muir PD, Barry TN, Veltman CJ, Hodgson J (1993) Grazing pattern of sambar deer (*Cervus unicolor*) and red deer (*Cervus elaphus*) in captivity. *New Zealand J Agric Res* 36: 253-260.
- Semiadi G, Muir PD, Barry TN (1994) General biology of sambar deer (*Cervus unicolor*) in captivity. *New Zealand J Agric Res* 37: 79-85.
- Semiadi G, Nugraha RTP (2004) *Tropical deer management*. LIPI, Bogor. [Indonesian]
- Semiadi G, Adhi IGMJ, Trasodiharto A (2005) Calving pattern of captive sambar deer (*Cervus unicolor*) in East Kalimantan. *Biodiversitas* 6 (1): 59-62.
- Soetrisno E, Putranto HD, Nurmeiliasari (2009) Reproductive physiology of sambar deer (*Cervus unicolor* Equinus), Bengkulu endemic ruminant. *LPPM Universitas Bengkulu*, Indonesia. [Indonesian]
- She-Jin L, Lin Y, Yu-qing L, Yan Y, Guo-Hong C, Wan-Hong W (2007) The effect of visitor density on the behavior of the captive fallow deer (*Dama dama*). *Res J Anim Sci* 1(3): 81-84.
- Schmidt AM, Hess DL, Schmidt MJ, Smith RC, Lewis CR (1988) Serum concentrations of oestradiol and progesterone and sexual behavior during the normal estrus cycle in the leopard (*Panthera pardus*). *J Reprod Fertil* 82: 43-49.
- Schmidt AM, Hess DL, Schmidt MJ, Lewis CR (1993) Serum concentrations of oestradiol and progesterone and frequency of sexual behaviour during the normal estrous cycle in the snow leopard (*Panthera uncia*). *J Reprod Fertil* 98: 91-95.
- Takandjandji M, Garsetiasih R (2002) Timor deer conservation in East Nusa Tenggara. *Puslit Biologi Dephut*, Bogor. [Indonesian]
- Van Mourik S, Schurig V (1985) Hybridization between sambar (*Cervus (rusa) unicolor*) and rusa (*Cervus (rusa) timorensis*) deer. *Zoologischer Anzeiger Jena* 214: 177-184.
- Villamor C (1985) Study on the feeding habits, general behavior and breeding biology of calamian deer (*Axis calamianensis* Heude) in captivity. *Forest Ecosyst Highlights* 1: 1-2.
- Webster JR, Matthews LR (2006) Behaviour of red deer following antler removal with two methods of analgesia. *Lives Sci* 100: 150-158.