Nest Building Behaviour of Sulawesi Babirusa (Babyrousa celebensis)

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ABSTRACT

A total of 504 observations of nest building behaviour and the re-use of sleeping nests exhibited by 10 individuals of Sulawesi babirusa (Babyrousa celebensis) were made in spacious outdoor enclosures on Bali, Indonesia. We recorded behavioural characteristics associated with the timing of nest building behaviour, nest sites, and selection of nest-building materials. Both sexes frequently participated in the construction of sleeping nests during the short period from 17:00 hr to 18:00 hr, which corresponded to the period between the evening feed and the time of sunset. Young babirusa contributed from the age of 15 weeks. The babirusa favoured specific nesting sites in the enclosures determined by available structural supports such as walls, trees or corners. Various kinds of plant materials available in the enclosure were used. In addition to picking up fallen plant matters, they also pulled various parts off trees while standing on the hind limbs. In one instance, parts of a wooden fence were used due to the lack of other nesting materials. When housed as a group, consistent leadership of the nesting behaviour was not recognised; they seemed to prefer cooperative behaviour and built a communal nest. We concluded that nest building behaviour, for resting and sleeping, was a normal and important behaviour of the babirusa and that the provision of nest building materials to captive babirusa was an effective form of enrichment.

Key words: babirusa, enrichment, nest building, nest material gathering, sleeping nest

INTRODUCTION

The babirusa (Babyrousa spp.) are wild pigs native to Indonesia, restricted to Sulawesi, the Togian Islands, the Sula Islands and Buru. One of their defining external characters includes the unique shape and size of the canine teeth of the male. The adult male has large maxillary canines that penetrate the skin of the snout, and curve back toward the forehead [1]. The corresponding teeth in the female are either small or absent [2]. According to the current taxonomy, the Genus Babyrousa consists of three living species; Sulawesi babirusa (Babyrousa celebensis) (Deninger, 1909) [3], Togian babirusa (Babyrousa togeanensis) (Sody, 1949) [4] and Moluccan babirusa (Babyrousa babyrussa) (Linnaeus, 1758) [5]. All babirusa mainly inhabit tropical rain forest, and have been accorded national protection under Indonesian law since 1931. However, due to multiple threats to survival, they have been
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included on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) since 1982. Sulawesi babirusa has been categorised as ‘Vulnerable’ in the International Union for Conservation of Nature (IUCN) Red List [6]. The family Suidae exhibit specific and unique types of nest building behaviours [7], and babirusa has also been reported as a nest-builder. Babirusa sows prepare for parturition by building nests a couple of days before delivery of the piglets [8]. Sleeping nests of babirusa in the wild have been described [9, 10]. Sulawesi babirusa in zoological collections also makes nests to sleep in [8, 11, 12]. However, these published accounts do not provide detailed and comprehensive overviews of this type of nesting behaviour. In addition, the relationship of the babirusa with their natural environment, and a number of their behavioural characteristics are still incompletely understood. Therefore, based on our knowledge from previous reports of babirusa husbandry [8, 13] and field studies of babirusa in their natural habitat [14-16], and also we feel positive towards the concept that a better understanding of the animal’s behavioural repertoire helps contribute to the successful conservation breeding management of this species, we set up a five-year project of conservation breeding and behavioural research on Sulawesi babirusa in a spacious outdoor enclosure with sufficient vegetation, in Indonesia [17].

Subsequently, observations of the same group of babirusa have intermittently been made at a professional zoo close to the project site under the same weather conditions, but different enclosure and husbandry conditions. The purpose of this article was 1) to profile the characteristics of babirusa nesting behaviour for resting and sleeping and 2) to investigate the importance of the availability of nest materials in the babirusa enclosure.

**MATERIALS and METHODS**

**Study sites and periods:** Observations were made at Babirusa Park and Bali Zoo, Bali, Indonesia. The former was located within the rice-growing area of Lodtunduh village. The latter is located at Singapadu village, 5 km south of Lodtunduh. The study period lasted 1936 days, from 1st January 2005 until 20th April 2010, in Babirusa Park and a total of 24 days from 09th July 2012 until 14th August 2012, as a component part of 10 months of study of babirusa husbandry in Bali Zoo. Additional follow up observations of nesting behaviour were intermittently made in Bali Zoo between 31st October 2016 and 19th April 2018.

**Animals:** Two adult pairs of Sulawesi babirusa (Babyrousa celebensis) and their six infants (Table 1) were observed at Babirusa Park. Babirusa has no breeding season in zoos within Indonesia. However, under our breeding programmes, all babirusa piglets were born between May and August at Babirusa Park. This was arranged to have them delivered during the dry season to prevent diarrhoea in the piglets. On 23rd April 2010 after the project period at Babirusa Park, the two adult pairs were transferred to Bali Zoo. Two adult females and their two male offspring were observed at Bali Zoo (Table 2).

**Table 1** Sulawesi babirusa observed at Babirusa Park during the period from 01st January 2005 until 20th April 2010.

<table>
<thead>
<tr>
<th>Name</th>
<th>Sex</th>
<th>Date of birth</th>
<th>Age*</th>
<th>No. days observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indro M</td>
<td>17/10/2001</td>
<td>3-8 yrs</td>
<td>1769</td>
<td></td>
</tr>
<tr>
<td>Shela F</td>
<td>07/01/2003</td>
<td>1-7 yrs</td>
<td>1308</td>
<td></td>
</tr>
<tr>
<td>April M</td>
<td>23/04/2003</td>
<td>1-6 yrs</td>
<td>1930</td>
<td></td>
</tr>
<tr>
<td>Priska F</td>
<td>10/10/2003</td>
<td>1-6 yrs</td>
<td>1369</td>
<td></td>
</tr>
<tr>
<td>Sherly F</td>
<td>29/06/2005</td>
<td>3 mths-4 yrs</td>
<td>1372</td>
<td></td>
</tr>
<tr>
<td>Karlo M</td>
<td>19/05/2006</td>
<td>3 mths-3 yrs</td>
<td>1085</td>
<td></td>
</tr>
<tr>
<td>Shandro M</td>
<td>12/08/2006</td>
<td>3 mths-2 yrs</td>
<td>547</td>
<td></td>
</tr>
<tr>
<td>Pindo M</td>
<td>09/05/2009</td>
<td>5-11 mths</td>
<td>167</td>
<td></td>
</tr>
<tr>
<td>Shergio M</td>
<td>10/05/2009</td>
<td>5-11 mths</td>
<td>174</td>
<td></td>
</tr>
<tr>
<td>Sherina F</td>
<td>10/05/2009</td>
<td>5-11 mths</td>
<td>174</td>
<td></td>
</tr>
</tbody>
</table>

The number of days observed excluded periods when animals stayed in the pen all day long.

*: Ages at onset and termination of the observation.

**Table 2** Sulawesi babirusa observed at Bali Zoo during the period of the first observation year.

<table>
<thead>
<tr>
<th>Name</th>
<th>Sex</th>
<th>Date of birth</th>
<th>Age</th>
<th>No. days observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shela F</td>
<td>07/01/2003</td>
<td>9 yrs</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Priska F</td>
<td>10/10/2003</td>
<td>8 yrs</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Tito M</td>
<td>12/08/2011</td>
<td>11-12 mths</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Toti M</td>
<td>11/10/2011</td>
<td>9-10 mths</td>
<td>24</td>
<td></td>
</tr>
</tbody>
</table>

The number of days observed included a total of 24 days from 09th July 2012 until 14th August 2012 when the babirusa enclosure and husbandry conditions were contrastive to those at Babirusa Park. Other than this observation period, follow up observations were intermittently made from 31st October 2016 until 19th April 2018.
Enclosures and penning arrangement

**Babirusa Park:** Animals were maintained in two adjacent enclosures. Area I had 480 m$^2$, 8-37% of vegetation cover including nine coconut palm trees (*Cocos nucifera*), eight clusters of banana plants (*Musa acuminata*) and cogongrass (*Imperata cylindrica*). Area II had 560 m$^2$, 33-79% of vegetation cover dominated by cogongrass and shaded by two clusters of banana plants, nine coconut palm trees and various other local trees. Eight roofed concrete pens (8 m$^2$) were installed for each animal, and to which they usually had open access. A water pool and surrounded swamp area (60 m$^2$) contributed to the space available for the daytime activities of the babirusa. In principle, both areas accommodated a breeding pair and their infant (Table 3). Area II was largely used for reproduction; Sherly and Karlo were transferred to Area I after they had grown up. A male (Indro) and two adult females (Shela and Priska) lived together in Area II from 20th October 2008 for 177 days. When the females in Area II were in oestrus, Indro was housed in the pen for 80 days in total. We limited the sexual contact between the adult male and female for approximately one year after parturition as a necessary birth control measure. From approximately 10 days before the expected date of birth until the end of nursing, the sow and piglet(s) were housed in the pen. They were physically separated from the boar which had access to the outdoor enclosure.

**Bali Zoo:** In July 2012, each mother-infant pair of babirusa was accommodated in adjacent 48 m$^2$ enclosures separated by a 1.2 m high horizontal wooden fence. The surfaces of both enclosures were covered with a thick layer of sand. In the daytime, 50-80% of the ground surface lay in the shade of a mango tree (*Mangifera indica*), a coconut palm tree and an ylang-ylang tree (*Cananga odorata*). In each enclosure, there was a simple shelter, a mud wallow, a feed trough and a water trough. In 2016-2018, the environmental conditions of the enclosures were altered. The young males were removed, the wooden partitions were taken away, and the adult females were housed together. Thus the ground area per individual female doubled.

**Husbandry, diets and feeding schedules:** At both study sites, animal handling was kept to a minimum.

**Babirusa Park:** The enclosure was cleaned in the early morning. Sleeping nests once constructed were left untouched unless they were extremely dirty. Animals were fed twice a day at 06:30 hr and 16:00 hr. Each adult animal was given 1.5 kg of sweet potato, 400 g of fresh green leaf fodder such as water spinach (*Ipomoea aquatica*), sawah lettuce (*Limnocharis flava*) and water hyacinth (*Eichhornia crassipes*), 110 g of banana, 580 g of other seasonal fresh fruits such as papaya (*Carica papaya*), cashew apple (*Anacardium occidentale*), carambola (starfruit, *Averrhoa carambola*) and 150 g of commercial swine pellet per day.

**Bali Zoo:** Keepers cleaned the enclosure daily to remove all fallen leaves and twigs. Throughout the 2012 study period, keepers fed the animals three times a day, at approximately 09:30 hr, 13:00 hr and 16:00 hr. Until the end of July 2012, a relatively large, *ad libitum* amount of such food items as 6 kg of sweet potato, 2.3 kg of peeled banana and 750 g of commercial swine pellets had been provided to the animals daily, with 2.1 kg residue removed daily. Irregularly, approximately 1 kg of rain tree (saman, *Albizia saman*) leaves or water spinach was also given at mid-day. From August 2012, an improved diet formulation was offered which included these three core items as well as other constituents such as papaya, water spinach, yard long bean (*Vigna unguiculata sesquipedalis*), water hyacinth, corn on the cob (*Zea mays*) and tree leaf fodder. Bedding or nesting material was not provided by keepers during the period from the beginning of 2012 until the middle of 2016. During the follow up period in 2016-2018, animals were fed twice a day, morning and late afternoon, with

<table>
<thead>
<tr>
<th>Table 3 Penning arrangement at Babirusa Park.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Adult males</td>
</tr>
<tr>
<td>0 1 2</td>
</tr>
<tr>
<td>Adult females</td>
</tr>
<tr>
<td>0 female only 2.4 15.4 0.1</td>
</tr>
<tr>
<td>0 female + young 0 3.4 0</td>
</tr>
<tr>
<td>1 female only 0 24.3 4.8</td>
</tr>
<tr>
<td>1 female + young 0.03 35.5 0</td>
</tr>
<tr>
<td>2 females only 0 4.7 0</td>
</tr>
<tr>
<td>2 females + young 2.1 7.6 0</td>
</tr>
</tbody>
</table>

Values are expressed as a percentage of the total observation days. Overall, 59.8% of 3872 observation days in both Areas I (1936 days) and II (1936 days) are related to an adult male-female pair (with young). “0 animals” either means that the animal was housed in the pen all day long, or was absent from that Area. “0 female + young” means that the female was housed in the pen all day long, but her infant stayed in the outdoor area.
extra tree leaf fodder at mid-day. The total daily amount of feed provided for the two females was 4 kg of sweet potato, 3 kg of fresh vegetables such as water spinach, yard-long bean and other green foods and 1.8 kg of rice bran or commercial swine pellets [18]. Paddy straw was occasionally placed in the roofed shelter for nesting. Additional materials, such as dry banana leaves, leaf-based fibres of coconut palm and round-leaf fountain palm (Saribus rotundifolius) were also provided.

**Observation and data collection:** A total of 12 staff took turns participating in the data collection and animal care at Babirusa Park. At least five staff per day stayed on the site for 24 hours a day and seven days a week. During the 17 hours from 05:00 hr, observations and video recordings were made from a shed that faced both outdoor enclosures. No observation or recordings were carried out during the seven hours from 22:00 hr to 05:00 hr, because the babirusa was sleeping [8]. Observers recorded the following data; date and time, enclosure area ID, animal names, oestrous status, nesting place, nest materials, nest material gathering and building behaviours until sleeping, and also other resting behaviour such as lying and sleeping on the ground and in the indoor enclosure. Since August 2006, the interaction between individuals was also recorded to document cooperative behaviours. At Bali Zoo, observations and video recordings in 2012 were made from outside of the enclosure through the wire fence during the nine hours from 09:00 hr to 18:00 hr. Behavioural data such as date and time, animal names, oestrous status, nesting place, nest materials, nest material gathering and building behaviours were collected. Individual interactions between the animals were also recorded. In 2016-2018, follow up observations, to check their nesting behaviour with nest materials provided by keepers, were intermittently carried out for two hours including morning and/or evening feedings. In both study sites, sunrise occurred at 05:48 hr in November at the earliest, and 06:34 hr in July at the latest. Sunset occurred at 18:06 hr in May-June and at 18:46 hr in January-February.

**Data analysis:** In this study, nest material gathering and subsequent nest building behaviours, and also re-use of nests were referred as to ‘nesting behaviour’. Nesting behaviour and its products for sleeping purpose observed at Babirusa Park were exclusively analysed. Data of animals lying on the bare ground without nesting materials were not included. Data obtained during the first year at Babirusa Park were used mainly for the descriptive aspects of nesting behaviour. The other data obtained at Babirusa Park were used to examine the individual difference in the monthly frequency of nesting behaviour among the seven animals with a one-way analysis of variance (ANOVA). Because of variation in the number of observation days in any one month, and the variation in the frequency of the nesting behaviour, the number of observation days in each month were normalised to 30 days. Further, the consistency of the frequency of nesting behaviour among the seven individuals was analysed with intra-class correlation coefficient (ICC) using statistical software R version 2.8.1[19], based on multiple measurements \( (k = 7) \), consistency, two-way mixed-effects model, that is ICC \((3, k)\) that is functionally equivalent to Cronbach’s alpha coefficient. \( P\)-values of less than .05 were considered significant. Statistical results were written along with the APA style.

**RESULTS**

Babirusa built nests with plant materials prior to sleeping as well as prior to the birth of their young. During the 1936 days of observation at Babirusa Park, a total of 504 examples of nesting behaviour for sleeping by 10 individuals of babirusa were recorded.

**Timing of nesting behaviour:** The peak time of nesting behaviour was one hour after the evening feeding at 16:00 hr (Fig. 1), and 84.7% (n=427) were recorded for two hours until 19:00 hr. The remaining 15.3% (n=77) were observed later in the evening, or extremely rarely, after the morning feeding period at 06:30 hr. When the 504 examples of nesting behaviour were analysed in relation to before or after noon, and before or after feeding, except for two occasions (0.4%), all other examples were observed after the feeding time. In particular, it should be noted that 5.6% (n=28) of examples was recorded after the morning feed. Further, with regard to the relationship with the time of sunset, some babirusa also started nesting behaviour after dark (9.9%, n=50). Two occasions of rare nesting behaviours in one day were observed; for example, at 07:30 hr and 17:00 hr on 04th January 2008 in Area II.

**Nest site, size and structure:** At Babirusa Park, babirusa selected spaces where their bodies could be partially supported or covered. These included places adjacent to a fence, in the corner of a wall or pen, in a narrow gap, around the root of a large tree, in a cluster of shrubs and dense field grass, and particularly in a depression in the grass; they made their own occupied spaces. Their nests varied in type and appearance.
Nest building behaviour of babirusa

from the simplicity of a depression on the bare ground to the complexity of stacks of various kinds of plant materials. In the field of dense grass, and when sufficient fallen leaves were available, ceilinged nests were constructed. In the case of ceilinged nests, the tip of the snout was frequently seen protruding through the nest wall (Fig. 2A). At the end of July 2005, we recorded 12 sleeping nests in good condition in the 384 m² of grass in Area II. When babirusa used a large amount of nesting materials, most of these nests had an oval or oblong shape, 150-250 cm long and 80-120 cm wide. The largest nest was 432 cm long and 115 cm wide, and was a communal nest. When nest building materials were sparsely available, a simple bed lined with some vegetation was often made. Occasionally babirusa created a donut-shaped nest of grass around its body with its back exposed (Fig. 2B).

**Effect of sex and age:** Both sexes showed nesting behaviour (Table 4). No significant difference was noted in the individual frequency of nesting behaviour among the seven animals (one-way ANOVA, $F [6, 77] = .46, p = .84$). The shapes of the nests constructed appeared very similar. ICC (3, 7) value for consistency of the monthly frequency among seven individuals was 0.94 with 95% confidence interval 0.86-0.98, indicating ‘good’ to ‘excellent’ reliability. The first expressions of nesting behaviour by piglets Karlo, Sherly, Shandro and a twin piglet of Shergio and Sherina were recorded at 108 days, 120 days, 188 days and 196 days of age, respectively (Table 5). In the earliest case, a male piglet Karlo exhibited his first cooperative nest building behaviour at the age of 108 days when he was on his fourth day in the outdoor area. By way of contrast, the male piglet Shandro was released at the beginning of November, and did not display his first behaviour of nest building until more than three months later, in the middle of February (Fig. 3).

**Nest materials and nest building behaviours:** Various kinds of plant parts such as green grasses, fallen leaves, twigs, young branches and other parts of the tree were used for nest building at Babirusa Park. Depending on the kinds of plant materials available, a variety of patterns of material gathering behaviour were observed.

**Fresh cogongrass:** Throughout the period, babirusa used

![Fig. 1](image)

*Fig. 1* The timing of the 504 examples of nesting behaviour for the sleeping purpose observed at Babirusa Park and the breakdown of the examples, according to before or after noon, before or after each feeding time, and before or after sunset time.

In this graph, sunset time was set as the period of 1 hr from 30 min before sunset time until 30 min after. Because there is variation in the sunset time in any day, onset and termination of the sunset period cannot be defined.

<table>
<thead>
<tr>
<th>Name</th>
<th>Sex</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indro</td>
<td>M</td>
<td>1.7</td>
<td>1.8</td>
<td>2.8</td>
<td>2.0</td>
<td>3.9</td>
<td>5.1</td>
<td>7.0</td>
<td>12.5</td>
<td>12.5</td>
<td>4.3</td>
<td>3.4</td>
<td>1.1</td>
<td>3.9</td>
<td>3.08</td>
</tr>
<tr>
<td>Sela</td>
<td>F</td>
<td>1.0</td>
<td>2.0</td>
<td>0.9</td>
<td>1.5</td>
<td>4.1</td>
<td>8.0</td>
<td>7.3</td>
<td>7.5</td>
<td>7.5</td>
<td>2.4</td>
<td>3.9</td>
<td>1.9</td>
<td>1.1</td>
<td>3.5</td>
</tr>
<tr>
<td>April</td>
<td>M</td>
<td>1.2</td>
<td>0.6</td>
<td>0.8</td>
<td>1.5</td>
<td>2.9</td>
<td>7.3</td>
<td>4.8</td>
<td>5.2</td>
<td>5.0</td>
<td>2.7</td>
<td>0.5</td>
<td>0.6</td>
<td>2.8</td>
<td>2.21</td>
</tr>
<tr>
<td>Priska</td>
<td>F</td>
<td>1.5</td>
<td>2.0</td>
<td>2.3</td>
<td>2.7</td>
<td>2.7</td>
<td>2.5</td>
<td>9.0</td>
<td>7.5</td>
<td>11.5</td>
<td>2.8</td>
<td>1.4</td>
<td>1.1</td>
<td>3.9</td>
<td>3.28</td>
</tr>
<tr>
<td>Sherly</td>
<td>F</td>
<td>0.8</td>
<td>1.2</td>
<td>0.9</td>
<td>2.2</td>
<td>3.2</td>
<td>7.4</td>
<td>5.0</td>
<td>5.1</td>
<td>6.3</td>
<td>5.4</td>
<td>0.0</td>
<td>0.6</td>
<td>3.2</td>
<td>2.45</td>
</tr>
<tr>
<td>Karlo</td>
<td>M</td>
<td>1.7</td>
<td>0.6</td>
<td>2.2</td>
<td>2.1</td>
<td>2.3</td>
<td>3.4</td>
<td>5.4</td>
<td>4.3</td>
<td>5.9</td>
<td>1.6</td>
<td>0.6</td>
<td>0.3</td>
<td>2.6</td>
<td>1.78</td>
</tr>
<tr>
<td>Shandro</td>
<td>M</td>
<td>1.7</td>
<td>2.4</td>
<td>1.5</td>
<td>1.4</td>
<td>4.4</td>
<td>2.8</td>
<td>8.6</td>
<td>7.5</td>
<td>3.3</td>
<td>3.1</td>
<td>0.7</td>
<td>0.0</td>
<td>3.1</td>
<td>2.49</td>
</tr>
</tbody>
</table>

The number of observation days per month was normalised to 30 days.
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Table 5  Ages of babirusa piglets, at the time of release from the pen to the outdoor area, and at the time of first expression of nest building behaviour in the outdoor area of Babirusa Park.

<table>
<thead>
<tr>
<th>Name</th>
<th>Sex</th>
<th>Date of birth</th>
<th>Age at Release to the outdoor</th>
<th>First nest building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sherly F</td>
<td>F</td>
<td>29/06/2005</td>
<td>88 days</td>
<td>120 days</td>
</tr>
<tr>
<td>Karlo M</td>
<td>M</td>
<td>19/05/2006</td>
<td>104 days</td>
<td>108 days</td>
</tr>
<tr>
<td>Shandro M</td>
<td>M</td>
<td>12/08/2006</td>
<td>86 days</td>
<td>188 days</td>
</tr>
<tr>
<td>Pindo M</td>
<td>M</td>
<td>09/05/2009</td>
<td>176 days</td>
<td>-</td>
</tr>
<tr>
<td>Shergio M</td>
<td>M</td>
<td>10/05/2009</td>
<td>172 days</td>
<td>196 days</td>
</tr>
<tr>
<td>Sherina F</td>
<td>F</td>
<td>10/05/2009</td>
<td>172 days</td>
<td>196 days</td>
</tr>
</tbody>
</table>

"-" means that no nest-building behaviour was recorded during the observation period.

**cogongrass growing in the enclosure as a nest material** (Figs. 2B and C). They bit through the green grass at its base (rarely plucking it up with the root). They would carry a bunch of grass in their mouth (Fig. 2C), place it in their selected nest site and go back for more, repeatedly piling it up. Subsequently, they would put their snout into the stack, move the nest components up and down with the snout, drive it forward with the snout and draw it back with the hoof of the forelimb. Finally, the babirusa would slide headfirst into the nest with the carpal joints bent. Fully grown cogongrass can attain over approximately 80 cm in height. When exposed to a strong wind or to heavy rains, the grass easily bent over, and the field became a good hiding place for the animal without any nest building behaviour.

**Banana leaf:** Dry leaves and pseudo-stem, the so-called ‘banana-tree’ of a total of 10 clusters, were collected by babirusa for nesting (Fig. 2D). The babirusa pulled the dead leaf blade down with its mouth while stepping backward or shaking its head to cut it off from the tree. It then carried it to the nest.

**Coconut leaflet, leaf sheath and bract:** From April 2007 when the last banana plant completely disappeared from Area I of Babirusa Park, babirusa began to collect the coconut leaf sheath wrapped around the tree trunk. The sheath was taken off with the mouth while the babirusa stood up on its hind limbs (Fig. 2E). It then transported the leaf sheath to its sleeping nest. Leaflets, bracts and coconut shells were also carried to the nest.

**Cooperative works:** Most of the sleeping nests were cooperatively structured in both study sites; no consistent leader took the initiative to start building a nest. When an individual started the nesting behaviour, other members soon joined in, after examining the selected nest site or having made physical snout to body contact with the initiator, thereby somehow indicating the construction of a communal nest by collaboration.

**Learning of nesting behaviour:** After necessary nursing in the pen, mother-infant pairs were released to the outdoor area at Babirusa Park. Each piglet followed its mother everywhere, and they slept together in the nest that was made by the adult animal. With the physical growth of piglets, they started to mimic mother’s actions: when she picked up nest-making materials and held them in her mouth, the young copied the sequence of motions and learned the nest building behaviour.

**Examples of animal concentration during nest building behaviour:** 1). In video footage of 08th August 2005 taken at Babirusa Park, an adult male April started gathering green grass at 18:00 hr and repeated the transportation of this material to the nest site 47 times in the following 50 min. 2). In some cases at Bali Zoo, despite the noisy vocalization of monkeys, or the presence of zoo visitors standing outside the enclosure 1.5 m away from the nesting site, the babirusa did not stop nest building behaviour once they had begun. 3). On 04th June 2017, 30 minutes before the evening feeding time at Bali Zoo, dry banana leaves were provided to Priska and Shela, together with their regular supply of paddy straw. Their nesting behaviour began beside the enclosure door in the ordinary manner. Subsequently, at feeding time, a babirusa keeper entered the enclosure and put their diet into the feed trough. Even though both animals recognised the presence of the keeper and their regular foods in the trough, shortly after sniffing all items and tasting some pellets, they went back to the nesting site to continue their work.

**Response to the absence of nesting materials:** In the second study site where nesting material had not been provided by keepers, nesting behaviour by mother-infant pairs, using small amounts of fallen plant materials and leftovers of leaf fodders, was also seen. However, all four animals could not produce typical sleeping nests due to the shortage of material in the enclosure. Under such enclosure condition, odd behaviours were often observed in both enclosures of Bali Zoo. For example, on 12th July 2012, after a mother-infant pair had
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Fig. 2  Sleeping nests and the nest building behaviour of Sulawesi babirusa
A: A female babirusa Shela resting in a paddy straw nest. The snout appeared through the nest wall, Bali Zoo.
B: A male babirusa Indro sleeping in a donut-shaped nest of cogongrass while exposing its dorsum, Babirusa Park.
C: A female babirusa Priska carrying fresh cogongrass to build a sleeping nest, Babirusa Park.
D: A female babirusa Priska resting in a banana leaf nest. Pseudo-stems of banana plants growing in Area I of Babirusa Park fell down on 31st December 2006 due to the northwest monsoon. The next day, Priska bit and tore the banana leaves to make nest material.
E: A female babirusa Priska standing on her hind limbs to pull the coconut leaf sheath off the tree, Babirusa Park.

Fig. 3  The number of days after babirusa piglets were released from the pen to the outdoor area until the time of first expression of nest building behaviour in the outdoor area of Babirusa Park. Although babirusa piglets had different birth years, the timing of each life event was indicated on the Y axis. The sample size is small, but there seems to be a relationship between the month of release into the outdoor area and the time to the first exhibition of piglet nest-building behaviour. Black arrowhead: Timing of the first exhibition of nest building behaviour. White arrowhead: Timing of the birth.

gathered the small amount of fallen leaves and twigs to the nest site. After an elapse of 10 min of the start, the adult female Shela detected a wobbly wooden bar in the enclosure fence. She started partially disassembling the fence by biting the bar, pushing it up and down with her snout, and actively knocking it down with the hoof of her forelimb (Fig. 4A). Two
minutes later, she pulled the bar out of the fence (Fig. 4B) and carried it to the nest site (Figs. 4C and D). An additional bar was then removed from the fence and taken to the nest. The other three animals were also video-recorded. They manipulated the wooden bar, biting it and taking the bark off with their mouths.

**DISCUSSION**

In the profile of nesting behaviour of babirusa, the following aspects are worthy of special mention.

1) Babirusa nest building behaviour for sleeping and the re-use of sleeping nests in this study was most frequently exhibited during the short period from 17:00 hr to 18:00 hr corresponding to the period between the evening feeding and the time of sunset (Fig. 1).

2) A wide variety of plant materials were gathered with different techniques. These included taking parts off the tree with their mouth while standing on their hind limbs (Fig. 2E).

3) There was a high degree of consistency, irrespective of age and sex, in the frequency of nesting behaviour for sleeping among the animals (Table 4).

4) Babirusa initiated nesting behaviour while still suckling, at the age of 15 weeks (Table 5; Fig. 3).

5) Sleeping nests were co-operatively produced, with no consistent leader taking the initiative to start building a nest. Members of the same group shared the product as a communal nest.

6) Sleeping nest building of babirusa is one of their normal behavioural repertories.

In order to properly interpret the data recorded in this study, careful consideration and discussion should be given to some aspects as follows.

**Timing of nesting behaviour:** The babirusa is known to be a diurnal animal in zoological collections and spends hours of time lying down after eating [8]. Therefore, we focused mainly on the period from the termination of feeding behaviour until the onset of lying behaviour. Babirusa were fed at 16:00 hr at Babirusa Park and usually finished feeding behaviour after about 20 minutes; subsequently nesting behaviour occurred intensively for one hour from about 17:00 hr (Fig. 1). Sunset occurred in the period from 18:06 hr to 18:46 hr depending on the month. Then, 20 minutes later, the outdoor enclosure became dark. There was therefore a period of more than two hours between the fixed feeding time and the end of dusk throughout the period of this study. There was no evidence that our feeding schedule delayed nesting behaviour. The fact that 15.5% (n=78) of examples were recorded in the morning and in the night was note-worthy. Judging from the observational data shown in Fig. 1, the two hours from 17:00 until 19:00 was the peak time of nesting behaviour expression recorded at Babirusa Park. It was also note-worthy that babirusa did not necessarily exhibit nesting behaviour every day in the study site, and these factors have been analysed in detail elsewhere (Ito et al., Unpublished data).

In accordance with the peak time of occurrence of nesting behaviour observed in this study, active behaviours including social interaction among the group in the early evening before the dusk were observed in zoological collections [8] and in the wild [14, 15].

**Babirusa piglets to build communal nests:** Our observations demonstrated that babirusa piglets initiated nest building behaviour when they were still suckling, although there were individual differences in the timing between the piglets (Table 5; Fig. 3). It was conceivable that climatic elements contributed triggers to the development of the nest building behaviour in the babirusa piglet (Ito et al., Unpublished data). In addition, social structure would also appear to play a role and contributed to differences seen in piglet behavioural patterns.

Leus et al. [8] observed comparable nesting behaviour, using straw and plant branches, by both sexes of babirusa. Bowles [13] pointed out that a babirusa sow and a male juvenile spent a longer time than the adult male on more meticulous nesting behaviour. In this study we saw no differences between babirusa boars and other family members in the nesting frequency. Cooperative nesting behaviour in the grass of Babirusa Park agreed with observations of communal nests constructed by all the animals within the pen [12].

**Behavioural differences depending on the enclosure design:** It has been pointed out that the enclosure design affected babirusa behaviours. For instance, in the freshly sand-filled enclosure, mainly adult males performed ploughing behaviour, putting the snout down into the sand [20]. If water pool or wallow were available in the enclosure, the animal displayed lively activities daytime [8, 17]. Further, nesting behaviours were also reported to be influenced by the external condition. Under the condition without bedding, babirusa slept on the bare ground. However sleeping nests were built if nesting material was provided [8, 21]. Among various kinds
of organic materials in the study site, babirusa selected dry banana leaves first, then parts of coconut palm trees as nest materials, although they used green grasses throughout the period. Such ability of babirusa to select certain plants for foraging has also been described in detail [22]. Therefore, the behavioural data on plant matters in this study does suggest particular nesting material preferences of babirusa. In the enclosure where clusters of clumping bamboos were growing, babirusa preferred to make communal nests at the foot of the bamboo [12]. It would appear that the babirusa were adaptable and made use of the resources available in the enclosure.

A normal behavioural repertory worth spending costs: Babirusa mowed the grass to prepare the nesting materials (Figs. 2B and C); therefore keepers did not need to provide any nest materials to the animals in the first study site. In many cases, the babirusa spent about 30 min to complete a sleeping nest, but occasionally 50 min were required for a new nest of grass. Even after the grasses around the nest had been harvested by the animal, they repeated the transportation of materials 47 times from the grass field more than 20 m away from the nest. Occasionally, they gathered nesting material from tree trunks standing straight with the hind limbs (Fig. 2E). This standing posture has been also observed when plucking leaves from the tree during foraging [8, 18, 23]. Furthermore, it is noted that the babirusa focused on nesting behaviour once begun even if there was disturbance from outside. Although Shela partially destroyed the wooden fence at the second study site (Fig. 4), it was clearly an understandable behaviour; she was seeking to supplement the available nest materials. ‘Fence destruction’ did not recur after relatively large amount of tree leaf fodder or more appropriate nest-building materials were routinely provided to her. Our observations suggested that nesting behaviour is important to the babirusa as they spend a considerable amount of time and energy on this activity.

Benefits: Our observations of the various types of behaviour associated with gathering nest-making material provided suggestions for babirusa enclosure design, to enrich them and to help zoo visitors obtain further understanding of the nature of normal babirusa behaviour. The outdoor area of Babirusa Park, a semi-natural environment with sustainable vegetation covering in the babirusa enclosure was ideal. However, if this is not possible to provide, there are still other practical alternatives. The routine provision of nesting materials in the enclosure permits expression of this often-unobserved talent by this species. Additionally, the installation of vertical structures in the enclosure such as the planting of living trees or wooden posts from which to hang tree leaf fodders would enable hind-limb standing to be exhibited (Fig. 5).

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Fig. 4  ‘Fence destruction’ by Sulawesi babirusa when the nest materials were not provided by keepers.
A: The female babirusa *Shela* knocking a wooden bar of the enclosure fence of Bali Zoo with the hoof of her forelimb. Many repair marks on the fence indicate that the animal had frequently touched the bar.
B: *Shela* pulling the wooden bar out of the fence.
C and D: *Shela* carrying the wooden bar to the sleeping nest.

Fig. 5  An effective feeding enrichment for Sulawesi babirusa.
A: Branches of browse suspended from a beam in the babirusa shelter, Bali Zoo.
B: The female babirusa *Priska* at Bali Zoo standing on her hind limbs examining the leafy browse before eating.
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原著論文 動物行動学

スラウェシバビルサ（Babyrousa celebensis）の営巣行動

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要 約
インドネシアにおいて飼育下スラウェシバビルサの営巣行動504例が観察され, 時刻, 場所, 巣材を含む行動特性が記録された。本種は, 性別を問わず, 生後15週以降の幅広い年齢で, 夕方の給餌時刻と日没時刻の間に相当する午後5時から午後6時の時間帯に高頻度に, 壁, 大木, 間隙等の構造物の傍らに寝屋を作った。落葉落枝の収集のみならず, 後肢で起立し, 立木から様々な部位を採取する巣材収集行動も観察された。また, 巣材不足の際, 牧柵から棒材を引き抜き, 巣材を補足する行動も記録された。群飼では, 営巣行動を主導する特定の個体は認められず, 共同作業により完成した巣は共用された。バビルサの休息睡眠用の営巣行動は正常な行動レパートリーの一つであり, 飼育下個体への巣材の提供は効果的なエンリッチメントになる。

キーワード: 営巣行動, エンリッチメント, 巣材収集行動, 寝屋, バビルサ

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