Breeding of Female Mongoose on Okinawa

Full Paper

Relationship between Body Size and Sexual Maturation, and Seasonal Change of Reproductive Activities in the Female Feral Small Asian Mongoose on Okinawa Island

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沖縄島に生息する雌のジャワマングースの体サイズと性成熟の関係, ならびに繁殖活動の季節推移

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ABSTRACT. The breeding characteristics of female feral small Asian mongooses on the island of Okinawa are herein described. Based on the analysis of head and body lengths and sexual maturity, it was found that most females whose head and body lengths were under 240 mm on Okinawa were sexually immature females. Moreover, it was observed that the females attained puberty at a head and body length range of 240 mm to 255 mm, and attained sexual maturity at approximately 265 mm, in those females demonstrating comparatively rapid growth. The results from captive females of each reproductive status suggested that the mating season begins predominantly in February, the prime parturient season is from April to September, and the lactational season continues until November. The annual changes in the rate of pregnant females showed only one peak, indicating that most females produce one litter per year and the rate of pregnancy calculated from February to November, when pregnant females were trapped, was 32.3%. The number of fetuses varied from one to three, and averaged 2.15, and the number of placental scars ranged from one to five, and averaged 2.54. It appears that five embryos can implant in the uterus at once; however, the results of the strength of placental scars and the range of the number of fetuses indicated that several embryos might be lost if as many as four or five embryos implanted.

Key Words: body size, reproductive cycle, sexual maturation, small Asian mongooses
INTRODUCTION

The small Asian mongoose (*Herpestes javanicus*), which inhabits the island of Okinawa, was introduced from British India in 1910 in an attempt to control Habu snakes and rats [1]. According to recent studies of the mongoose on the island of Okinawa, the introduced mongoose has had an impact on the populations of domestic fowls [2] and native animals (Ogura et al., unpublished data). In light of this situation, the Okinawa Prefectural Government planned to take countermeasures against the mongoose.

The reproduction of the introduced mongoose has been studied in the Hawaiian islands [3, 4], the Fijian islands [5], and the Caribbean islands [6, 7], and the mongooses in these regions have been reported to be seasonal breeders. On the island of Okinawa, the reproductive pattern in the male definitely showed a seasonal cycle, demonstrating the possibility that the male mongooses active reproductive season is from February to August [8]. However, to our knowledge, no previous report has described the breeding of female mongooses in Okinawa. In advance of the development of a project aimed at ridding feral mongooses in Okinawa, it is imperative to investigate the reproduction of the feral mongoose. This paper describes the breeding characteristic of the female mongoose on the island of Okinawa.

MATERIALS AND METHODS

Animals and autopsy procedure

Mongooses were trapped alive on the island of Okinawa from April 1995 to December 1999 (n=126). The female mongooses, none of which showed remarkable clinical findings, were euthanised with diethyl ether inhalation or pentobarbital sodium injection and frozen at −20°C until dissection. Body weight was measured on an electronic scale (0.1 g graduation) after thawing. Total length (with the animal laid on its back and stretched out, from tip of nose to tip of tail) and tail length (from the upper base of tail to tip) were measured according to standard measuring procedures [9] using a ruler (1 mm graduation) before dissection. Their head and body lengths (HBLs; total length-tail length) were calculated.

Females were first examined for signs of lactation by squeezing nipples. When the animals were autopsied, the uteruses were inspected for evidence of pregnancy, then macroscopically examined for the presence of embryos, fetuses and placental scars. Both ovaries were excised, weighed (0.1 mg graduation), and fixed for several days in 10% formaldehyde solution, after which about eight micro millimeter transverse sections were cut from the ovaries and stained with Mayer's hematoxylin and eosin. The ovaries were examined for the presence of mature follicles and the corpora lutea under an optical microscope. Both adrenal glands were removed and weighed (0.1 mg graduation), and the diameter of both proximal uterus horns was measured (0.01 mm graduation).

Body size and sexual maturity

Female mongooses, caught between November 1997 and August 1999 (n=76), were classified as pregnant (status-C) when an embryo or fetus was found in the uterus, or when corpora lutea were found in the ovary, or both; as lactating (status-B) when milk could be expressed from the nipples; or as non-breeding when none of these conditions existed. In addition, non-breeding females were categorized according to reproductive status as follows: 1)
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Table 1 Definitions of the female reproductive statuses with the gross findings and the histological findings of the female reproductive organs examined in this study.

<table>
<thead>
<tr>
<th>Reproductive status</th>
<th>Mature ovarian follicle</th>
<th>Placental scar</th>
<th>Fetus, embryo or corpora lutea</th>
<th>Milk expressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, Non-breeding</td>
<td>+ or -</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B, Lactating</td>
<td>+ or -</td>
<td>+ or -</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>C, Pregnant</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+ or -</td>
</tr>
<tr>
<td>D, Non-breeding</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>E, Non-breeding</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

+ : observed, - : not observed

parous females (status-A), which had placental scars in the uterus, 2) females that had a mature ovarian follicle in the ovaries (status-D), and 3) females that had no placental scars and no mature follicle (status-E; Table 1). In this classification, we assumed that pseudopregnancy does not occur in the small Asian mongoose according to Hoffman et al. [4], because it is unknown whether the species is a pseudopregnant animal or not. The relationship of reproductive status to HBL and body weight was analyzed.

Annual reproductive cycle

Female mongooses, caught between April 1995 and November 1999 (n=121), whose HBLs were 255 mm and over were classified as pregnant when an embryo or fetus was found in the uterus; as lactating when milk could be expressed from the nipples; or as non-breeding when none of these conditions existed. The incidence per month of each of the three reproductive statuses was calculated and the annual reproductive cycle was determined. The ovarian weights, adrenal weights, and the diameters of uterus horns were compared among the three reproductive statuses (analysis of variance was used, and when appropriate, the Scheffe method was applied). Furthermore, these measurements were used to compare between the breeding and non-breeding season (unpaired two-group t-test was used).

Litter size

The litter size was deduced from the number of embryos or fetuses (n=26) and placental scars (n=50).

RESULTS

Body size and sexual maturity

The HBLs and body weights for each reproductive state are shown in Fig. 1. The HBL increased in relation to reproductive status. In the non-pregnant and non-lactating females, which had no mature ovarian follicle or placental scars (status-E), the...
HBLs of three females were 240 mm and under, and a fourth female was 280 mm in HBL. The HBLs of the non-breeding females, which had a mature ovarian follicle (status-D) were 255 mm to 310 mm; the pregnant females (status-C) were 265 mm to 305 mm in HBL; and the lactating females (status-B) and females that had placental scars (status-A) showed HBLs of 275 mm to 311 mm. Body weight increased in relation to reproductive status, in a manner similar to the increase of HBLs, though the dispersion of the values of the body weights (C.V. = 15.3–37.3) was larger than that of the HBLs (C.V. = 2.8–15.6) in each reproductive status.

**Annual reproductive cycle**

Pregnant females were caught in February, November, and from April to September. The incidence which the pregnant females were captured was notably higher from May to August, and peaked in June and July. Lactating females were caught from May to November. The non-breeding females were mainly caught from November to April (Fig. 2). The mean ovarian weight and the mean diameter of uterus horns in the pregnant females were higher than those in the females of other status (p<0.05). The mean adrenal weight in the pregnant and lactating females was higher than those in the non-breeding females (p<0.05, Table 2). In addition, the adrenal weight and the uterus diameter in the non-breeding females were higher from February to September than from October to January (Table 2).

**Litter size and rate of pregnancy**

The number of fetuses (including embryos) per pregnant female was usually two or three and rarely one. The mean number of placental scars per

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**Table 2** Ovarian weights, adrenal weights, and uterus horn diameters in each reproductive status group.

<table>
<thead>
<tr>
<th></th>
<th>Ovaries weight (mg/100 g body weight)</th>
<th>Adrenal glands weight (mg/100 g body weight)</th>
<th>Proximal uterus horn diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pregnant</td>
<td>6.5±2.1*</td>
<td>32.0±7.4*</td>
<td>9.7±7.3*</td>
</tr>
<tr>
<td>(n=21)</td>
<td></td>
<td>(n=20)</td>
<td>(n=20)</td>
</tr>
<tr>
<td>Lactating</td>
<td>4.6±1.2*</td>
<td>32.5±9.1*</td>
<td>3.7±1.7*</td>
</tr>
<tr>
<td>(n=24)</td>
<td></td>
<td>(n=24)</td>
<td>(n=24)</td>
</tr>
<tr>
<td>Non-breeding</td>
<td>4.6±1.3*</td>
<td>24.6±6.8*</td>
<td>2.7±1.2*</td>
</tr>
<tr>
<td>(n=68)</td>
<td></td>
<td>(n=58)</td>
<td>(n=70)</td>
</tr>
<tr>
<td>Non-breeding (Oct.-Jan.)</td>
<td>4.3±1.3</td>
<td>22.3±5.6</td>
<td>2.1±0.6</td>
</tr>
<tr>
<td>(n=33)</td>
<td></td>
<td>(n=27)</td>
<td>(n=34)</td>
</tr>
<tr>
<td>Non-breeding (Feb.-Sep.)</td>
<td>4.9±1.3</td>
<td>26.6±7.2*</td>
<td>3.2±1.4**</td>
</tr>
<tr>
<td>(n=35)</td>
<td></td>
<td>(n=31)</td>
<td>(n=36)</td>
</tr>
</tbody>
</table>

Values are mean±S.D. The different letters in each measurement item indicate a significant difference (p<0.05). *p<0.05 and **p<0.0001, as compared with values obtained in non-breeding females (Oct.-Jan.).

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Table 3 Percentage of females according to number of placental scars and fetuses, and mean number of placental scars and fetuses.

<table>
<thead>
<tr>
<th>Number of placental scars and fetuses</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Mean number of placental scars and fetuses(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Placental scars((n=50))</td>
<td>8.0</td>
<td>54.0</td>
<td>22.0</td>
<td>8.0</td>
<td>8.0</td>
<td>2.54±1.03</td>
</tr>
<tr>
<td>Fetuses(^2)((n=26))</td>
<td>3.8</td>
<td>76.9</td>
<td>19.2</td>
<td>0.0</td>
<td>0.0</td>
<td>2.15±0.46</td>
</tr>
</tbody>
</table>

\(^1\)mean±S.D., \(^2\)Includes embryos

female (2.54) was similar to the mean number of fetuses (2.15), but the range of the number of placental scars was from one to five (Table 3). The mean number of fetuses in the left and right uterus horns were 1.04 and 1.12, respectively, and the mean number of placental scars in the left and right uterus horns were 1.34 and 1.20, respectively. No significant differences were observed between the mean values for fetuses and placental scars, and the mean values in the left horn and the right horn (p > 0.05). The highest number of fetuses and placental scars in one side uterus horn were two and four, respectively. The pregnant females had no placental scars. The strength of the placental scars in the uterus varied. There were pale placental scars in three of five females that had five placental scars, and in one of four females that had four placental scars.

In the two-year period from November 1997 to October 1999 (n=112), the percentage of pregnant females was 20.5%, and the percentage of females having a placental scar was 42.0%. The rate of pregnancy calculated from February to November, when pregnant females were trapped, was 32.3%.

DISCUSSION

Body size and the Sexual maturity

In the West Indies, reproductive maturity in female mongoose occurred at about six months of age or later, though three of 43 pregnant females were less than six months old at the time they conceived, the youngest being about 130 days old [7]. The conception dates of embryos were calculated by eye lens weight [10]. In the mongoose on Okinawa, the method of age determination using the eye lens or the penis bone has not been established. Therefore, in this study, the stage at which females attain sexual maturity was assumed to correlate to the HBL and body weight. In the status-E group females, three of four females were 240 mm and under in HBL, indicating that many feral females on Okinawa, whose HBL is under 240 mm, are sexually immature. One female in the status-E group showed 280 mm in HBL, larger than that of the HBL in all other sexually immature females on Okinawa, and is more comparable to that of HBL in the reproductive status-A to -D groups (Fig. 1).

The results of the HBLs in the reproductive status -C, -D, and -E groups (Fig. 1) indicated that the comparatively rapid growth females attained puberty at a range from 240 mm to 255 mm in HBLs, and attain sexual maturity at 265 mm in HBLs.

The result of the body weight analysis indicated that females that weighed less than 230 g were sexually immature. Puberty began at a weight of 230 g to 240 g, and sexual maturity began at a weight of about 265 g, in the females showing comparatively rapid growth. However, in each reproductive status group, the weights showed broader dispersion than the HBLs, suggesting that the HBL was more suitable than the weight as an indicator of sexual maturity.

Annual reproductive cycle

On the island of Okinawa, the season during
which pregnant females were mainly captured, from April to September, approximately corresponded with the male active reproductive season, from February to August [8]. It was clarified that the mating of most of the feral mongooses on Okinawa begins in February, and the main parturition season is from April to September. Moreover, the results from captured lactating females suggested that the lactational season continued until November.

The ovarian weight, adrenal weight, and the uterus horn diameter were lower in the non-breeding females than in the pregnant or lactating females; however, these values in the non-breeding females were higher in February to September. This period was the active reproductive season of the male mongoose on Okinawa [8] and it was assumed that the reproductive activity of the non-breeding females was also heightened from February to September.

A difference of several months was observed in the breeding season between Okinawa and that in three other regions, including Oahu island [4], the West Indies [7], and Viti Levu island [5]. Nevertheless, the general trend of the breeding season in Okinawa was mainly from spring to summer, which was similar to that observed in the other three regions. With regard to the ridding of the mongoose on Okinawa island, if year-round capture can not be maintained, capture during the breeding season, from spring to summer, can be undertaken to limit the increase of the mongoose population effectively.

Our findings strongly suggest that few reproductive females exist during the non-breeding season, from December to January. Two fetuses were found in a pregnant female captured on February 4. The fetus weights were 6.81 g and 6.53 g, and crown-rump lengths were 54.8 mm and 52.7 mm, respectively. These measurements corresponded to the seventh prenatal week according to the report of Tomich and Devick [10]. These results suggest that the mongoose on Okinawa also copulates in December. In addition, one female captured on November 16 was not carrying a fetus, but corpora lutea were observed. Considering that the mongoose is a copulatory ovulator [11, 12] and that the gestation period is about seven weeks [10], there is a possibility that the female produces a litter in January.

**Frequency of the parturition per a year**

The annual change of the pregnant females captured on Okinawa showed one reproductive peak. This characteristic was also found in females captured on Viti Levu [5]. On the other hand there were two distinct peaks observed on Oahu [4], Hawaii [11], Puerto Rico [6], and St. Croix [7]; and three peaks observed on Grenada [7]. In the small Asian mongoose, the gestation period is about seven weeks [10], the lactation period is about five weeks [5], and second estrus in the year is post-lactational [5, 11]. Based on the supposition that many females produce two litters per year, it would follow that captured pregnant females would show reproductive peaks at an interval of three months. However, the annual change in pregnant females captured on Okinawa showed only one peak, indicating that most females produce one litter per year.

**Litter size and rate of pregnancy**

In India, the small Asian mongoose produces two to three newborns per litter [13]. In Grenada [7], St Croix [7], Puerto Rico [6], Viti Levu [5], and Hawaii [11], the number of newborns per a litter ranged from 1 to 5, 1 to 3, 2 to 4, 1 to 4, and 2 to 4, respectively. In Okinawa, a female produced two newborns, one male and one female [14]. Among the 26 females in our study, the number of fetuses was usually two, sometime three, and rarely one; these findings are similar to those reported in the West Indies [7]. The number of placental scars ranged from one to five, suggesting that five embryos can implant in the uterus at once. However, females that had four or five placental scars had a
few pale placental scars, indicating that several of the embryos might be lost after four or five embryos implanted. The fact that the female produced a maximum of only three fetuses per litter also supports the above conjecture.

The rate of pregnancy, calculated from February to November, on Okinawa was higher (32.3%) than that on Oahu (26.9%) [4] or that on Grenada (18.5%) [7]. The significance of this finding was unclear. Over the two-year period from November 1997 to October 1999, the percentage of captive pregnant females was 20.5%, and the percentage of parous females with placental scars was 42.0%, which suggested that more than 60% of feral adult females participated in reproduction.

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