Body temperatures of *Manis pentadactyla* and *Manis javanica*

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Abstract

Body temperature is an important parameter for assessing animal health and physiological function. An iButton thermometer was used to measure the body temperatures of three Chinese pangolins (*Manis pentadactyla*) and three Sunda pangolins (*M. javanica*). The body temperature of Chinese pangolins was $33.2 \pm 0.95$ °C (30.6–34.2 °C, $n = 3$) and that of Sunda pangolins was $32.8 \pm 0.48$ °C (31.7–34.2 °C, $n = 3$). The daily variation in body temperature was 1.0–2.9 °C in three Chinese pangolins and 1.2–1.9 °C in three Sunda pangolins. The body temperature of Sunda pangolins tended to rise at night, with the highest body temperatures occurring mostly at night. This study provides valuable body temperature data for Chinese and Sunda pangolins and lays the foundation for future research on their mechanisms of body temperature regulation.

KEYWORDS
body temperature, Chinese pangolin, fluctuation, Sunda pangolin

1 | INTRODUCTION

Mammals are advance endothermal animals that able to maintain stable body temperatures within certain ambient temperature ranges (Yang, 2015). Mammals able to maintain is temperature as it has a high degree of metabolic heat production and various mechanisms to control body-surface heat dissipation (Li & Zheng, 2009). In addition, mammals are able to maintain homeostasis when faced with changes in environmental factors (Sun, 2001; Liu & Zheng, 2009). Approximately 95% of mammals belong to Eutheria, a group of higher mammals with good thermoregulatory abilities (Liu & Zheng, 2009). Refinetti (2010) summarised the body temperatures of more than 60 mammalian species and found that most species had body temperatures of 36.0–40.4 °C, with significant differences in the body temperatures of different types of animals.

Body temperature is the average heat energy generated by the internal metabolism of animals (Yang, 2015). Stable body temperature is an important prerequisite for maintaining normal metabolism and life activities in animals (Chen, 2019). The body temperature of mammals remain relatively constant to certain ambient temperatures. However, when ambient temperatures are too high or low, the body temperatures will fluctuate significantly (Fuller et al., 1978; Refinetti, 1996, 1997). A number of factors such as age, food availability, reproductive status and activity level can affect physiological function of animal body temperature (Refinetti & Menaker, 1992; Refinetti, 2010).

Pangolins belong to the order Pholidota that lacks dense hair and its body covered with scales (Corbet & Hill, 1992; Gaubert & Antunes, 2005; Gaudin et al., 2020). Pangolins are unable to adapt to environmental temperature fluctuation and pangolins kept in captivity are susceptible to pneumonia due to sudden temperature fluctuation.
(Wang 2012). Data on the body temperatures of healthy Chinese and Sunda pangolins have not been established. Heath and Hammel (1986) measured the body temperatures of four Chinese pangolins (two males and two females) and found that their body temperatures were maintained within a range of 33–35°C. McNab (1984) found the body temperatures of a juvenile male and an adult female Sunda pangolin to be 31.7°C and 32.3°C, respectively. Heath (1987) collected continuous body temperature data on four Chinese pangolins and the results show an obvious body temperature fluctuation rhythms. Body temperatures were lower during the day than at night, with the highest temperature around midnight and the lowest around noon. However, previous studies have not consistently measured body temperature or daily fluctuations in body temperature.

The purpose of this study is to understand body temperature characteristics and fluctuation patterns in Chinese and Sunda pangolins and to increase our knowledge of basic physiological data of pangolins.

2 MATERIALS AND METHODS

2.1 Study animals

A total of three Chinese pangolins and three Sunda pangolins were used in this study. The Chinese pangolin numbered HS09 and the three Sunda pangolins numbered FS06, FS15 and FS18 were from the Pangolin Research Base for Artificial Rescue and Conservation Breeding of South China Normal University, Guangdong, China. Pangolins were kept in separate enclosures with artificial food and drinking water were provided daily (Zhang et al., 2015, 2017). The two Chinese pangolins numbered GX01 and GX02 were kept at the Terrestrial Wildlife Rescue Center of the Guangxi Zhuang Autonomous Region, Guangxi, China. These two pangolins were kept at a different location and provided a different diet. All pangolins were in good health during the study with normal levels of activity, eating and defecating. When body temperatures were measured, all pangolins appeared in good physical and mental condition with normal levels of activity, eating and defecating.

2.2 Measuring body temperature

Body temperatures of the pangolins were measured using the DS1922L temperature recorder (Wodisen Electronic Technology Company, Shanghai, China). The device measured temperature every 10 min, and the data were stored in the instrument. Data were transferred by ElitechLog V3.0.0. to Microsoft Excel 2010 for analysis. The temperature measurements stopped when the thermometer dropped from the animal’s rectum.

The DS1922L temperature recorder was wrapped with rubber film and a length of string (0.3 m) was attached before the study. The film was used to protect the instrument from short circuits and the string was used to retrieve the button thermometer from the animal’s rectum at the end of the study. After preparations were complete, the tail of the pangolin were lifted so that its body was perpendicular to the ground with the anus exposed and let the pangolin’s forelimbs and head dangle close to the ground to prevent it from curling. Blunt long tweezers were used to clamp the end of the temperature recorder and applied lubricant to the film covering the recorder. When the pangolin was in a relaxed state, the temperature recorder were placed approximately 3 cm into the rectum to measure the animal’s rectal temperature. Finally, after situating the temperature recorder, the handler gently put the pangolin down and observed it for 15 min to ensure that the animal showed no abnormal behaviour and that the thermometer did not fall from the anus.

2.3 Measuring ambient temperature

The DS1922L temperature recorder was placed approximately 30 cm from the ground to measure the ambient temperature of the enclosure.

2.4 Data collation and analysis

The data were sorted and analysed using Microsoft Excel 2010 and IBM SSPS 19.0 and are expressed as the mean ± SD. SigmaPlot 12.5 was used to draw a timing sequence diagram for body temperature.

3 RESULTS

3.1 Pangolin body temperature

The body temperatures of the six pangolins are shown in Table 1. The mean body temperature of the three Chinese pangolins was

| TABLE 1 Body temperatures of pangolins |
|----------------------------------------|
| Species                | No. | Sex | Body weight (kg) | Body temperature (°C, mean ± SD) |
| Manis pentadactyla     |     |     |                 |                                  |
| HS09                   | ♀   | 4.93| 31.7 ± 0.79 (30.6–33.5, n = 124) |
| GX01                   | ♂   | 5.50| 33.6 ± 0.23 (33.2–34.2, n = 99)  |
| GX02                   | ♀   | 7.50| 33.7 ± 0.28 (32.8–34.2, n = 269) |
| Manis javanica         |     |     |                 |                                  |
| FS06                   | ♀   | 3.75| 32.8 ± 0.47 (31.8–34.1, n = 1424) |
| FS15                   | ♂   | 3.90| 32.9 ± 0.56 (31.7–34.0, n = 216)  |
| FS18                   | ♂   | 4.07| 33.0 ± 0.37 (32.4–34.2, n = 144)  |
### TABLE 2  Body temperature fluctuations in pangolins

| Species              | No.    | Time                  | Duration (h) | Lowest (°C) | Highest (°C) | Range (°C) |
|----------------------|--------|-----------------------|--------------|-------------|--------------|------------|
| *Manis pentadactyla* | HS09   | 2018/5/11 23:30–5/13 00:30 | 25           | 30.6        | 33.5         | 2.9        |
|                      | GX01   | 2019/6/23 11:30–23:50   | 12           | 33.2        | 34.2         | 1.0        |
|                      | GX02   | 2019/6/23 23:20–6/25 9:00 | 33.5         | 32.9        | 34.2         | 1.3        |
| *Manis javanica*     | FS06   | 2018/12/28 0:00–24:00   | 24           | 32.7        | 33.9         | 1.2        |
|                      |        | 2018/12/29 0:00–24:00   | 24           | 32.2        | 33.6         | 1.4        |
|                      |        | 2018/12/30 0:00–24:00   | 24           | 32.2        | 34.1         | 1.9        |
|                      |        | 2018/12/31 0:00–24:00   | 24           | 32.2        | 33.5         | 1.3        |
|                      |        | 2019/1/1 0:00–24:00     | 24           | 31.9        | 33.3         | 1.4        |
|                      |        | 2019/1/2 0:00–24:00     | 24           | 31.9        | 33.6         | 1.7        |
|                      |        | 2019/1/3 0:00–24:00     | 24           | 32.2        | 33.5         | 1.3        |
|                      |        | 2019/1/4 0:00–24:00     | 24           | 31.8        | 33.2         | 1.4        |
|                      |        | 2019/1/5 0:00–24:00     | 24           | 31.9        | 33.3         | 1.4        |
|                      |        | 2019/1/6 0:00–21:20     | 21.5         | 31.5        | 33.1         | 1.6        |

* The body temperature of HS09 was measured at ambient temperatures of 22.7–30.5°C. The body temperatures of GX01 and GX02 were measured at ambient temperatures of 27.4–29.6°C. The body temperatures of FS06, FS15 and FS18 were measured at ambient temperatures of 25.8–28.5°C.

### FIGURE 1  Variations in Sunda pangolin FS06 body temperature (mean)

33.2 ± 0.95°C (30.6–34.2°C) and the three Sunda pangolins was 32.8 ± 0.48°C (31.7–34.2°C).

### 3.2 Fluctuations in body temperature

Fluctuations in the body temperatures of four pangolins are shown in Table 2. The body temperature fluctuations of pangolins FS15 and FS18 were not recorded as the iButton dropped from these individuals during the study. The body temperatures of the Chinese pangolins fluctuated from 1.0°C to 2.9°C (HS09, GX01 and GX02) and the body temperature of the Sunda pangolin (FS06) fluctuated from 1.2°C to 1.9°C. Continuous recording of body temperature for 9 consecutive days was obtained for only one Sunda pangolin (FS06). Figure 1 shows that body temperatures exhibited an upward trend at night. The highest body temperature (+1.9°C) of the animals occurred mostly at night (Table 3). The accumulated daytime body temperature of FS06 was 21001.4°C which was lower than the accumulated nighttime body temperature (21518.1°C).

### TABLE 3  Extreme temperatures of Sunda pangolin FS06

| Date      | Body temperature (Max/Min, °C) | Time | Day/night |
|-----------|---------------------------------|------|-----------|
| 2018.12.28| Max 33.9                        | 20:20 | N         |
|           | Min 32.7                        | 14:10 | D         |
| 2018.12.29| Max 33.6                        | 20:30 | N         |
|           | Min 32.2                        | 13:00 | D         |
| 2018.12.30| Max 34.1                        | 08:20 | D         |
|           | Min 32.2                        | 23:50 | N         |
| 2018.12.31| Max 33.5                        | 20:00 | N         |
|           | Min 32.2                        | 03:50 | N         |
| 2019.01.01| Max 33.3                        | 23:50 | N         |
|           | Min 31.9                        | 15:20 | D         |
| 2019.01.02| Max 33.6                        | 21:40 | N         |
|           | Min 31.9                        | 12:50 | D         |
| 2019.01.03| Max 33.5                        | 23:40 | N         |
|           | Min 32.2                        | 12:50 | D         |
| 2019.01.04| Max 33.2                        | 23:40 | N         |
|           | Min 31.8                        | 20:30 | N         |
| 2019.01.05| Max 33.3                        | 23:40 | N         |
|           | Min 31.9                        | 03:40 | N         |

* Day 06:00–18:00, Night 18:00–06:00.
4 | DISCUSSION

The body temperature of Chinese pangolins in this study was 33.20 ± 0.95°C and that of Sunda pangolins was 32.80 ± 0.48°C. The body temperature for both species were lower than the body temperature of Eutheria (35.0–39.0°C). The findings are similar to those reported previously in other pangolins (Table 4).

The body temperature of an animal is closely related to its basal metabolic rate (Chen, 2019). The basal metabolic rate of animals is affected by many factors including body weight, phylogeny, diet, climate, season, habits, and reproduction (Song & Wang, 2002). The low body temperatures in pangolins are possibly due to the low metabolic rates of species. Kleiber (1932) suggested that the low body temperature are related to the diet of pangolins as diets of Chinese and Sunda pangolin consist primarily of ants and termites. These food items have high fractions of non-digestible chitinous exoskeleton (Heath & Hammel, 1986; Wu et al., 2005). Pangolin will ingest both the prey and non-digestible debris of its prey (McNab, 1984). The ingestion of non-digestible debris will reduce the nutritional and caloric density of the food (McNab, 1984). Additionally, these low caloric dense foods are not abundant enough to permit their predators to maintain constant or periodic high rates of energy expenditure (McNab, 1984).

The body temperature fluctuations of the Chinese pangolins measured in this study were as high as 2.9°C, that was greater than 48 species of Eutheria recorded by Refinetti (2010) that recorded fluctuation of 2.5°C of its body temperature. Previous studies on two African pangolins, Phataginus tricuspis and P. tetradactyla also recorded temperature fluctuations of 2.5°C and 4.5°C, respectively (Jones, 1973). Pangolins have poor temperature regulation due to the lack of heat-insulating fur and their hair erector muscles are underdeveloped (Heath & Hammel, 1986). This hinders the prevention of heat loss and leads to fluctuations of its body temperature (Heath & Hammel, 1986).

Authors found that the highest body temperatures of Sunda pangolin FS06 occurred mostly at night. The higher body temperature at night than during the day may be related to its activity levels. Sunda pangolins are nocturnal mammals, and their activity level is highest at night. Sunda pangolin FS06 was observed to emerge mainly after 20:00 and was provided with artificial food from 23:00 to 00:00 every day. This increase of activity level leads to increased metabolic rate and body temperature. A similar finding was recorded in three Chinese pangolins when their body temperature changes were recorded in day time and night time (Heath, 1987). The daily fluctuation in body temperatures was 0.5–1.9°C with the highest body temperature occurred at night and the lowest during the day. Pangolin body temperature increased significantly after pangolin increase its activity at night.

This study provides baseline data on the body temperatures of pangolins that provide for the management of captive pangolins. These baseline data on the body temperature ranges of Chinese and Sunda pangolins enable researchers to monitor pangolin health status and detect physiological abnormalities that may affect pangolin health.

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AUTHOR CONTRIBUTIONS

Yishuang Yu: Investigation, methodology and writing-original draft. Shibao Wu: Conceptualisation, data curation, project administration and supervision. Fuhua Zhang: Investigation and supervision. Amna Mahmood: Writing-review and editing. Wenhua Wang: Investigation.

PEER REVIEW

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DATA AVAILABILITY STATEMENT
The data analysed in this study is subject to the following licenses/restrictions: protect the personal privacy of interviewees. Requests to access these datasets should be directed to Wu shibao: wushibao@163.com.

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REFERENCES
Chen, W. (2019). Thermometry and interpretation of body temperature. Biomedical Engineering Letters, 9(1), 3–17.
Corbet, G. B., & Hill, J. E. (1992). The mammals of the Indomalayan region: A systematic review. London, UK: Oxford University Press.
Eisentraut, M. (1956). Korpcrtemperaturen bei tropischen Fledermausen und Schuppentieren. SIUUGDRIK. Milt., 4, 64–67.
Fuller, C. A., Sulzman, F. M., & Moore-Ede, M. C. (1978). Thermoregulation is impaired in an environment without circadian time cues. Science, 199, 794–796.
Gaubert, P., & Antunes, A. (2005). Assessing the taxonomic status of the Palawan pangolin Manis culionensis (Pholidota) using discrete morphological characters. Journal of Mammalogy, 86, 1068–1074.
Gaudin, T. J., Gaubert, P., Billet, G., Hautier, L., Ferreira-Cardoso, S., & Wible, J. R. (2020). Evolution and morphology. In Challender, D. W. S., Nash, H. C. & Waterman, C. (Eds.), Biodiversity of world: Conservation from genes to landscapes, Pangolins (pp. 5–23). Academic Press. https://doi.org/10.1016/B978-0-12-815507-3.00001-0
Heath, M. E. (1987). Twenty-four-hour variations in activity, core temperature, metabolic rate, and respiratory quotient in captive Chinese pangolins. Zoo Biology, 6(1), 1–10. https://doi.org/10.1002/zoo.1430060102
Heath, M. E., & Hammel, H. T. (1986). Body temperature and rate of O2 consumption in Chinese pangolins. AJP – Regulatory, Integrative and Comparative Physiology, 250(3 Pt 2), R377–R382.
Hildwein, G. (1974). Resting metabolic rate in pangolins (Pholidota) and squirrels of the equatorial rain forest. Arch. Sci. Physiol., 28(2), 183–195.
Jones, C. (1973). Body temperatures of Manis gigantea and Manis tricuspis. Mammal, 54, 253–266.
Kleiber, M. (1932). Body size and metabolism. Hilgardia, 6, 315–353.
Li, L., & Zheng, G. (2009). Zoology. Higher Education Press.
Liu, L., & Zheng, G. (2009). General Zoology, Beijing, China: Higher Education Press.
McNab, B. (1984). Physiological convergence amongst ant-eating and termite-eating mammals. Journal of Zoology, 203(4), 485–510.
Refinetti, R. (1996). The body temperature rhythm of the thirteen-lined ground squirrel, Spermophilus tridecemlineatus. Physiological Zoology, 69, 270–275.
Refinetti, R. (1997). The effects of ambient temperature on the body temperature rhythm of rats, hamsters, gerbils, and tree shrews. Journal of Thermal Biology, 22, 281–284.
Refinetti, R. (2010). The circadian rhythm of body temperature. Frontiers in Bioscience, 15, 564–594.
Refinetti, R., & Menaker, M. (1992). The circadian rhythm of body temperature. Physiological Behavior, 51, 613–637.
Song, Z., & Wang, D. (2002). Influencing factors on basal metabolic rate in mammals. Acta Theriologica Sinica, 1(1), 53–60.
Sun, R. (2001). Animal ecology (3rd edn.). Beijing Normal University.
Wang, H. (2012). Preliminary exploration on the artificial breeding of Manis javanica. Zhejiang Normal University.
Wu, S., Liu, N., Li, Y., & Sun, R. (2005). Observation on food habits and foraging behavior of Chinese pangolin (Manis pentadactyla). Chinese Journal of Applied and Environmental Biology, 11(3), 337–341.
Yang, Y. (2015). Body temperature and the physiology of thermoregulation. People’s Military Doctor Press.
Zhang, F., Wu, S., Yang, L., Zhang, L., Sun, R., & Li, S. (2015). Reproductive parameters of the Sunda pangolin, Manis javanica. Folia Zoologica, 64(2), 129–135.
Zhang, F., Yu, J., Wu, S., Li, S., Zou, C., Wang, Q., & Sun, R. (2017). Keeping and breeding the rescued Sunda pangolins (Manis javanica) in captivity. Zoo Biology, 36, 387–396. https://doi.org/10.1002/zoo.21388

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