SCIENTIFIC NOTE

Nest Thermoregulation in *Polybia scutellaris* (White) (Hymenoptera: Vespidae)

Satoshi Hozumi[1], Sidnei Mateus[2], Kazuyuki Kudô[3], Takaaki Kuwahara[4], Sôichi Yamane[5], Ronaldo Zucchi[2]

[1]Venture Business Laboratory, Graduate School of Science and Engineering, Ibaraki Univ, 316-8511, Japan; e-mail: shoz@mx.ibaraki.ac.jp; [2]Depto de Biologia, Faculdade de Filosofia Ciências e Letras de Ribeirão Preto, USP, 14040-901 Ribeirão Preto, SP, Brasil; sidneim@ffclrp.usp.br; rzucchi@ffclrp.usp.br; [3]Lab of Entomology, Dept of Biology, Faculty of Education and Human Sciences, Niigata Univ, 950-2181, Japan; kudok@ed.niigata-u.ac.jp; [4]Graduate School of Natural Science & Technology, Kanazawa Univ, Kakuma-machi, Kanazawa, Ishikawa, 920-1192 Japan; palladium@bird.zero.ad.jp; [5]Dept of Education, Ibaraki Univ, 310-8511, Japan; yamaneso@mx.ibaraki.ac.jp

Edited by Fernando Noll – UNESP

Neotropical Entomology 39(5):826-828 (2010)

ABSTRACT - *Polybia scutellaris* (White) builds large nests characterized by numerous spiny projections on the surface. In order to determine whether or not the nest temperature is maintained because of homeothermic conditions of the nest individuals or otherwise, we investigated the thermal conditions within the nests built by *P. scutellaris*. We measured the temperature within active and abandoned nests. The temperature in the active nest was almost stable at 27°C during data collection, whereas the temperature in the abandoned nest varied with changes in ambient temperature. These results suggest that nest temperature was maintained by the thermogenesis of the individuals of the colony. This is the first report of nest incubation caused by thermogenesis of species of *Polybia* wasps.

KEY WORDS: Epiponini, nest architecture, nest temperature

It is well established that social wasps regulate the internal temperature of their nests (Heinrich 1993). Many vespid species from cold to tropical regions maintain a constant nest temperature (28-30°C) during production of the first sexuals (Martin 1990). However, few studies have dealt with the thermal conditions of nests built by epiponine wasps, which predominantly inhabit the neotropical and neosubtropical ecozones. Hozumi *et al* (2005, 2008) revealed that unlike in the case of the vespine nests, the temperature in *Polybia* nests were strongly related to both the nest architecture and the microenvironment of the nesting sites, and that this species generates little heat for nest incubation. *Polybia scutellaris* (White) is a consubgeneric species of *P. occidenalis* Oliver, which forms large colonies and builds nests characterized with many spiny projections on the surface (Richards 1978). However, details of the nest architecture with regard to the internal thermal conditions and the thermal conditions of the microenvironment have not yet been studied. In here, the architecture of *P. scutellaris* nests was studied and nest temperatures were measured during this short study.

Three abandoned nests were collected from Cajuru (21°16′S, 47°17′W), São Paulo State, Brazil. The thickness of the nest envelope and the size of the spines were measured to the nearest 0.1 cm with vernier calipers. The thickness of the envelope was measured around the entrance of the nest and at the sides. Twenty spines were randomly chosen from each nest, and the maximum height and width of the spines were measured.

The temperature of an active *P. scutellaris* nest found on the west-facing concrete wall of a building in Cajuru was measured (Fig 1a). The nest was built 2.5 m above the ground and was located just below the eaves (Fig 1c). *Polybia scutellaris* carries out nesting activities even during the winter season, and in mid-July, the nest was found to contain >30,000 adults. The nest was composed of plant materials and oral secretions, which function as a binding agent and a water repellent. The nest was approximately 34 × 40 × 35 cm (L × W × H) in size and had >800 spines on the surface. The internal architecture of the nest consisted of horizontal combs that were conjoined and enclosed by a continuous envelope. The nest entrance was stretched horizontally (approximately 22 × 1 cm). To facilitate comparative studies, we measured the temperature in an abandoned nest with similar size (32 × 27 × 41 cm; 1231 spines; Fig 1b). In both sites, the nests were often shaded by the building.

The temperature of the active nest was measured over a 5h period during the daytime (0900h-1400h) on July 26, 2005. The temperature of the abandoned nest was recorded continuously for an entire day from 0900h on September 5, 2004 to 0900h on September 6, 2004. During the measurements, a sensor was inserted into the central part of the nests, and another sensor was positioned 5 cm above the top surface of the nest (Fig 1c) to simultaneously record the environment temperature. Temperatures were measured

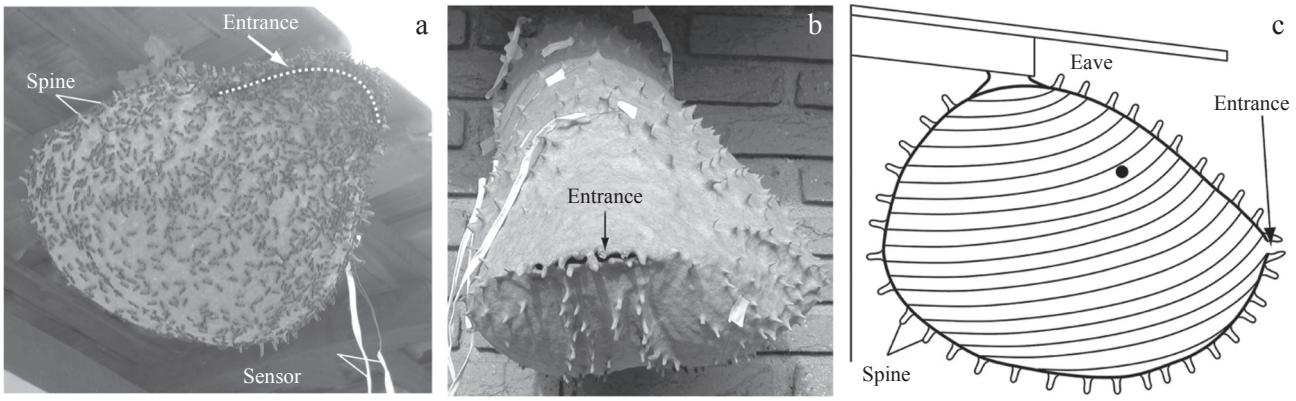

Fig 1 Photographs and scheme of nests of *Polybia scutellaris*: a) active nest; b) abandoned nest; c) scheme of active nest and point of measurement. Black circle indicates the location of thermo-couples.

to the nearest 0.1°C every 1 min with copper-constantan thermocouples (ø = 0.32 mm) connected to a data logger (Keyence, NR1000).

The thickness of the envelope was 2.5-3.8 mm (mean ± SD, 3.2 ± 0.1 mm). Spines were present all over the nest surface, and their number (mean, 620 ± 546, range 255-1231) increased with the nest size. The spines were either cylindrical or conical, and their mean height and width were 1.4 ± 0.4 cm (0.7-2.6 cm) and 1.3 ± 0.3 cm (0.5-1.9 cm), respectively. The width of the entrance also varied with the nest size; the width of the entrance ranged from 8 cm to 25 cm and the height was 1 cm.

The nest temperature (T_n) in the active nest remained almost stable during the measurement period, despite changes in the ambient temperature (T_a) (Fig. 2). The mean T_n ± SD was 27.1 ± 0.9°C, and the temperature fluctuation was 2.7°C (range, 25.4-28.1°C). The T_a gradually rose from morning to noon, and the mean temperature was 17.8 ± 1.9°C; the fluctuation in this case was 6.3°C (range,_14.6-20.9°C), twice that in the case of T_n. However, in the abandoned nest, changes in T_n (mean, 24.9 ± 4.3°C) were similar to those in T_a (mean 23.7 ± 3.5°C) throughout the day (Fig 2). During the daytime (0900–1400 hours), the T_n (mean 28.8°C ± 2.3°C) was slightly higher than the T_a (mean, 27.6 ± 2.2°C), while the fluctuations between T_n and T_a were similar: 6.7°C (range, 26.4-33.1°C) and 7.1°C (range, 24.8-31.9°C), respectively. During the nighttime (2100–0500h), i.e., 3h after sunset to just before sunrise, T_n (mean, 22.2 ± 1.9°C) was almost similar to T_a (mean 21.7 ± 1.9°C), and the fluctuation in T_n (8.2°C; range, 19.2-27.4°C) was also similar to that in T_a (8.7°C; range, 18.6-27.6°C), suggesting that T_n varied with T_a with relatively small fluctuations.

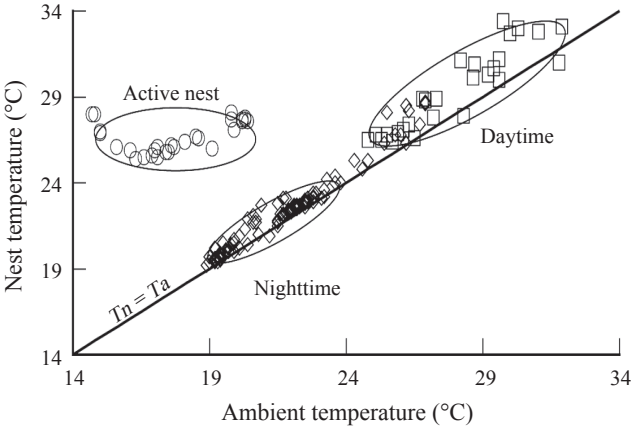

Fig 2 Relationship between ambient temperature and nest temperature of *Polybia scutellaris*: each symbol, i.e., square, triangle and circle represents temperatures of active nest (measurement time, 0900-1400h), abandoned nest in daytime (0900-1400h) and nighttime (1800-0600h), respectively. Solid line represents $T_n = T_a$.

The active nest of *P. scutellaris* maintained a constant temperature despite the low T_a. The nest temperature (approximately 27°C) was similar to that of vespine nests (28-30°C; Himmer 1927, Ishay 1973, Martin 1990, 1992), whereas the temperature in the abandoned nest was almost similar to the T_a throughout the day, indicating heat generation (thermogenesis) by the individuals of the colony, as observed in several social insects (Seeley & Heinrich 1981). Although nest cooling activities have been observed in swarm-founding epiponine wasps (Hunt *et al* 1987, 1995, Jeanne 1991), very few cases are known reporting the occurrence of the incubation behavior (Yamane *et al* 2009). To the best of our knowledge, this is the first study to report nest incubation by *Polybia* species.

References

Heinrich B (1993) Hot blooded insects. Harvard University Press, Cambridge, Massachusetts, 608p.

Himmer A (1927) Ein Beitrag zur Kenntnis des Wärmehaushalts im Nestbau sozialer Hautflügler. Z Vgl Physiol 5:375-389.

Hozumi S, Kudô K, Zucchi R (2008) Promotion of thermoregulatory insulation in nests of neotropical wasps by building extra-combs with empty cells. Neotrop Entomol 37: 59-166.

Hozumi S, Yamane Sô, Miyano S, Mateus S, Zucchi R (2005) Diel changes of temperature in the nests of two *Polybia* species, *P. paulista* and *P. occidentalis* (Hymenoptera, Vespidae) in the subtropical climate. J Ethol 23:153-159.

Hunt J H, Jeanne R L, Baker I, Grogan D E (1987) Nutrient dynamics of a swarm-founding social wasp species, *Polybia occidentalis* (Hymenoptera: Vespidae). Ethology 75: 291-305.

Hunt J H, Jeanne R L, Keeping M G (1995) Observations on *Apoica pallens*, a nocturnal Neotropical social wasp (Hymenoptera: Vespidae, Polistinae, Epiponini). Ins Soc 42: 223-236.

Ishay J S (1973) Thermoregulation by social wasps. Experientia 28: 128-196.

Jeanne R L (1991) The swarm-founding Polistinae, p.191-231. In Ross K G, Matthews R W (eds) The social biology of wasps. Ithaca, Cornell University Press, 678p.

Martin S (1990) Nest thermoregulation in *Vespa simillima*, *V. tropica* and *V. analis*. Ecol Entomol 15: 301-310.

Martin S (1992) Nest thermoregulation in *Vespa affinis* (Hymenoptera, Vespidae). Jpn J Entomol 60: 483-486.

Richards O W (1978) The social wasps of the Americas, excluding the Vespinae. British Museum (Natural History), London, 580p.

Seeley T, Heinrich B (1981) Regulation of temperature in the nests of social insects, p.159-234. In Heinrich B (ed) Insect thermoregulation. New York, Wiley-Interscience Publication, 328 p.

Yamane S, Mateus S, Hozumi S, Kudô K, Zucchi R (2009) How does a colony of *Apoica flavissima* (Hymenoptera, Vespidae, Epiponini) maintain a constant temperature? Entomol Sci 12: 341-345.

Received 15/XI/08. Accepted 02/II/09.