pictures. The white noise was set at an intensity level of 68 db (16 db above the background level of the testing chamber) which preliminary observations indicated would create an appropriate degree of unpleasure.

The monkeys were given three categories of tests: 'picture only', 'noise only' and 'picture plus noise'. As Fig. 2 shows, the response to the pictures only was an initial strong positive preference which declined towards indifference; that to the noise only was a steady aversion (increasing slightly over the first 100 s of the test); that to the pictures plus noise was an initial positive preference which then turned into a marked aversion. In line with the predictions of the mathematical model, the response to pictures plus noise could be almost perfectly fitted by a theoretical curve computed from the separate responses to pictures only and noise only[1].

Comparison of Figs 1 and 2 illustrates the close correspondence between the response to the fearsome pictures and that to the non-fearsome pictures plus noise. It seems fair to say that the 'fearsomeness' of the fearsome pictures had on average the same effect as 68 db of white noise. But we believe there are grounds here for a stronger assertion, namely that at a causal level fearsomeness influences behavioural preference in the same way as noisiness (or redness) through the evocation of a common factor of 'unpleasure', a factor which is strictly subservient to 'interest'.

In functional terms the lesson of these results seems clear: the benefits that come from increased understanding outweigh the immediate rewards of a comfortable life.

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Behavioural thermoregulation in a wolf spider

LABORATORY studies have shown that wolf spiders (Lycosidae) may prefer temperatures above the ambient air temperature of their normal environment[1,2]. They are commonly active on clear days in winter and may repeatedly move in and out of the sun. In addition, they carry their egg sacs on their spinerettes and apparently incubate them in the sun[3,4]. While the observations suggest that these spiders may exhibit behavioural thermoregulation, it has not been demonstrated.

During a study into the ecological energetics of the large, burrow-inhabiting wolf spider *Geolycosa godeffroyi* (L. Koch 1865) in the Australian Capital Territory[5], continuous temperature records were obtained of both the egg sac temperature and the temperature of the cephalothorax of the spiders.

Egg sac temperature was measured by implanting a temperature transmitter into the egg sac after the removal of about 70% of the eggs. The egg sac was returned to the female in the field and the transmissions monitored during the daylight hours. The resulting magnetic tapes were transcribed at intervals and records obtained from six individuals. The temperature of the spiders was recorded in the field by implanting a fine thermocouple junction into the cephalothorax and recording the temperature with an electric thermometer with an external reference junction at 0° C. The fine thermocouple lead (2.3 mg cm^{-1}) allowed the spider free movement within the burrow and through its normal activity range. The ambient air temperature was recorded from the dry bulb of an aspirated hygrometer placed 1 cm above the ground surface. Temperatures were recorded for 24 h periods from spiders weighing 0.1–1.5 g from February to November 1972.

Figure 1 shows two representative records of the cocoon temperature in summer. Figure 1*b* is the record for an intermittently overcast day showing that the egg sac could achieve a considerable temperature excess[6]. In Fig. 1*a* the spider provided its own control. At A the spider was placed with its 'bugged' cocoon next to its burrow which was partly occluded by debris. The spider began to clear the debris from the burrow but at B dropped the egg sac in full sunlight outside the burrow and continued with its work. The sun was masked by cloud at C and when the spider had cleared the burrow it recovered the egg sac (D) and entered the burrow. Between D and E the sky cleared and the spider began to sun the egg sac at E. The burrow was lightly shaded by trees after 1500h but was bathed in full sunlight at 1800h, just before sunset. The spider maintained a fairly constant egg sac temperature in full sunlight (1200h to 1500h) but the temperature excess potentially reached was considerably greater (A to E in Fig. 1*a*) than that maintained by the behaviour of the spider.

Figure 2 shows three representative records of the cephalothorax temperature of the spiders at different times of the year. Figure 2*b* represents part of the record obtained on a subfemale on March 13, 1972. At 0600h the spider was still benefiting from the thermal lag in the soil temperature profile and by remaining at the bottom of the burrow maintained its temperature 8° C above the ambient air temperature. As the ambient temperature rose in the morning the spider came to the top of the burrow and maintained a temperature close to the ambient temperature until the sun struck the burrow entrance at about 1000h. The body temperature rose rapidly to about 40° C when

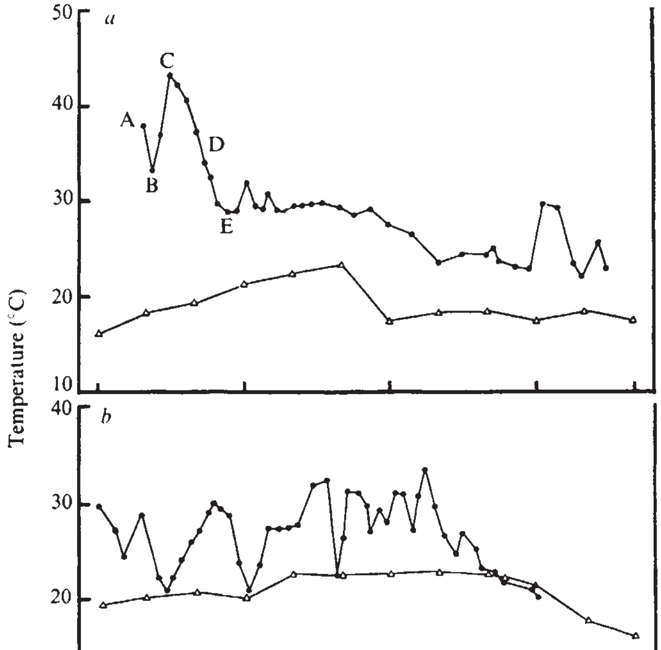

Fig. 1 Egg sac temperatures of *G. godeffroyi* obtained from implanted temperature transmitters (●) and ambient air temperatures (△). The letters A–E are explained in the text.

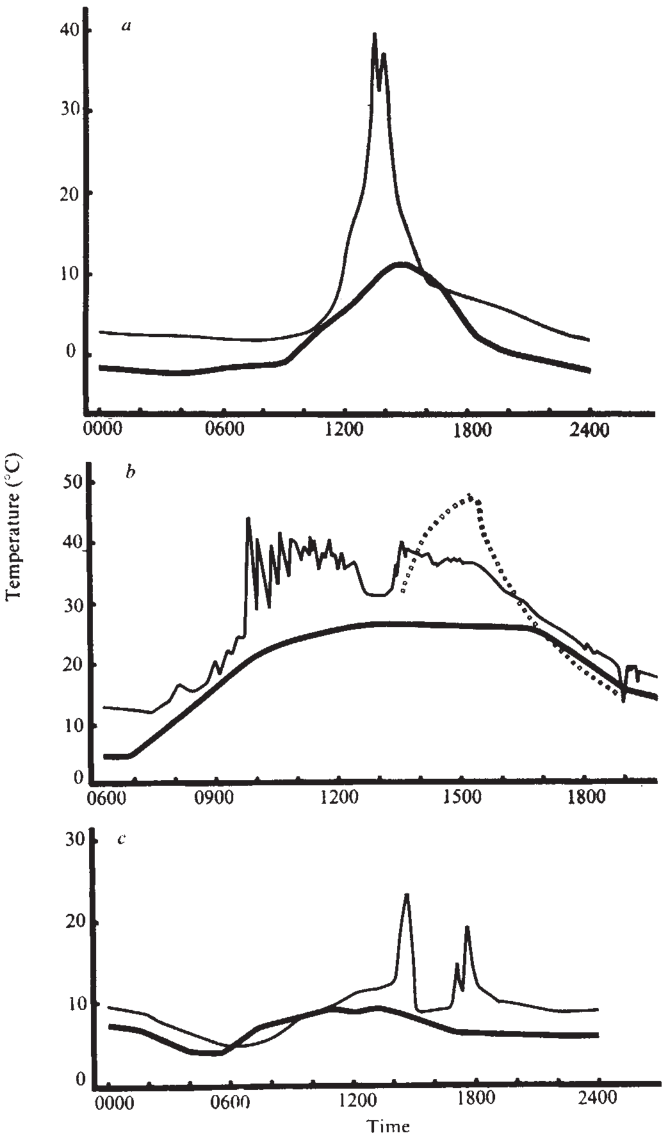

Fig. 2 Cephalothorax temperatures of *G. godeffroyi* obtained from implanted thermocouples (————) compared with ambient air temperatures (————) and dead spider temperatures (□). The records were obtained in, *a*, mid-winter (June 25, 1972), *b*, early autumn (March 13, 1972) and, *c*, late winter (September 13, 1972).

the spider retreated into the shade of the burrow. This pocess continued until about 1200h when the sun was partially obscured by cloud until 1330h. The ambient temperature dropped after 1600h and the spider retired down the burrow, save for some minor excursions up the burrow at about 1900h, and again maintained its temperature above the ambient air temperature. At 1400h a freshly killed spider of similar size was placed on the grass next to the burrow and its temperature monitored. The temperature excess obtained by the dead spider greatly exceeded that of the live spider and shows the controlling effect of the spider's movement within the burrow on the body temperature and showing, at night, the moderating influence of the burrow. The finer control over the body temperature in the afternoon was characteristic and may result from the spider adopting thigmothermic as well as heliothermic regulation. This is supported by the more gradual drop in temperature in the afternoon after the ground had been thoroughly heated compared with the rapid temperature changes in the morning and in winter (Fig. 2*a* and 2*c*) whenever the sun was obscured.

Figure 2*a* represents the temperature of a spider on a clear winter's day. While the ambient air temperature reached 11° C, the spider's temperature rose rapidly to 39.7° C when the sun was on the burrow, resulting in a temperature differential of 30° C at 1345h. At night the spider's temperature fell to only 1.8° C in spite of the ambient temperature falling to −2.3° C. Figure 2*c* is the record from a spider on a generally overcast day in early spring and shows the immediate use the spider made of radiant energy when the sun struck the burrow at 1300h and 1800h.

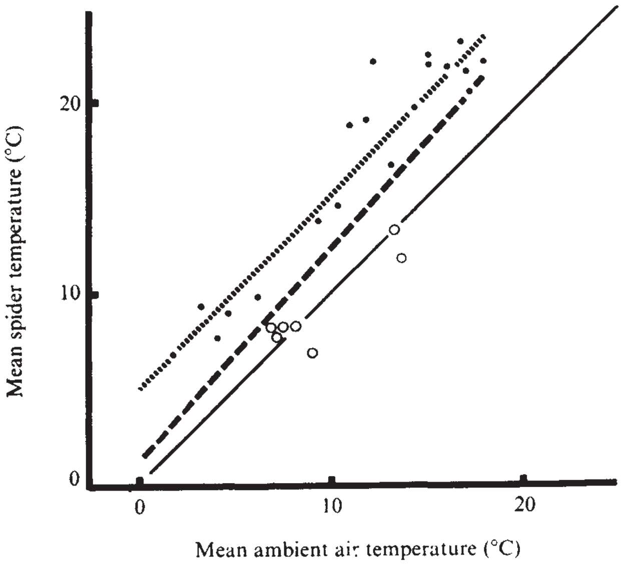

Fig. 3 The relationship between the mean daily cephalothorax temperature and the mean daily air temperature for each of 26 individual *G. godeffroyi* recorded throughout 1972. The null line (————) assumes that the ambient and spider temperatures are equal. The records are divided into those obtained on clear days (●) and overcast days (○) and the regressions shown for all days (– – – –) and clear days (- - - - -).

In Fig. 3 the mean daily spider and ambient temperatures are plotted for the 26 d of recording throughout 1972. The slope of regression through the data for the clear days only is not different from a slope of 1.0 (t_{19}=0.845, 0.5>P>0.4). On clear days throughout the year the spiders maintained their body temperature an average of 4.6° C above the ambient air temperature by basking in the sun during the day and retreating down their burrows at night.

The similarity between the thermoregulation in *G. godeffroyi* and that found in some lizards[6–8] is striking, the main difference lying in the finesse of the control in the plateau temperature. While the lizards exhibited fine control at the upper temperature, that of the spiders was erratic, probably due to their low thermal capacity.

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