Examination of warming and cooling dynamics of owl-fly *Libelloides macaronius*

Primož Pirih & Peter Stušek
Animal Physiology Chair, Dept. of Biology, Biotechnical Faculty, University of Ljubljana
Večna pot 111, PO Box 2995 SI-1001 Ljubljana, Slovenija. E-mail: primoz.pirih@uni-lj.si

Rationalle. The thermal properties of the Ascalaphus owl-fly *Libelloides macaronius* (Scop.), (Insecta: Neuroptera: Plannipenia), were examined by monitoring temperature changes during heating by direct insolation and subsequent cooling in shade, mimicking the conditions of morning shade/ sun alternation in a grassland being owergrown due to phytocenotic succesion.

Materials & Methods. The experiment was performed in Ljubljana in July 2001, during a bright, sunny early afternoon, when the temperature in the shade was over 30°C. A temperature probe was carefully inserted into the abdomen of a female owl-fly resting on a grass stem in the laboratory at room temperature 27°C (figure 1). The probe (K-type thermocouple) was connected to A/D converter CED 1401plus via Axon AI418 transducer adapter and signal conditioner CyberAmp 380. Temperature data were recorded using the Strathclyde WinWCP. Prior to the experiment, the insect was kept away from direct sunlight at temperatures under 25°C for one day. The insect was moved from a non-insolated location into direct sunlight coming through an open window; after warm-up it was moved to the shade again and left to cool down.

Figure 1: A female on a grass stem fixed to a laboratory holder. (Note the egg-laying.)

The cycle was repeated with different insolation times (4, 6 and 7 minutes)

Results. A few seconds after the first insolation began*, the insect opened its wings and turned its back towards the sun, and later started moving its wings. The abdominal temperature started to rise and reached 47°C in 4 minutes of insolation. The insect was then moved back to the shade and the abdominal temperature decreased to 30°C, compared to 27°C at the beginning of the experiment. Following the first warm-up and cool-down, the cycle was repeated twice with 6 and 7 minutes of insolation The abdominal temperature in sun reached 48 and 46°C, while the temperatures in the shade were around 32°C (figures 2 & 3)**.

Mathematical analysis. We attempted to fit the time courses with single exponential fit curves in WinWCP curve-fitting module. Both cooling and warming phases fit very well (figures 4 & 5). The estimated steady state (SS) temperature after the first cycle was around 30°C and time constant was around 85 seconds for both warming and cooling. Time constants for the cool-down increased to 100 s in the following two cycles, while warm-up time constants remained under 90 seconds (figure 5).

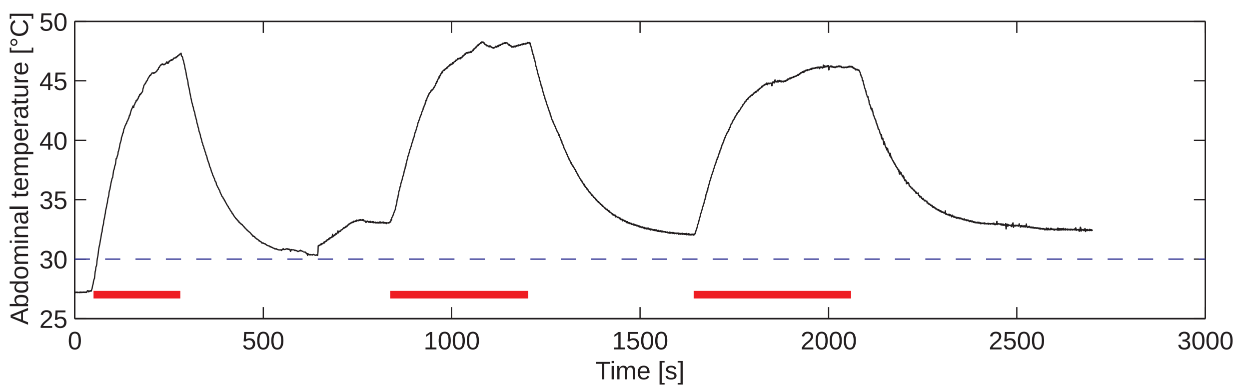


Figure 2: Time course of warming and cooling of all three cycles. Insolation phases are marked with thick line.

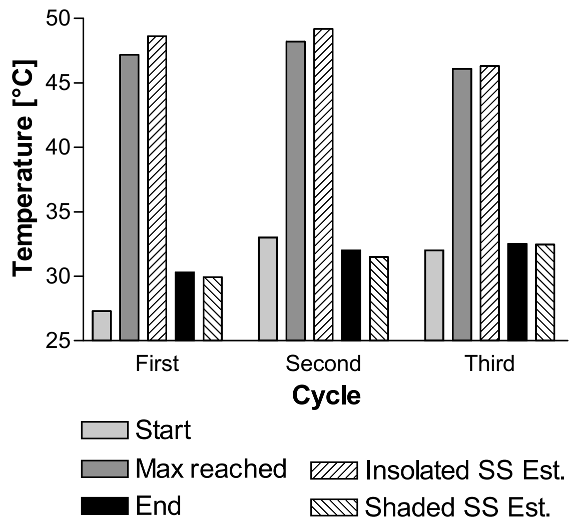


Figure 3: Abdominal temperatures measured before the insolation, before the end of direct insolation and after the insolation for all three cycles. The stippled bars (3rd & 5th) represent steady state temperature estimates derived from single exponential fits (cf. figure 4).

Discussion. The insect's abdominal temperature reached almost 50°C under direct insolation. This fact, together with ecological data and data from behavioural (Pangršič & Zupančič) and electrophysiological studies (Belušič & Pirih), published in this report, implies that owl-fly is a highly thermophilic animal.

The very tight single exponential fits also imply that both warming and cooling were probably passive processes. The slightly longer time constant for cooling is attributable to differences in heat-transfer properties for VIS and IR radiation (glasshouse effect). The raised abdominal temperature at the end of the cycles** could also mean that there is an active mechanism, possibly wing-muscle thermogenesis, which was triggered by insolation. The posture change, however, is a behavioural adaptation mechanism and, strictly speaking, represents an active component on the highest organisational level.

The prolongation of cool-down time constants in cycles two and three might mean that there is another mechanism for retaining heat, probably triggered by the first warm-up, but it would be premature to draw any conclusions from the mathematical analysis performed on data derived from single animal. A well-controlled experiment would require a discrete, repeated and time-stamped transition from shadow to sun, as well as a precisely-controlled ambient temperature, a better numerus and a control.

Thanks are due to Prof. Kazimir Drašlar and Prof. Uwe Wolfrum, co-organisers of the *Ascalaphus Summer School 2001* joint project. This experiment is a logical outgrowth of the summer school.

Additional Notes

* Note that heat came not only from radiation but also from convection of warm air rising from the surface of the table.

** The temperature increase could also be an artefact due to decalibration of the probe or a change in experimental parameters (rising room temperature, for example).

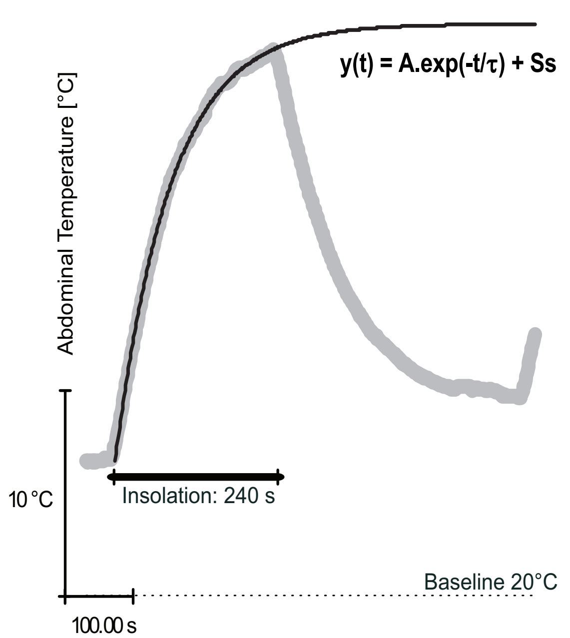
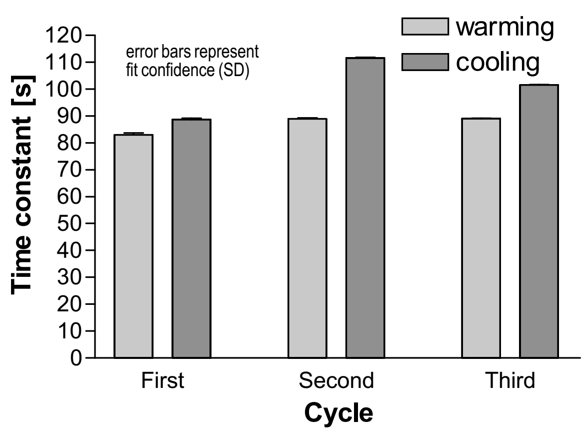


Figure 4: Time course of the first cycle with the exponential fit for the insolation phase.



Exponential fit data

Starting temperature before the first cycle:			T_{start} = 27.05°C
1. warming:	τ = 83.05 s,	A = -21.59°C,	Ss = 48.64°C
1. cooling:	τ = 88.76 s,	A = 17.71°C,	Ss = 29.93°C
2. warming:	τ = 88.94 s,	A = -15.95°C,	Ss = 49.19°C
2. cooling:	τ = 111.70 s,	A = 17.02°C,	Ss = 31.51°C
3. warming:	τ = 89.03 s,	A = -14.98°C,	Ss = 46.32°C
3. cooling:	τ = 101.6 s,	A = 13.97°C,	Ss = 32.46°C
fit confidence:	SD(τ)<0.7 s,	SD(A)<0.05°C,	SD(Ss)<0.06°C

Figure 5: Time constants (τ) of the exponential fits for warming and cooling and fit data.