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Short Note
Critical thermal minima of three sub-Antarctic insects from the French southern Indian Ocean islands

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Introduction

Until now, 23 sub-Antarctic insect species have been described from the Iles Kerguelen (Schermann-Legionnet *et al*. 2007), and 46 species from Iles Crozet (Ile de la Possession) (Vernon *et al*. 1998). Despite the high level of adaptation to the specific environmental conditions evolved by sub-Antarctic insect species (Vernon *et al*. 1998, Schermann-Legionnet *et al*. 2007), their thermal biology has been little studied. At iles Crozet and Kerguelen, organisms must complete their entire life cycle at mean monthly temperatures ranging from 1.3°C (SD 0.7°C) in July (mean minimum temperature reaches -5.0 ± 1.6°C) to 9.0°C (SD: 0.9°C) in January (Lebouvier *et al*. 2011).

Chill coma onset, the temperature at which locomotor activities are interrupted (Hazell & Bale 2011, Macmillan & Sinclair 2011), and chill coma recovery are key fitness attribute in these flightless insects. The critical thermal limits of these insects determine the thermal window in which they can feed, breed and escape from predators. In addition, critical thermal minimum and recovery from chill coma vary both within and between species (Castañeda *et al*. 2005, Jumbam *et al*. 2008). Here we report the critical thermal limits of three native sub-Antarctic insect species: *Amblystogenium pacificum* (Putzeys) (Coleoptera: Carabidae), endemic to Iles Crozet, *Anatalanta aptera* Eaton (Diptera: Sphaeroceridae) from Crozet, Kerguelen and Heard islands and *Calycopteryx moseleyi* Eaton (Diptera: Micropezidae) from Kerguelen and Heard islands. The thermal biology of *C. moseleyi* and *A. pacificum* has not yet been investigated and we hypothesize that the geographical distribution of these three insect species should result in a distinctive thermal performance.

Material and methods

Imagoes of *Amblystogenium pacificum* ($n = 24$; fresh mass = 14.4 ± 2.3 mg; mean ± SD) were collected in fellfield at Ile de la Possession (Iles Crozet, 46°25'S, 51°51'E, altitude: 110 m). Imagoes of *Anatalanta aptera* ($n = 13$; fresh mass = 8.4 ± 2.3 mg) and *Calycopteryx moseleyi* ($n = 23$; fresh mass = 20.8 ± 4.7 mg) were collected in coastal areas at Point Suzanne, Iles Kerguelen (49°21'S, 70°13'E, altitude: 5 m). All specimens were sampled in December 2007 and were kept at 4°C (R.H. of 70 ± 5%), with a 15 h/9 h light/dark cycle, for one week before being used for the experiments. Critical thermal minimum (CT_{min}) was measured using a method described by Lalouette *et al*. (2010). Briefly, individual insects were placed in a 35 × 5 cm double-jacketed glass column, and the temperature was reduced from 4°C to the CT_{min} at 0.5°C min^{-1}. The CT_{min} was the temperature at which each beetle lost coordinated muscle function. Individuals were immediately transferred to a Petri dish at 4 ± 1°C, and the duration needed to regain complete motor function (co-ordinated movements of the legs, T) was recorded. Each individual was weighed using a Sartorius M4 microbalance (d = 0.1 mg). Adults of *A. aptera* and *C. moseleyi* were sexed just after CT_{min} was measured. Kruskal-Wallis tests (H test) were performed to compare CT_{min} and the time necessary to recover from chill coma among species and genders. Mann-Whitney *post hoc* tests with Bonferroni correction were conducted. Statistical analyses were carried out using MINITAB Statistical Software Release 13 (MINITAB, Penn State University, USA).

Results

There was no correlation among FM, CT_{min} and the duration of recovery ($P > 0.05$). There were no significant differences between genders for CT_{min} and T in either *A. aptera* or *C. moseleyi* and the genders were thus pooled in subsequent analyses. Fresh mass (FM) and CT_{min} differed significantly among the three species ($H_2 = 49.15$, $P < 0.001$; $H_2 = 30.73$, $P < 0.001$ respectively) (Fig. 1a). CT_{min} fell to -6.1 ± 0.7°C in *C. moseleyi* and differed significantly from both *A. aptera* and from the beetle endemic to the Iles Crozet *A. pacificum* having a CT_{min} in the order of -4.2°C ($W = 339.5$, $P < 0.001$; $W = 497.5$, $P < 0.001$, respectively) (Fig. 1a). The duration of the recovery from chill coma did not differ significantly between the three species ($H_2 = 1.59$, $P > 0.05$) (Fig. 1b).

Discussion

The activity threshold has rarely been investigated in sub-Antarctic insects (Klok & Chown 1997, 2003, Slabber & Chown 2005, Lalouette *et al*. 2010). In the present work,

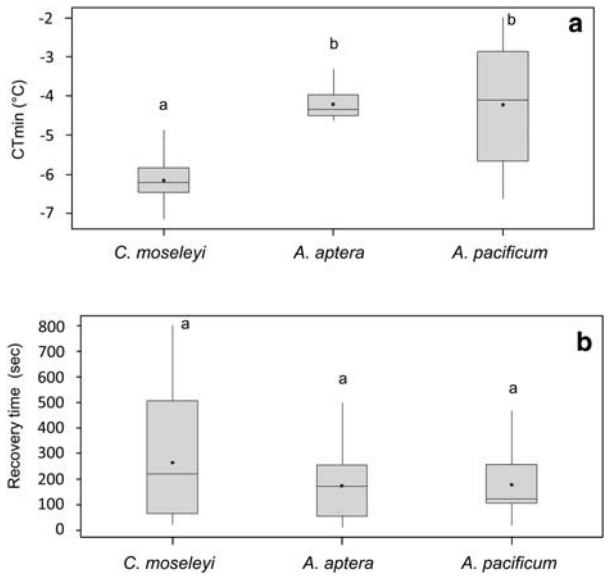

Fig. 1. a. Critical thermal minima (CT_{min}), and **b.** recovery from chill coma (duration needed to recover walking activities with coordinated movements of the legs) in adult *Calycopteryx moseleyi*, *Anatalanta aptera* and *Amblystogenium pacificum*. Boxes represent quartiles, black dots represent mean values, lines within the box represent the medians, and whiskers represent the extreme values. Distinct letters indicate significant differences ($P < 0.05$).

CT_{min} ranged from -4 to -6°C and may be an important feature for yearly active insects that are regularly subjected to negative temperatures at the Southern Ocean islands (see Lebouvier *et al*. 2011 for more information on the meteorological conditions). Our results are consistent with the current geographical distribution of these three species: whereas *A. pacificum* is endemic from Iles Crozet (Davies *et al*. 2007) and was thus characterized by the most northern geographical distribution, *C. moseleyi* is restricted to locations with the higher latitudes in the Southern Indian Ocean - Kerguelen and Heard islands (53°06'S, 73°31'00"E) (Harrison 1970) - and *A. aptera* occur at Crozet, Kerguelen and Heard islands (Harrison 1970). Moreover, despite the differences among species for the CT_{min}, similar duration of recovery after the flies entered chill coma were found. This finding suggests that similar cold damages were experienced by the adults of *C. moseleyi* despite their lower CT_{min} and/or that they are better able to recover from chill coma than the two other studied species.

Matching of the species' critical thermal limits to the microclimates of their environments has already been demonstrated in two sub-Antarctic spiders from Marion Island (Jumbam *et al*. 2008), and at a larger geographical scale in populations of a given species sampled along latitudinal gradients (Castañeda *et al*. 2005). As Lalouette *et al*. (2010) recently found a higher thermal tolerance when ageing in adults of *A. aptera*, further studies should examine if age-related differences could also occur in both *C. moseleyi* and *A. pacificum*.

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References

Castañeda, L.E., Lardies, M.A. & Bozinovic, F. 2005. Interpopulational variation in recovery time from chill coma along a geographic gradient: a study in the common woodlouse, *Porcellio laevis*. *Journal of Insect Physiology*, **51**, 1346–1351.

Davies, L., Bouvet, S. & Vernon, P. 2007. All-year reproduction and possible thermal melanism in *Ambystogenium pacificum* (Coleoptera: Carabidae) on the sub-Antarctic Ile de la Possession (Iles Crozet). *Polar Biology*, **30**, 253–260.

Harrison, R.A. 1970. Diptera: Acalypterates of South Georgia, Heard and Kerguelen. *Pacific Insects Monograph*, **23**, 285–289.

Hazell, S.P. & Bale, J.S. 2011. Low temperature thresholds: are chill coma and CTmin synonymous? *Journal of Insect Physiology*, **57**, 1085–1089.

Jumbam, K.R., Terblanche, J.S., Deere, J.A., Somers, M.J. & Chown, S.L. 2008. Critical thermal limits and their response in two sub-Antarctic spiders: *Myro kerguelensis* and *Prinerigone vagans*. *Polar Biology*, **31**, 215–222.

Klok, C.J. & Chown, S.L. 1997. Critical thermal limits, temperature tolerance and water balance of a sub-Antarctic caterpillar, *Pringleophaga marioni* (Lepidoptera: Tineidae). *Journal of Insect Physiology*, **43**, 685–694.

Klok, C.J. & Chown, S.L. 2003. Resistance to temperature extremes in sub-Antarctic weevils: interspecific variation, population differentiation and acclimation. *Biological Journal of the Linnean Society*, **78**, 401–414.

Lalouette, L., Vernon, P., Amat, H. & Renault, D. 2010. Ageing and thermal performance in the sub-Antarctic wingless fly *Anatalanta aptera* (Diptera: Sphaeroceridae): older is better. *Biology Letters*, **6**, 346–349.

Lebouvier, M., Laparie, M., Hullé, M., Marais, A., Cozic, Y., Lalouette, L., Vernon, P., Candresse, T., Frenot, Y. & Renault, D. 2011. The significance of the sub-Antarctic Kerguelen Islands for the assessment of the vulnerability of native communities to climate change, alien insect invasions and plant viruses. *Biological Invasions*, **13**, 1195–1208.

Macmillan, H.A. & Sinclair, B.J. 2011. Mechanisms underlying insect chill-coma. *Journal of Insect Physiology*, **57**, 12–20.

Schermann-Legionnet, A., Hennion, F., Vernon, P. & Atlan, A. 2007. Breeding system of the sub-Antarctic plant species *Pringlea antiscorbutica* R. Br. and search for potential insect pollinators in the Kerguelen Islands. *Polar Biology*, **30**, 1183–1193.

Slabber, S. & Chown, S.L. 2005. Differential responses of thermal tolerance to acclimation in the sub-Antarctic rove beetle *Halmaeusa atriceps*. *Physiological Entomology*, **30**, 195–204.

Vernon, P., Vannier, G. & Tréhen, P. 1998. A comparative approach to the entomological diversity of polar regions. *Acta Oecologica*, **19**, 303–308.