Concurrent infestations by *Aethina tumida* and *Varroa destructor* alters thermoregulation in *Apis mellifera* winter clusters

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The small hive beetle, *Aethina tumida*, and the ectoparasitic mite, *Varroa destructor*, are parasites of the honeybee, *Apis mellifera*. Both parasites overwinter in honeybee colonies. Occasionally, these parasites are found concurrently within honeybee winter clusters. We tested if the efficacy of thermoregulation by bees in concurrently infested clusters is altered. We examined thermal fluctuations and maxima inside winter cluster core zones. Concurrently infested colonies showed higher thermal maxima in the winter clusters cores compared to the controls, whereas winter clusters with one parasite species alone showed no significant effect on thermoregulation. Furthermore, combined infestations and infestations by *V. destructor* alone resulted in significantly higher thermal fluctuations compared to infestations with *A. tumida* alone. One factor which could induce these changes could be altered physiology of the host workers due to *V. destructor* infestations during their pupal stage which leads to reduction in body weight and longevity. Moreover such workers don't fully develop typical winter bee features. Other factors affecting thermoregulation could be altered bee behaviour due to phoretic influences of *V. destructor* which induce general unrest, grooming behaviour and altered nestmate cleaning behaviour. Also, the presence of adult small hive beetles which induce trophallactic feeding and aggressive behaviour could be a contributing factor. Our data indicate that heavy infestations by *V. destructor* in combination with infestations by *A. tumida* reduce the efficacy of thermoregulation in honeybee winter clusters which could contribute to winter losses.