New Zealand Journal of Zoology, 2003, *Vol. 30*: 11–15

0301–4223/03/3001–0011 $7.00/0

Effects of temperature and humidity on flight initiation and mortality of *Euophryum confine*

M. GREEN

A. J. PITMAN

Forest Products Research Centre
Buckinghamshire Chilterns University College
Queen Alexandra Road
High Wycombe, Bucks.
HP11 2JZ, United Kingdom
email: Matthew.Green@bcuc.ac.uk

Abstract The effect of temperature and humidity on flight initiation and mortality of adult *Euophryum confine* (Broun) (Coleoptera: Curculionidae) was investigated in the laboratory. Conditions for flight in this species are optimal when relative humidity (r.h.) drops below 30% (±5% r.h.) at 23 and 28°C (±1°C). Less flight activity was observed at higher levels of temperature (33°C) and humidity. Observations of flight at 23° and 28°C varied at humidities between 10–30%: 50% of the sampled population flew at 20% r.h. Temperature had no significant influence on flight initiation between 23–28°C throughout the relative humidity range found to support flight. However, percentage adult mortality was significantly higher at 33 than at 28°C, and decreased as relative humidity increased over the 10–30% range.

Keywords *Euophryum confine*; wood-boring insect; weevil flight

Z02004; published 21 March 2003
Received 19 February 2002; accepted 10 September 2002

INTRODUCTION

Euophryum is a genus of wood-boring weevils native to New Zealand and Chile. Two species are found in the United Kingdom: *E. confine* (Broun) and *E. rufum* (Broun). These weevils are associated with fungally decayed wood and are considered secondary pests of United Kingdom building timbers (Hickin 1967). For the purposes of United Kingdom building surveys these two species are not usually differentiated from each other, or from another common wood-boring weevil, *Pentarthrum huttoni* (Woll.). Out of doors, *Euophryum* spp. are common in woodlands, in pockets of decay on standing trees, or fallen logs (Allen 1942; McClenaghan 1987).

First recorded in England in 1940 (Allen 1942), *E. confine* has since spread throughout the British Isles. Its method of dispersal has not been investigated either in the United Kingdom or New Zealand, where it is not regarded as a pest. There have been a number of anecdotal reports of this weevil in flight, with at least one instance of an *E. confine* adult being captured in a flight trap (Ridout pers. comm.). Hum et al. (1980) showed that *E. rufum* adults could be made to extend their wings from beneath their elytra and that they possessed the musculature required for wing use. Oevering (2001) reported that *E. confine* have unfused elytra, providing further evidence that *E. confine* is capable of flight. However, flight in *E. confine* has never been initiated in the laboratory. A previous study to assess the response of *E. rufum* adults to increased temperature at constant humidity failed to initiate flight (Hum et al. 1980). O'Connor & Ashe (2000) found that *E. confine* were reluctant to fly although environmental conditions were not recorded.

Since Hinton (1947) reported *E. rufum* in a wooden-floored grain store in West Wycombe (Buckinghamshire, United Kingdom), a number of authors have regarded *E. rufum* as a stored product pest (Seymour 1989; Hodge & Jones 1995). This led to a belief that *E. rufum* dispersed via cereal movement (Sawyer & Cragg 1994).

In United Kingdom buildings, *Euophryum* weevils are normally found in wood decayed by "wet rot fungi", most frequently the "cellar fungus", *Coniophora puteana* (Karst.) (Linscott 1967; Coggins 1980). No survey of fungi that precondition the substrate in woodland colonies has ever been attempted. Although both adult and larval weevils tunnel wood, only the adult stage is free living. As with other wood-boring Coleoptera, they are relatively long-lived (14–18 months). *Euophryum* weevils are not observed in wood that has become too dry to support fungal decay (moisture content <21%) (Ridout 2000). This observation is the basis for treatment of domestic wood-boring weevil infestations: once the source of moisture has been removed and the timber dried, the weevils abandon the wood (Bravery et al. 1987; Ridout 2000). This suggests that adults leave wood in response to a lowering of substrate moisture content or a decline in relative humidity.

This study quantifies the effects of humidity and temperature on flight initiation and mortality of mature *E. confine* adults.

MATERIALS AND METHODS

Adult weevils were collected from wild populations at Little Brickhill, Buckinghamshire, United Kingdom (Ordnance Survey Grid Reference: SP9032) and maintained on the substrate from which they were collected (*Betula pubescens* Ehrh.) at 20°C (±1°C) and 95% r.h (±5%).

All experiments were carried out in a 25 cm^3 polycarbonate desiccator containing a platform 60 mm above a bed of silica gel. Humidity within the desiccator was controlled for the duration of these experiments by varying the amount of silica gel and then leaving the apparatus for 24 h to allow the humidity within the desiccator to stabilise.

A flight arena containing a raised platform, to initiate flight, was attached to the wall of the dessicator (Cymorek 1968; Palrang & Grigarick 1993; Shimzu & Moriya 1996). The arena consisted of a glass bottle (5 cm diam. base, 1 cm diam. neck, and 7 cm in height) placed on its side atop the platform. A 0.5 cm dowel was fixed perpendicular to the lower side of the bottle to provide a flight perch. The interior neck of the bottle was coated with Fluon® to prevent weevils from leaving the chamber by means other than flight. A temperature/humidity meter (IDT: THGM880 LCD module) was also positioned on the platform.

Five mature *E. confine* adults (determined by coloration (Oevering 2001)) were introduced into the flight arena through a 10 mm^2 side vent in the dessicator to minimise atmospheric change. The behavioural response of *E. confine* adults was recorded after 72 h. Insects found outside the arena were assumed to have flown, since they were unable to exit the arena by crossing the Fluon® barrier any other way. Any adults that had died within the arena before the 72-h observation period were replaced with individuals from the same colony after each observation. The experiment was repeated at 10, 20, 30, 40, 50, 70, and 90% r.h., 4 times each. The mean number of adults flying at each humidity level was then calculated. The initial temperature within the dessicator was 23°C ± 1°C.

The effect of temperature on flight initiation was examined using the same experimental apparatus. A heating mat (R.S. Supplies: 240 V, 100 W) was placed on the platform beneath the flight arena. The heating mat was connected to a rheostat via the side vent through an airtight seal, allowing temperature to be varied without compromising humidity. By this means, adults were exposed to temperatures of 28 and 33°C ± 1°C at the same humidity levels using identical methods. The number of adults flying at each combination of temperature and r.h. was determined after 72 h. Adults found outside the arena with their wings extending beyond their elytra, as would result from flight, were assumed to have flown. It was also assumed that weevils that left the arena were unable to return to it through the narrow aperture and that all weevils that flew left the arena.

The effects of temperature and humidity on the mortality of adults was also examined with the same experimental apparatus. Five mature adult *E. confine* were placed in a Petri dish (with inner sides coated with Fluon®), placed on the platform within the chamber. Levels of humidity and temperature used in the above methods were reproduced. The chamber was monitored after 72 h and adult mortality assessed. This procedure was repeated 4 times to establish mean adult mortality at each temperature/humidity combination.

The influence of humidity and temperature on flight and mortality was investigated using analysis of variance (ANOVA) (Bailey 1995).

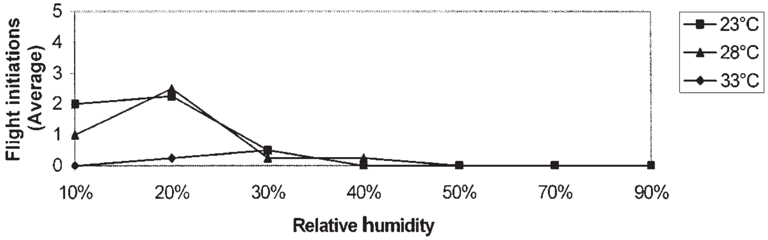

Fig. 1 Influence of temperature and relative humidity on flight initiation.

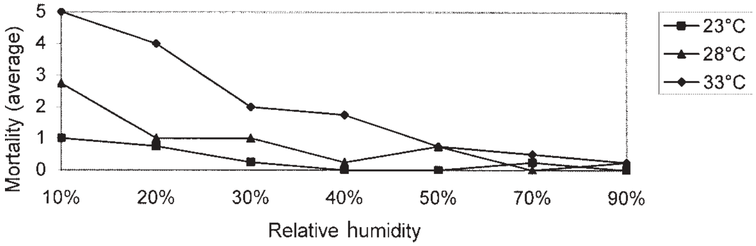

Fig. 2 Influence of temperature and relative humidity on adult mortality after 72 h.

RESULTS

When relative humidity was increased above 20%, fewer adults flew at 23 and 28°C (±1°C) (Fig. 1). Increases in relative humidity above 30% had no significant influence on flight initiation at any temperature. At 33°C, changes in humidity over the range 10–90% had no significant influence on flight activity. There was no significant difference between the number of adults flying at 23 or 28°C at 10% ($F_{1,6=3.00}$, $F_{CRIT=5.98}$) and 20% r.h. (±5%) ($F_{1,6=0.06}$, $F_{CRIT=5.98}$). However, at 10 and 20% (±5% r.h.) significantly fewer adults flew at 33 than 23°C ($F_{1,6=6.4}$), $P = 0.0447$ or 28°C ($F_{1,6=10.56}$), $P = 0.0174$.

Significantly greater mortality was observed at 33 than at 23 and 28°C at 10% ($F_{1,6=6.94}$), $P = 0.0388$ and 20% r.h. ($F_{1,6=13.5}$), $P = 0.0104$ (Fig. 2). No significant difference was seen in mortality between 23 and 28°C across the 10–90% humidity range. Decreasing r.h. at a constant temperature tended to increase mortality.

DISCUSSION

This study showed that flight initiation in adult *E. confine* increased when relative humidity fell below 30% (±5%). This strategy probably relates to the influence of relative humidity on the equilibrium moisture content of the wood substrate at the temperatures employed. For example, at 23°C, 30% r.h. the substrate will acquire an equilibrium moisture content of between 6.5–8.5%, which is insufficient to support fungal decay and, therefore, an active weevil infestation. This may stimulate adults to seek a new substrate with moisture content sufficient to support fungal decay. The importance of fungal decay to adult *E. confine* has yet to be fully analysed, although initial work has suggested that there is a relationship between wood hardness and susceptibility to attack (Green & Pitman 2002). Decay reduces the hardness of wood, which facilitates tunnelling by adults, an interpretation supported by the fact that adults are capable of tunnelling undecayed balsa wood (*Ochroma* sp. Urb.) which is naturally soft (Green & Pitman 2001). Since immature stages are unable to continue development in wood in which decay has been arrested, a flight strategy becomes a useful mechanism for ensuring survival of adults and continuation of the life cycle once suitable substrate has been found.

Fadamiro & Wyatt (1995) state that changes in relative humidity have a pronounced effect on insects with relatively small body sizes because they have such a low haemolymph volume. Mortality studies confirm that decreasing relative humidity tends to increase mortality over 72 h. A reduction in humidity also increases mortality in other adult wood-boring Coleoptera, e.g., *Nacerdes melanura* L. (Pitman et al. 1998). Given the relatively small size of *E. confine* (<5 mm) compared with other wood-boring Coleoptera, a low haemolymph volume might also preclude flight at higher temperatures or lower humidity levels if these conditions cause excessive water loss (Unwin & Corbet 1991).

For many wood-boring Coleoptera, flight is synchronised to coincide with increasing spring/summer temperatures, e.g., flight of *Hylotrupes bajulus* (L.) at 27°C (Dürr 1957; Cymorek 1968), or when weekly maximum temperatures exceed a given minimum, e.g., flight of *Xestobium rufovillosum* de Geer at 17°C (Belmain et al. 1999). The lower threshold temperature for flight in *E. confine* was not determined in this study, although many other wood-boring Coleopteran pests of building timbers, e.g., *H. bajulus*, do not fly at temperatures as low as 23°C, whereas *E. confine* does. These findings indicate that *E. confine* is capable of flight throughout the United Kingdom at certain times of the year, which explains the widespread distribution of this species compared with other introduced wood-boring Coleoptera such as *H. bajulus*.

This study has documented that falling relative humidity is the most important factor influencing flight and mortality of *E. confine* adults, given that fungal decay necessary for weevil attack is arrested at these low humidity levels. Further work might establish how dispersing adults locate substrate suitable for colonisation.

REFERENCES

Allen, A. A. 1942: *Pentarthrum huttoni* Woll. Col., Curculionidae in south-east Herts. *Entomologists' Monthly Magazine 78*: 117.

Bailey, N. T. J. 1995: Statistical methods in biology. 3rd ed. Cambridge, Cambridge University Press.

Belmain, S. R.; Simmonds, M. S. J.; Blaney, W. M. 1999: Deathwatch beetle, *Xestobium rufovillosum*, in historical buildings: monitoring the pest and its predators. *Entomologia Experimentalis et Applicata 93*: 97–104.

Bravery, A. F.; Berry, R. W.; Carey, J. K.; Cooper, D. E. 1987: Recognising wood rot and insect damage in buildings. Building Research Establishment 120 p.

Coggins, C. R. 1980: Decay of timber in buildings. Dry rot, wet rot and other fungi. East Grinstead, Rentokil Ltd.

Cymorek, S. 1968: *Hylotrupes bajulus*—Verpuppung und—Flug, deren Klima-abhängigkeit und Beziehung zur artverbreitung. *Zeitschrift für Anglewndle Entomologie 62(3)*: 316–344.

Dürr, H. J. R. 1957: The morphology and bionomics of the European houseborer *Hylotrupes bajulus* (Coleoptera: Cerambycidae). *Entomological Memoirs 4(1)*: 64–129.

Fadamiro, H. Y.; Wyatt, T. D. 1995: Flight initiation by *Prostephanus truncatus* in relation to time of day, temperature, relative humidity and starvation. *Entomologia Experimentalis et Applicata 75*: 273–277.

Green, M.; Pitman, A. J. 2001: A preliminary study of timber susceptibility to attack by the weevil *Euophryum confine* (Broun). *In*: Proceedings of the 5th International Conference on Development of Wood Science, Technology and Forestry. Ljublijana, Slovenia.

Green, M.; Pitman, A. J. 2002: The influence of fungal species and the level of decay on the mortality and feeding activity of adult *Euophryum confine* (Broun). *In*: Proceedings of the 33rd meeting of the International Research Group on Wood Preservation. Cardiff, Wales. IRG/WP 02-10448.

Hickin, N. E. 1967: The insect factor in wood decay. 3rd ed. London, Hutchinson Press. 383 p.

Hinton, H. E. 1947: Notes on two beetles that may have become established in Britain and are associated with stored products. *Entomologist 80*: 187.

Hodge, P. J.; Jones, R. A. 1995: New British beetles: species not in Joy's practical handbook. The British Entomological and Natural History Society. 175 p.

Hum, M.; Glaser, A. E.; Edwards, R. 1980: Wood-boring weevils of economic importance in Britain. *Journal of the Institute of Wood Science 8(5)*: 201–208.

Linscott, D. 1967: Wood-boring weevils in Great Britain. Proceedings of the 2nd IPCA Conference. Pp. 42–47.

McClenaghan, I. 1987: Some not-so-recent Irish records of *Euophryum confine* Broun Col.: Curculionidae. *Entomologists' Monthly Magazine 123*: 178.

O'Connor, J. P.; Ashe P. 2000: Irish indoor insects: a popular guide. Dublin, Town House Publishing. 256 p.

Oevering, P. 2001: Aspects of the biology and ecology of *Pselactus spadix* Herbst. PhD thesis. Forest Products Research Centre, BCUC, Brunel University, Buckinghamshire, United Kingdom.

Palrang, A. T.; Grigarick, A. A. 1993: Flight response of the rice water weevil (Coleoptera: Curculionidae) to simulated habitat conditions. *Journal of Economic Entomology 86(5)*: 1376–1380.

Pitman, A. J.; Cragg, S. M.; Sawyer, G. S. 1994: The role of fungal degradation in facilitating boring in wood by the weevil *Euophryum confine* Broun. *In*: Proceedings of the 1st International Conference on Development of Wood Science, Technology and Forestry, Buckinghamshire, Chilterns University College, United Kingdom.

Pitman, A. J.; Jones, A. M.; Jones, E. B. G. 1998: An investigation of the life-history of wharf-borer beetle (*Nacerdes melanura* L.). *Journal of the Institute of Wood Science 14(6)*: 262–271.

Ridout, B. 2000: Timber decay in buildings: the conservative approach to treatment. London, Routledge.

Sawyer, G. S.; Cragg, S. M. 1994: Environmental requirements of some wood boring weevils. Proceedings of the 1st International Conference on the Development of Wood Science, Technology and Forestry. Buckinghamshire, United Kingdom.

Seymour, P. R. 1989: Invertebrates of economic importance in Britain. Common and scientific names. 4th ed. H.M.S.O. 147 p.

Shimzu, T.; Moriya, S. 1996: Flight time and flight age in the sweet potato weevil, *Cylas formicarius* (Fabricius) (Coleoptera: Brentidae). *Applied Entomology and Zoology 31(4)*: 575–580.

Unwin, D. M.; Corbet, S. A. 1991: Insects, plants and microclimate. Slough, Richmond Publishing Company. 68 p.