Seasonal activity of *Typhaeus typhoeus* (Linnaeus) (Geotrupidae)

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Introduction

Jessop (1986) gives the times of occurrence of *Typhaeus typhoeus* (Linnaeus) as January to May and August to October and states that most records are from the spring and autumn. This information is repeated by Shirt (1991) who categorises the beetle as a "spring species". The gap in Jessop's information coupled with brief field observations led one of us to make several wrong assumptions about their life history (Fremlin, 2005). Also, as it raised a few unanswered questions, she decided to study their seasonal activity in Colchester, Essex. The field monitoring was done by means of direct observations of their emergence, burrowing activity, and a combination of pitfall traps and mark-recapture.

At the same time as this work was in progress two pitfall surveys carried out for Natural England in Wiltshire (Darby, 2005, 2008) revealed that *T. typhoeus* is active throughout the winter months. Because the two studies complemented each other we decided to present our results together; our data show that *T. typhoeus* in both sites is active from late September till July, including the winter months.

Sites studied

The Spinney, Hilly Fields, Colchester, Essex, TL9825

The Spinney is a very young woodland (less than 50 years), part of Hilly Fields, a local nature reserve near the town centre. It has light sandy soil, teems with rabbits and in some areas, particularly close to their latrines, *T. typhoeus* are active. There are signs of the presence of muntjac deer, but no sightings. The area of study was south-facing, small (about 190m^2), grassy and slightly sloping.

Pitfall traps baited with rabbit dung were set up for short periods during 2005 to 2007. The number of traps in each experiment was 8 except during May 2006 and October 2007 when 6 and 10 were used, respectively. The traps were checked daily, at midday, for the duration of the experiment and all the beetles were promptly measured, marked on their elytra with a needle and released about 1m away from the trap. The marking method followed Mendéz (2008).

The traps were made out of 500ml drinks bottles and their design gradually improved. In the final version the top was cut off just below the shoulder and then small drainage holes were made in the bottom half with a sharp skewer. This was buried flush with the soil surface, baited with the rabbit dung collected within their vicinity, and fitted snugly with the inverted top, to make them fox-proof. They were

disguised with sticks to make them difficult for humans to see as it is a popular public area.

Typhaeus emergence holes were monitored for activity by plugging them with rolled up oak leaves, plus markings with twigs and other solids.

Soil temperature was measured at 18cm depth with a Dr Friedrichs soil thermometer. Weather data was measured in MF's garden (TL986244) by a LaCrosse wireless station WS2300, 0.9km south of the area of study. Further data on weather in Colchester was obtained from Tijou's station which is at TL997252, about 1.5km NE of the Spinney (Tijou).

Langley Wood NNR, Wiltshire, SU230210

Langley Wood is a 214ha ancient woodland on the north east edge of the New Forest. Although mainly oak-dominated high forest there is a wide range of other tree species present. Deer are common and five species have been recorded. The first phase of trapping (1 April 2004 to 24 March 2005), in the Bishops Wood area was carried out under a contract for English Nature as part of a programme to re-institute wood pasture by grazing cattle in compartments managed under a minimum intervention policy (Darby, 2005). The compartments were fenced as follows: A: 0.5ha fenced with 1.8m high tensile turbo netting; B: 0.75ha fenced as A; C: 0.75ha fenced with 1.2m high tensile horse netting; D: unfenced. The second phase (15 July 2006 to 2 July 2007), in the Outwood area, did not incorporate fencing and was commissioned by Natural England to enable a comparison to be made between that area and Bishops Wood (Darby, 2008). Neither study focused on *T. typhoeus* in particular.

The pitfall traps were put down according to the protocol established by Newcastle University (Luff, 1996) in runs of 9, 2 metres apart. In Bishops Wood 3 runs were used in each of 4 compartments (4x3x9 traps) and in Outwood single runs in 4 different areas (4x9 traps). The traps were partially filled with ethylene glycol (blue antifreeze) and emptied at approximately 4 week intervals.

Results

The Spinney

The results of six capture-mark-recapture trapping experiments are shown in Figure 1. The first experiment, 6 to 15 November 2005, took place during a period of considerable *T. typhoeus* feeding activity. Traps were set near their burrows and 17 males and 22 females caught; one male came to the same trap four times. However, there were problems with predators, probably foxes, due to bad trap design and the experiment had to be stopped. From late January 2006 onwards the burrows were monitored. There was great variation in *T. typhoeus* activity, strongly linked to temperature and to some extent humidity; they slowed down when the mean soil temperature was below 5^{o}C at 18cm depth, at noon, or the soil was very dry. There was only a brief period with no activity. This was in early March when there were

frosts; at noon the mean soil temperature was 2°C at 18cm below the surface.

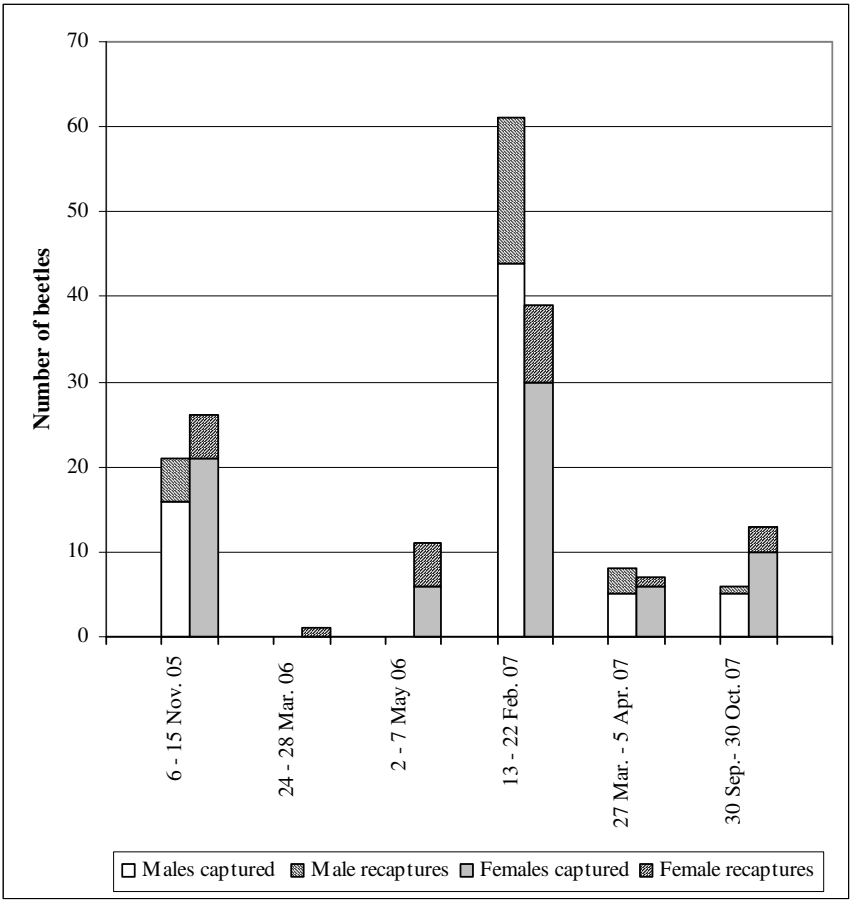

Figure 1 Trapping results at Hilly Fields, 2005-2007 Each column represents the total number of beetles of a given sex in a given period, with a lower section representing the number of different individuals found.

In March 2006 traps were set up in the same places as in November 2005 and only one female was trapped; she was found the next day in exactly the same place where she had been released. Later, in May, better designed traps set in areas near active burrows yielded slightly more catches - 6 females, one of which was recaptured three times.

Emergence in 2006 started on 23 September after rains; mean soil temperature, at 18cm below, was 18°C and nesting was under way in mid-January (Figure 2).

Traps were set in February 2007 and 44 males and 30 females captured, marked and released. Many males were recaptured; two came four times, not necessarily to the same trap. Two females were recaptured once. In both cases the distance between the traps was 5m. About one month later the same area was monitored with traps in the same place and the captures were much lower. One male was recaptured once, and one of the two recaptured females, twice. The greatest distance between traps in which the same individual was caught was 3.6m.

Figure 2 *T. typhoeus* fresh nesting mound. Scattered elytra are a common occurrence in the field. Photo taken on 14 January 2007.

From 19 September 2007 the area was monitored for activity at noon on a daily basis. Emergence started gradually on 30 September after rains (Figure 3) and maturation feeding mounds first appeared on 19 October. There was a gradual increase in activity in the field; it levelled off towards the end of the month. At the same time in 10 traps scattered around the area 5 males and 10 females were trapped (Figure 1). The first beetle to be captured, on 3 October, was a male which was recaptured the following day in another trap, 6.8m away. One female was recaptured in the same trap and later its marked elytron was found 3.6m away. At the end of this experiment some mounds were dug up and beetles were found in 3

out of 7, 1 male and 2 females, one of which was a recapture, 35cm away from the trap. They were about 8cm below the ground.

In a nearby area, Humberlands, Essex, TM0930, several identical traps were set near burrows by Jenny Francis in late February to early March 2008 and 9 males and 6 females were caught. Traps set in 18 to 20 April 2008 caught only 2 females. Little owl (*Athena noctuis*) pellets (determined by Joe Firmin) found near one of the traps contained remains of a male.

Other dung beetles (Scarabaeidae) found in The Spinney during the monitoring period were: *Aphodius obliteratus* (Sturm), October to February, followed by *A. sphacelatus* (Panzer) from February, both inside rabbit pellets. *Onthophagus similis* (Scriba) was trapped once in May 2006; all were determined by Nigel Cuming.

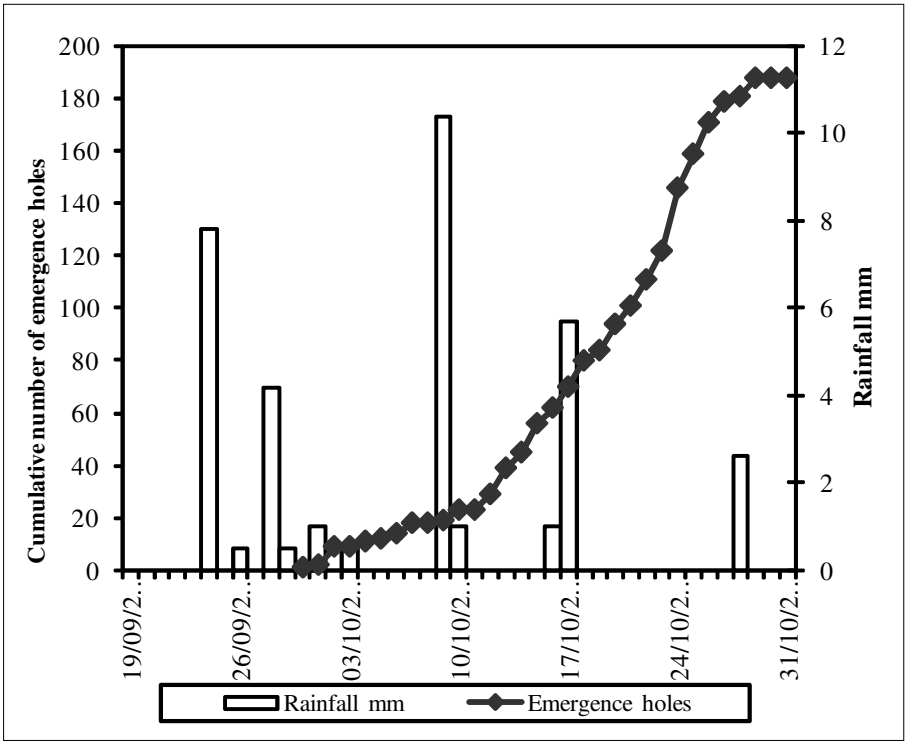

Figure 3 *T. typhoeus* activity at Hilly Fields 23 September - 28 October 2007 Cumulative number of emergence holes. Rainfall is the total over previous 24 hrs to noon.

Langley Wood

The results of the first phase of trapping in the Bishops Wood area are set out in Figure 4 with numbers and dates of capture of *T. typhoeus*. A total of 127 were trapped from October until July; 10 were not sexed and the remainder comprised 78 males and 39 females. Peak activity was in November (feeding) and January (nesting). The numbers trapped in the four areas of Bishops Wood were: A – 2, B – 1, C – 69, D – 55.

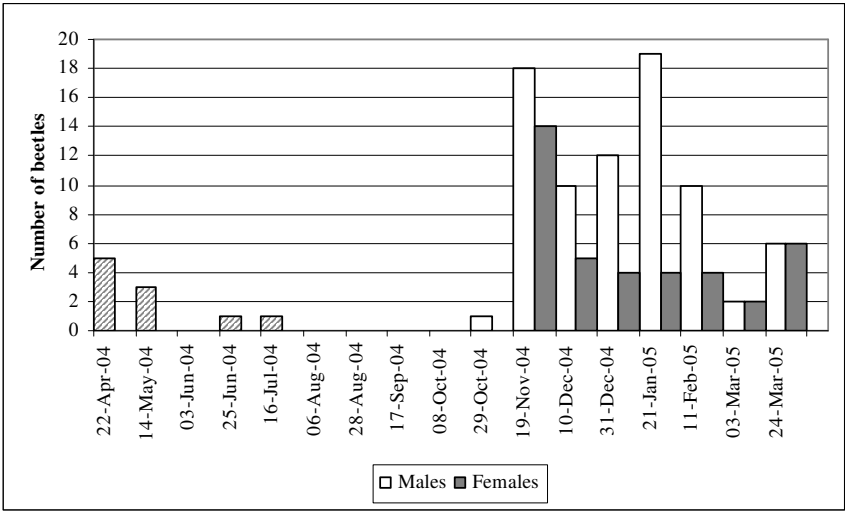

Figure 4 *T. typhoeus* individuals trapped at Bishops Wood between 2 April 2004 and 24 March 2005 Dates are those on which traps were emptied. The spring/summer 2004 captures (dashed bars) were not sexed.

Anoplotrupes stercorosus (Scriba) and *Geotrupes stercorarius* (Linnaeus) (Geotrupidae) were recorded in large quantities from March to October, total 999, with a peak of 310 in September of which 288 were in the area C. Thus in area C, *A. stercorosus* and *G. stercorarius* together were 12 times more abundant than *T. typhoeus*, respectively 31 and 2.6 beetles/trap.

Figure 5 shows the numbers trapped in Outwood. Peak activity was in October (feeding) and then in March (nesting). Here the traps were placed in open woodland; the number of *T. typhoeus* trapped was 181 comprising 105 males and 76 females, 5.1 beetles per trap, roughly twice the amount in the most abundant area in Bishops Wood, area C. The numbers trapped in the four areas of Outwood were: E – 9, F – 76, G – 59, H – 37.

The low score for area E is difficult to account for, the woodland structure being similar to that in the other areas. However, it was sited closer to the woodland boundary, and as such, may have provided less secure cover for visiting deer.

Other Geotrupidae species were recorded in vast numbers in Outwood (19,793 from April to November, peaking in September). E – 3550, F – 5129, G – 6012, H – 5102; 550 beetles/trap. They were mostly *A. stercorosus*. Thus in Outwood this species together with *G. stercorarius* were over 100 more times more abundant than *T. typhoeus*. Again, the lowest total was in area E.

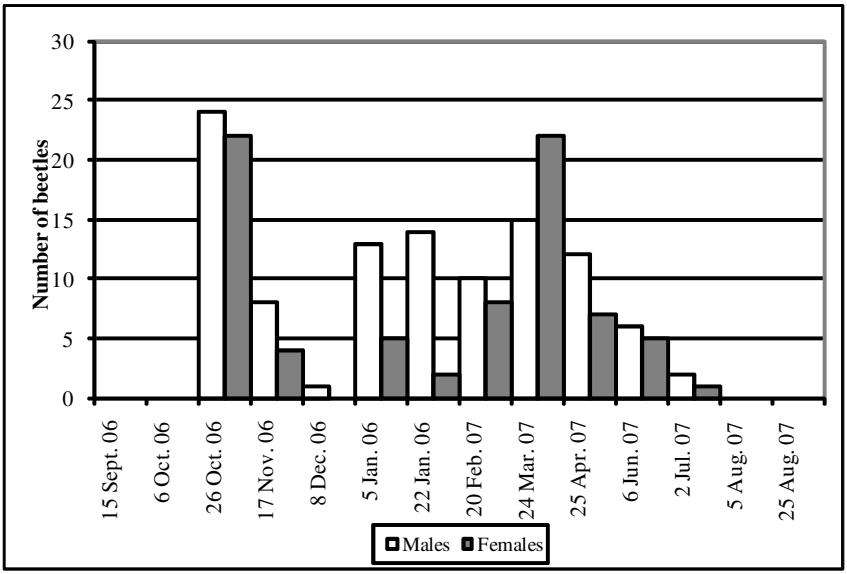

Figure 5 *T. typhoeus* individuals trapped at Outwood between 6 October 2006 and 5 August 2007. Dates are those on which traps were emptied. No *T. typhoeus* were captured outside these dates.

Other dung beetles (Scarabaeidae) recorded in Bishop's Wood were *Onthophagus coenobita* (Herbst), *O. joannae* Goljan, *Aphodius ater* (De Geer), *A. sticticus* (Panzer), *A. prodromus* (Brahm), *A. rufipes* (Linnaeus), *A. sphacelatus* (Panzer), and in Outwood were *Onthophagus coenobita, O. joannae, O. similis* (Scriba), *Aphodius sticticus* (Panzer), *A. granarius* (Linnaeus), *A. obliteratus* Sturm, *A. prodromus and A. sphacelatus.*

Discussion

T. typhoeus is a beetle of Mediterranean origin (Brussaard, pers. comm.) where winter activity coupled with nesting very deep are important strategies to avoid the region's extreme climatic conditions of summer, fires included. In particular the insect is able to take advantage of moister dung (Verdú & Galante, 2004) and avoids strong competition from summer dung dwellers like *A. stercorosus* and *G. stercorarius.*

Even though in Bishops Wood there were very low numbers of *T. typhoeus* trapped in October, our observations confirm that *T. typhoeus* activity in Essex and Wiltshire conforms to Brussaard's model (1983). The beetles emerge in the autumn, probably after the onset of wetter weather, and remain active throughout the winter months, except when the ground freezes or is covered with snow. *T. momus* (Olivier), a flightless species endemic to the south-western Iberian Peninsula, also conforms to this model (Gallardo *et al.,* 2002).

In Bishops Wood the height of fencing around the areas A and B meant that deer were excluded entirely; the height of the fence around C was intended to keep cattle (not yet introduced) in, but to allow deer in and out. Given this deterrent one might have expected that numbers of *T. typhoeus*, *A. stercorosus and G. stercorarius* in that area would be lower than in the unfenced area D. That they were not is probably explained by the open structure of the woodland in D compared with the closer canopy and denser understorey in C providing more cover for the deer. Therefore in Langley Wood they were feeding mainly on deer dung as opposed to rabbit dung in Essex.

In Outwood *T. typhoeus* were roughly twice the amount in the most abundant area in Bishops Wood, area C, and considering that there the other Geotrupidae were 100 times more abundant, this remarkable difference between the two sites remains unaccounted for given that the deer populations in both seem to be similar.

Following emergence, *T. typhoeus*, like all tunnelling Geotrupidae, has to undergo a maturation feeding period in order to reach sexual maturity (Cambefort & Hanski, 1991). This period is characterised by the appearance of small mounds of earth outside burrows and with *T. typhoeus* it lasts about 4 weeks (Brussaard, 1983) and our results confirm this. If the weather is mild nesting activity begins soon after; they form pairs and there is strong male-female cooperation (Fabre, 1907a). As they nest rather deep, as much as 150cm, this period is characterised by much larger mounds of earth which become flattened after completion, quite often hiding the emergence hole. Nesting is usually protracted, probably to compensate for adverse weather conditions coupled with low fertility (Verdú & Galante, 2004; Gallardo *et al.,* 2002).

In both studies, as well as in Brussaard's (1983) and the *T. momus* study (Gallardo *et al.,* 2002), females were trapped in significant numbers throughout the nesting period thus suggesting that they were either looking for a mate or foraging for dung. In the latter case this task falls to the male in normal circumstances (Fabre, 1907a, b; Main, 1916; Brussaard, 1983). Even though they form pairs there are observations in captivity of females who carried on nesting on their own after their partner had died (Fabre, 1907b; MF, pers. observ.).

Therefore these females' records suggest, indirectly, that male mortality increased as the season progressed. Foraging expeditions, even close to their burrows as the mark-recapture results suggest is the normal case, expose them to predators. Elytra are often found near to the burrows (see Figure 2); also male remains were found in owl pellets in late April.

Our findings indicate that nesting was complete in late April or early May in Essex, and possibly lasted longer in Wiltshire. In captivity, however, when the beetles do not face mate competition (Palmer, 1978; Fremlin & Nahaboo, 2010), predators, adverse weather conditions and other dangers, this period was reduced. In a rearing trial in an unheated garage nesting started on 1 January 2007 and was completed by 2 March, and 8 brood masses were made. The beetles then died and the offspring, 1 male and 1 female, emerged in October 2008). However, as the season progresses the beetles take much longer to complete their brood masses (Fremlin, unpublished).

This research shows that Jessop's times of occurrence for *T. typhoeus* should be amended to: *from late September till July the next year; most records are from autumn to spring thus indicating that the beetle is a 'winter insect'*.

Acknowledgments

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