THE STAG BEETLE *LUCANUS CERVUS* (LINNAEUS, 1758) (COLEOPTERA: LUCANIDAE): A MARK-RELEASE-RECAPTURE STUDY UNDERTAKEN IN ONE UNITED KINGDOM RESIDENTIAL GARDEN

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RÉSUMÉ. — *Le Lucane cerf-volant* Lucanus cervus *(Linné, 1758)* (Coleoptera: Lucanidae)*: une étude par capture-recapture dans un jardin résidentiel britannique.* — Au Royaume-Uni le bois mort présent dans les jardins résidentiels procure une ressource significative au Lucane cerf-volant (*Lucanus cervus*). Les données obtenues lors d'une étude par capture-recapture d'individus marqués effectuée de juin à août 2006 dans un jardin résidentiel du comté de Suffolk, en utilisant une méthode de marquage mise spécialement au point pour le lucane, suggèrent que la dispersion de cet insecte est très limitée. Ce facteur doit être pris en compte dans les plans de conservation de l'espèce.

Mots-clés: Jardins résidentiels, bois mort, techniques de marquage, dispersion, conservation.

SUMMARY. — In the UK, dead wood present in residential gardens provides a significant resource for stag beetles (*Lucanus cervus*). Data obtained in a mark-release-recapture study, undertaken from June to August 2006 in one residential garden in the county of Suffolk, using a marking technique developed specifically for use with *L. cervus*, suggest that dispersal of the insect is very limited. This is a factor which needs to be considered when planning for its conservation.

Keywords: Residential gardens, dead wood, marking technique, dispersal, conservation.

Traditionally the stag beetle (*Lucanus cervus*) has been associated with forests and woodland. However, records collected in the UK national surveys, organized by the People's Trust for Endangered Species (PTES) (1998 and 2002), showed that over 75% of the 12,000 beetles sighted came from urban areas rather than the rural environment. Furthermore, 93% of the urban sightings came from residential gardens. Currently we have no accurate information on the movement and dispersal of *L. cervus* in residential areas, data which is fundamental to providing appropriate conservation measures for the insect in the UK.

The mark-release-recapture study described here was undertaken following similar preliminary studies carried out by the author in several residential gardens 2001 to 2005, and preparatory to a residential garden radio-tracking study of stag beetles planned for 2007[2].

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[2] The planned presentation, "Tracking the movements of stag beetles *Lucanus cervus* L. (Coleoptera: Lucanidae) in the built environment", could not be made, as the radio-tracking equipment was not available in time to complete the research before the start date of this symposium. The materials and methods, plus results from the first 14 days of the capture-mark-recapture study described in this paper were presented in its place.

MATERIALS AND METHODS

In 2006 a mark-release-recapture field study was carried out in one village garden that forms part of Grove Lodge (0.154 ha, grid reference TM 1129 3670), Bentley, some 13 km south-west of the town of Ipswich in the county of Suffolk (East Anglia). The garden chosen for the study (Fig. 1), one of a large number in the parish of Bentley that have a regular annual emergence of *L. cervus*, was used in the earlier preliminary mark-release-recapture studies. Approximately 16% of the 0.154 ha comprised residential accommodation, sheds, greenhouse and concrete hard standing. A small area (approx. 4%) was used for growing vegetables. The remainder consisted largely of mown grass, with a flower border, some young fruit trees and one oak tree *Quercus robur* (2.3m circumference at 1.3 m). Two raised banks (Fig. 1a,b) lay at the north-western corner of the garden, the remains of a once tree-lined avenue leading to The Grove to the south-west. Close to these banks, in contact with the soil, were two large log piles (Fig. 1c,d & Fig. 2), each approximately 1.5 m high, 2 m wide and 3 m long, products of a felled sycamore tree *Acer pseudoplatanus*, the stump of which was still present by log pile c.

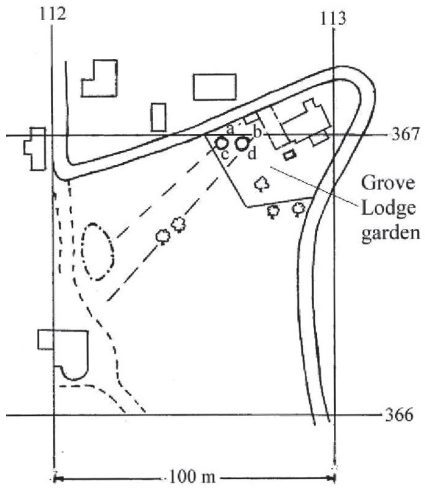

Figure 1. — Mark-release-recapture study site: Grove Lodge garden, Bentley, Suffolk, UK.

Figure 2. — Log pile d.

Stag beetles were captured in pitfall traps, in flight, or by hand. Four non-baited pitfall traps were positioned along the raised banks, each comprising a pair of 18 cm plastic flower pots, one fitted snugly inside the other with rims touching, sunk into the ground so that the mouth of the trap was level with the soil surface. A long-handled (0.8 m), circular-framed (0.4 m diameter) kite (butterfly) net was used to catch any *L. cervus* in flight during the insect's peak activity period between 21h00 and 22h00. A number of beetles were captured by hand, from the ground, tree trunks and branches, and from underneath logs (Fig. 3).

Figure 3. — Male stag beetles under log (log pile d).

Pitfall traps were put in place on 01.VI.2006. Grove Lodge garden was then visited daily at 07h00 and 21h00 from 02.VI. to 15.VIII.2006 to examine the traps and search for *L. cervus*. Each stag beetle captured for the first time was weighed, measured and then marked with an individual identification code on its ventral side using a Pentel Microcorrect needlepoint precision corrector (Pentel Stationery Ltd, Swindon, Wiltshire, UK). Captured beetles had their identification codes recorded before being released. Recaptured marked beetles were remeasured and their identification codes recorded. All beetles were released as quickly as possible at the same place where they had been captured. Air temperature was measured each evening on arrival at the study site and every 15 minutes thereafter until 22h00.

The stag beetle 4-spot decimal coding system used to mark the beetles was based on a scheme described by Richards & Waloff (1954), modified and developed by the author (2001-2005) for use with *L. cervus* (Hawes, in prep.). The system was designed to be flexible, accommodating low or high capture rates and a range of up to 16 recorders (Fig. 4). All captured beetles were marked with a 4-spot code (Fig. 5). The same number of code spots was marked on each beetle to ensure that if spots wore off during the investigation the number remaining would be recognized as an unreadable code. An additional spot mark was made in the mid-line on the head of all beetles to ensure recognition of marked individuals that might become dismembered by, for example, predators. Recorded identification codes were transferred to pre-printed record forms (Fig. 6).

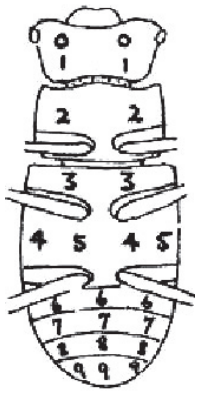

Figure 4. — Diagram of *L. cervus*: ventral side illustrating the 4 -spot marking system. *Key*: numbers represent the positions of mark-code spots. Numbers on the right of the mid-line represent units 0-9. Numbers 0-5 on the left represent tens. 00 - 59 provide a total of 60 individual beetle identification codes. Numbers 6-9 on the left and in the mid-line can be used to identify up to 16 recorders (66-99) or to extend the individual beetle code range in a variety of ways.

Figure 5. — *L. cervus* male: code-marked 2899 (the additional spot-mark, which should be present in the mid-line of the head, had not been placed when this photograph was taken).

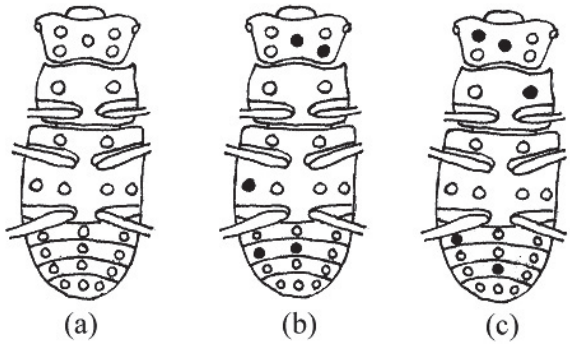

Figure 6. — (a) Ready-to-record beetle diagram (16 per A4 record sheet). (b) Record of beetle code-marked 4177. (c) Record of beetle code-marked 0268.

RESULTS

A total of 138 stag beetles were captured, marked and released in the garden at Grove Lodge (100 males and 38 females). Fifteen of these were caught in pitfall traps (4 males and 11 females). The first beetles captured, a male and female, were found in pitfall traps on the 02.VI.2006; the last beetle captured, a female, was found under a log on 09.VIII.2006. The largest numbers of male captures were made on 04 (14), 09 (11), 11 (15), and 12 (14) VI.2006. The largest numbers of females were captured on 17 (3), 27 (3) and 30 (4) VI.2006.

After release, 52 (38%) of the 138 individually marked beetles were recaptured at least once in subsequent visits to the garden (Tab. I). 36% of the males and 42% of the females were recaptured (Fig. 7). The majority of the males were flying or climbing trees when captured, whereas most captured females were found crawling on the ground or under logs. Apart from one female captured in a pitfall trap on 02.VI.2006, females were not captured again until one

was found over a week later on 11.VI.2006. Sixteen individually marked beetles (9 males, 7 females) were observed at both 07h00 and 21h00 on 23 separate days, mostly in the same location under logs.

TABLE I

Numbers of stag beetles recaptured in Grove Lodge garden (2 June to 9 August 2006)

Number of times individually marked beetles were recaptured	Number of recaptured individually marked beetles	Males	Females
1	25	20	5
2	13	9	4
3	8	6	2
4	0	0	0
5	3	1	2
6	0	0	0
7	2	0	2
8	1	0	1
Total	52	36	16

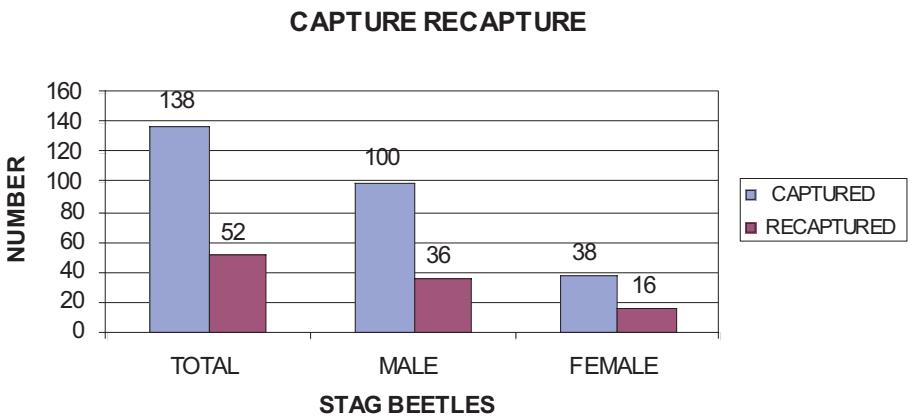

Figure 7. — Stag beetle capture recapture numbers.

The Pentel corrector 4-spot code was found to be very durable. Only 15 of the recaptured beetles (11 males, 4 females) were found to have lost some of their code spots and therefore could not be individually identified. Two males were recaptured 15 days after release (mean for males: 4 days) and one female after 27 days (mean for females: 10 days) all three with the full 4-spot code still in place.

DISCUSSION

Many ecological studies of insects depend on identifying marked specimens and numerous methods of marking them have been described (e.g. Southwood, 1978). Marks placed on insects can be simple, used only to identify released specimens, or individual if more detailed data is required. Systems for marking insects individually, using colour and position codes have been used in a large number of studies (e.g. Brussard, 1971; Richards & Waloff, 1954;

Sheppard *et al*., 1969; White, 1970). Also, beetles have been marked by engraving codes onto the elytra (e.g. Best *et al*, 1981; Griffiths *et al*., 2001; Unruh & Chauvin, 1993). Many methods to mark insects individually can produce a permanent code; however, the techniques are time consuming and can be expensive (Piper, 2003).

Studies made by the author (2001-2005) showed that a simple, non-expensive, needle-point corrector (normally used to correct written or typing errors) could be used to mark stag beetles. The technique to apply the correction fluid was quick and easy to use, gave fine control, plus needlepoint marks if these were required. The marks made were fast drying and, although non-permanent, remained in place for up to eight weeks, which suggested that the technique might lend itself to the study of stag beetle dispersal as, once emerged, adult stag beetles rarely live for more than four weeks (Hawes, in prep.).

The 4-spot code method of marking described in this paper evolved during the 2001-2005 pilot studies referred to above. Marks made were readily discernible but deliberately hidden on the ventral surface, so that they did not increase the chance of the beetles being taken by predators.

Disturbance of the surroundings was kept to a minimum when inserting the pitfall traps. The outer pot of each trap was left in the ground throughout the period of the study, whilst the inner pot could easily be removed for the collection of specimens (Scudder). Drainage holes in the base of the pots were too small to allow stag beetles to escape into the soil. All recaptured beetles were re-measured, thus providing a second check on individual identification.

Visiting the garden twice daily was labour intensive but enabled the maximum number of beetles to be captured. Pitfall traps and collection by hand were more effective in capturing females than using a butterfly net (only one female was caught with the net), whereas the use of a net and collection by hand captured more males than using pitfall traps. Recaptured males outnumbered females in a ratio of 2.25: 1, a result which is probably a reflection of the difference in the behaviour of the two sexes, males being more conspicuous in flight and when on the ground crawling rapidly in search of females. Females generally crawled slowly and often remained stationary, or remained hidden under logs. The number of times females were recaptured and the fact that they were more often than not found again under the same log suggests that they tend to remain close to the site from which they emerged. A good example of this home-range behaviour is perhaps best illustrated by the female observed at 21h00 on 11.VII.2006 resting on a concrete plinth supporting a water butt, 5m from the log under which it had been found at 07h00 that morning. At 21h35, the female began crawling directly back towards the same log, taking 25 minutes to complete the journey, when it then burrowed under the log, where it was found again the following morning. If the behaviour described is typical, then the beetle's ability to disperse, which is dependent on the female, is very limited (Hawes, 2005). There was a plentiful supply of suitable decaying wood in the garden at Grove Lodge to provide stag beetle larvae with food, which suggested that this was more likely to be used by ovipositing females than more distant, new sites. Searching for the latter would have necessarily caused them to expend valuable energy when it was better conserved and used for survival strategies, egg production and burrowing in their home habitat to find suitable places for ovipositing. A radio-tracking study of stag beetles carried out at a woodland site in Switzerland (Sprecher-Uebersax, 2001) found similar results for male and female behaviour and showed that females never took to the wing, but crawled and remained in the area where they emerged (home range 0.17 ha), while males travelled further afield (home range 1.06 ha).

The limited dispersal of *L. cervus* suggests that when considering conservation measures for the species, of prime importance is ensuring the continuity of suitable dead wood at known stag beetle locations. Dead wood in the form of logs or log piles (see: "Stag beetle friendly gardening", published by the People's Trust for Endangered Species) should be used continually to replenish decaying wood at such sites. Logs and log piles built too far away from stag beetle populations, especially those that are isolated, seem less likely to be colonized and might well be a waste of conservation effort.

Capture and recapture numbers were also influenced by air temperature. The correlation between air temperature and beetle activity agreeds with that described by Percy *et al* (2000)

and Sprecher-Uebersax (2001). On cool evenings, when the temperature was 15° C or below, there was little beetle activity, most beetles being found under logs or partly buried in the soil. There was evidence that there were also beetles that had burrowed into the soil and were hidden beneath its surface, but no attempt was made to disturb the soil to find them. In general, beetle flight occurred when the temperature was 16° C or above.

CONCLUSIONS

The study described here revealed some aspects of stag beetle dispersal and behaviour. Additionally, it showed that the mark-release-recapture method used has the potential to be developed for making a population estimate of the species at a stag beetle emergence site, such as a residential garden. The Pentel Microcorrect needlepoint corrector was effective and enabled quick-drying identification marks to be placed accurately on the ventral surface of the beetles. It also enabled the flow of the correcting fluid and subsequent shape and size of the marks to be readily controlled. A 4-spot code method of marking allowed quick, reliable, individual identification of over 70% of recaptured marked beetles. It should be noted, however, that correction fluid marking might may not be suitable for use on long-lived adult insects, such as carabids.

The investigation, which was deliberately labour intensive and used several methods to collect beetles, achieved its aims of high capture and recapture rates. A less labour intensive study and/or one that relied on single method of collecting is likely to have resulted in the capture and recapture of fewer beetles.

Air temperature also influenced the number of captures and recaptures. Temperatures of 15° C and below reduced the number of beetles observed and collected. The peak period for stag beetle activity and the highest capture and recapture numbers occurred from 04.VI to 17.VI.2006. The highest number of beetles, 15 captures and 8 recaptures, occurred on the 12.VI.2006 when the temperature at 21h00 was 21.7 °C.

Observations and analysis of capture and recapture data seem to indicate that stag beetle dispersal is limited, especially in the case of female beetles and when there is a plentiful supply of suitable dead, decaying wood close to the site of their emergence. If the majority of female beetles present at other locations show a similar limited dispersal, then this behaviour needs to be taken into account when planning for the conservation of this species. It is suggested that such effort should be focused on using suitable dead wood, in the form of logs or log piles, to continually replenish decaying wood at known stag beetle emergence sites.

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