© 2015 Universities Federation for Animal Welfare
The Old School, Brewhouse Hill, Wheathampstead,
Hertfordshire AL4 8AN, UK
www.ufaw.org.uk

Animal Welfare 2015, 24: 1-14
ISSN 0962-7286
doi: 10.7120/09627286.24.1.001

Potential welfare impacts of kill-trapping European moles (Talpa europaea) using scissor traps and Duffus traps: a post mortem examination study

SE Baker*†, RF Shaw†‡, RPD Atkinson§, P West# and DW Macdonald†

† Wildlife Conservation Research Unit, Department of Zoology, University of Oxford, Recanati-Kaplan Centre, Tubney House, Abingdon Road, Tubney, Abingdon, Oxfordshire OX13 5QL, UK
‡ Environment and Sustainability Institute, University of Exeter, Penryn Campus, Penryn, Cornwall TR10 9FE, UK
§ Wallmeadow, Cradley, Malvern, Worcestershire WR13 5LU, UK
# Oxford University Biomedical Services, The Old Observatory, South Parks Road, Oxford, Oxfordshire OX1 3RQ, UK
* Contact for correspondence and requests for reprints: sandra.baker@zoo.ox.ac.uk

Abstract

Moles are widely trapped as pests on farms and amenity land in Britain. Spring traps for killing mammals generally require welfare approval in the UK, but mole traps are exempt. Previous research demonstrated wide variation in the mechanical performance of mole traps. In this context, we aimed to produce new data on the welfare impact of kill-trapping moles in the field. We collected 50 moles trapped in southern England (November 2008–August 2009). Captures peaked during the peak in male breeding activity, when captures were almost exclusively male. Post mortem and x-ray (radiation) examinations were conducted to determine injuries and likely cause of death. No moles sustained damaged skulls or upper cervical vertebrae (which could cause unconsciousness immediately). The primary identifiable cause of death for all but one mole was acute haemorrhage; this contrasts with the findings of the only previous such study, in which only one mole showed clear evidence of haemorrhaging. Some moles may have asphyxiated although it was not possible to determine this. Moles most likely became unconscious before death, but times to unconsciousness, and death, can be determined only through killing trials and further investigation is urgently needed. This should be done through the spring traps approval process; this could improve the welfare standards of trapping for many thousands of moles each year. Mole trapping for long-term population control might be better targeted after the peak in male breeding activity, when females are more likely to be caught, but this would threaten the welfare of dependent young underground.

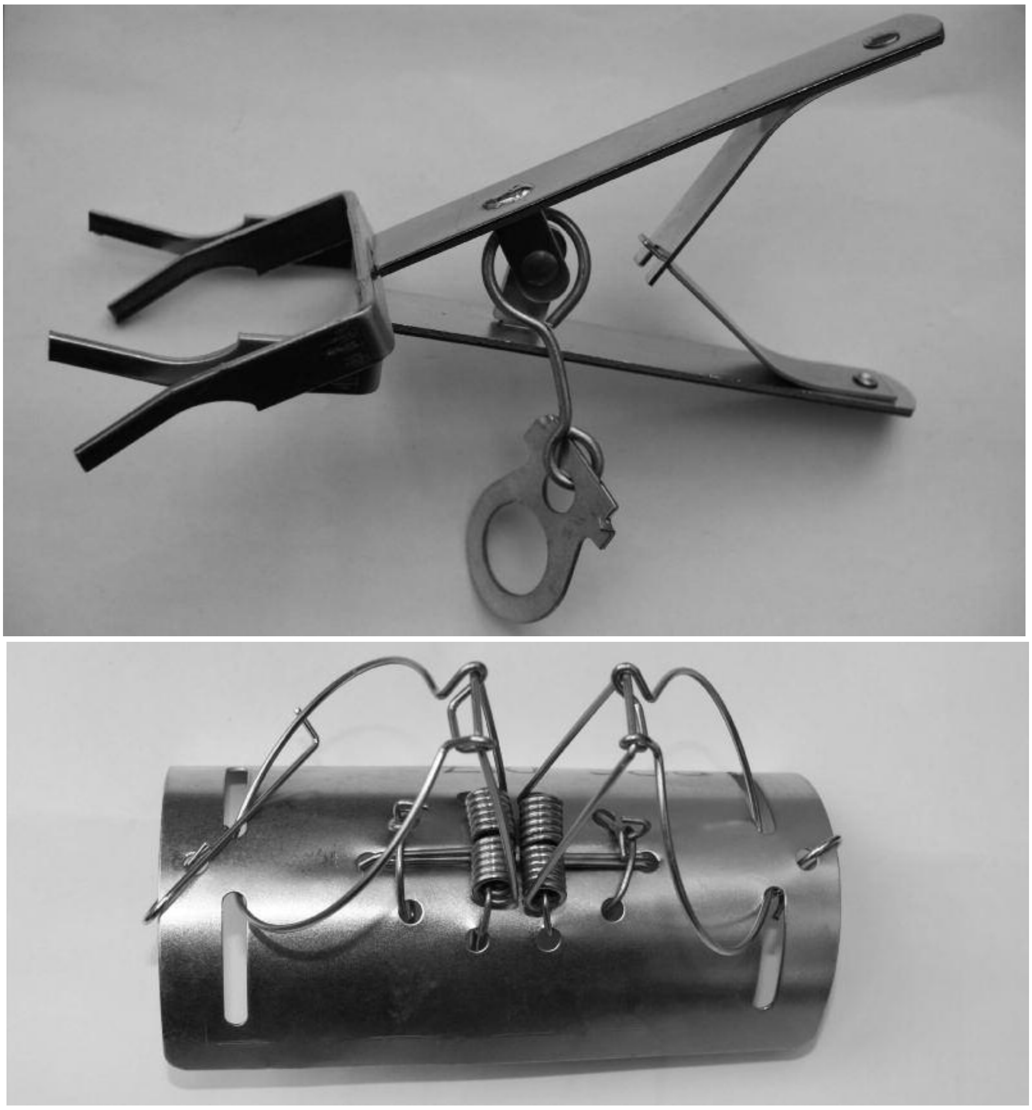
Keywords: *animal welfare, European mole, sex bias, spring trap, trap, wildlife management*

Introduction

European moles (*Talpa europaea*) are widely perceived as pests throughout Britain and mainland Europe (Quy & Poole 2004). Moles are absent from the whole of Ireland, but in Britain they are reported as pests by the majority of farmers, and managers of amenities, such as racecourses, golf courses, parks and ornamental gardens (Atkinson *et al* 1994; Sandra Baker, unpublished data 2007). Perceived problems caused by moles relate to the underground feeding tunnel systems and associated spoil heaps ('molehills') that they produce. Problems include coverage of grass or pasture with soil and subsequent weed invasion, damage to silage production (by contamination of silage with soil bacteria), machinery, plants and drainage systems, and injury or risk of injury to people and animals where tunnels collapse (Mellanby 1971; Atkinson *et al* 1994; Quy & Poole 2004). In 1992, strychnine poison was the most popular method of mole control among British farmers (Atkinson *et al* 1994), but strychnine was withdrawn from use for this purpose in September 2006. In 2007, British farmers and amenity managers reported kill-trapping as their most often used method of mole control. Kill-trapping was the method most widely considered humane by farmers and second most widely (after live-trapping) by amenity managers (Sandra Baker, unpublished data 2007). Where mole control can be justified, trapping (eg using scissor or Duffus [also known as half-barrel] traps) and phosphine gassing are the main mole control methods suggested by Natural England (2011): they recommend that, if moles are live trapped, they are humanely despatched, rather than released elsewhere, for welfare reasons.

Mole-catching is something of a tradition in Britain. Moles have long been trapped as pests and once attracted a bounty for their pelts (Mellanby 1971; Nicholls 2010). They have been trapped using a variety of devices since at least Roman times, but purpose-made metal spring traps first became available in the 19th century (Nicholls 2010). The two main types of mole spring trap used in Britain today are scissor (pincer) traps and Duffus (half-barrel) traps (Natural England 2011) (see Figures 1[a] and [b]). Both are designed to catch moles around the body when a trigger plate or wire

Figure 1



Spring traps for killing moles showing scissor (pincer) trap (upper) and Duffus (or half-barrel) trap (lower). Photographs courtesy of S Baker.

is pushed, releasing the killing mechanism, which according to Gorman and Stone (1990) kills the mole by crushing and they are widely accepted by mole trappers to be humane. These two types of trap offer different advantages in terms of ease of setting and monitoring, visibility above ground, and suitability for use in different situations (Nicholls 2010). Moles are widely trapped in Britain, Denmark and France, and less widely so in The Netherlands and Germany (Quy & Poole 2004). In their review of mole control methods in Europe, Quy and Poole (2004) concluded that while the deployment of traps is labour-intensive, trapping may be one of the most effective methods of controlling moles when conducted by an experienced operator in small-scale applications. Other advantages of trapping are that it can be targeted where damage arises and it is relatively safe for non-target wildlife, users and other people.

Under the 1954 UK Pests Act, spring traps require welfare approval. New trap types are expected to undergo killing tests as part of this process. In England and Wales, traps need to render the target animal irreversibly unconsciousness within 5 min in ≥ 80% of 12 tests (Department for Food, Environment and Rural Affairs [Defra], personal communication 2012; Welsh Environment and Agriculture Team, personal communication 2012). These criteria are based on the Agreement on International Humane Trapping Standards (AIHTS) (http://ec.europa.eu/world/agreements/prepareCreateTreatiesWorkspace/treatiesGeneralData.do?step=0&redirect=true&treatyId=625). However, in their report (which preceded the Pests Act), the Committee on Cruelty to Wild Animals stated that regarding moles they had:

> ...no evidence that trapping causes unnecessary suffering, except that one organisation mentioned that they had been given to understand that the spring of the ordinary type of mole-trap was too weak to kill instantaneously.

It is not clear which type of trap, or which organisation, they referred to, but the Committee anyway concluded that they did:

https://doi.org/10.7120/09627286.24.1.001 Published online by Cambridge University Press

> ...not think it necessary to make any special recommendations about the practices involving moles (Scott Henderson 1951).

Consequently, mole traps were made exempt from the UK spring traps approval process through the Small Ground Vermin Traps Order 1958, and they remain exempt today. However, previous research has questioned the humaneness of mole spring traps available in the UK (Rudge 1963; Atkinson *et al* 1994; Baker *et al* 2012) and mole traps are banned in some US states (eg Washington and Massachusetts) on welfare grounds.

The proposals contained in the Agreement on International Humane Trapping Standards (AIHTS), between the European Community, Canada and the Russian Federation (http://ec.europa.eu/world/agreements/prepareCreateTreatiesWorkspace/treatiesGeneralData.do?step=0&redirect=true&treatyId=625)), do not currently apply to mole traps. However, in 2004, the European Commission proposed an EU trapping Directive, which would set new standards for the approval and use of traps for wildlife management in Europe, and potentially alter which species were covered. A report, released by the EU in 2011, examining options for such a Directive, concluded that EU trapping legislation should cover all trapped species (Talling & Inglis 2009). However, the European Commission has since withdrawn its 2004 proposal for a trapping Directive. Therefore, the need remains to examine the case for including mole traps in the UK approvals process. This may be something the Law Commission will consider in its reform of UK Wildlife Law (commenced 2011 and still underway in July 2014; http://lawcommission.justice.gov.uk/areas/wildlife.htm).

Since mole traps have always been exempt from approval requirements in the UK, no mole trap data are available from the formal killing trials sometimes conducted as part of the approval process (eg by the Animal Health and Veterinary Laboratories Agency [AHVLA]). However, Baker *et al* (2012) demonstrated wide variation in the clamping force and impact momentum produced by mole spring traps of different types (scissor, Duffus and talpa [a newer design, resembling a wider scissor trap, with a different, stronger type of spring]), and among mole traps of the same type, produced by different manufacturers. Testing spring traps with killing trials under captive conditions, and measuring time to irreversible unconsciousness, is a crucial step in determining trap welfare impacts. However, it is also important to test the trapping system as deployed in the field (Broom 1999). For example, Barrett *et al* (1989) found that free-ranging wild American marten (*Martes americana*) were less well positioned in C120 Magnum traps and less likely to experience double strikes (affecting both head and thorax) than wild-caught animals in captive trials. Such differences could have important implications for animal welfare impacts. Previous post mortem examination studies on moles kill-trapped in the field have been inconclusive and based on limited sample sizes, eg Atkinson *et al* (1994), or reported few details, eg Rudge (1963), but both described animals being captured by a variety of body parts including forelimbs and skin.

We aimed to assess the potential welfare implications of mole trapping, as carried out by trappers in the field. First, we examined seasonal patterns in the sex of moles caught and any relationships between trap type and the body-weight and sex of mole caught. Then, we determined injuries and primary identifiable cause of death (from here 'cause of death') using information from post mortem examinations and x-ray images (radiographs). Ultimately, we examined relationships between trap type, mole sex, capture point (on the mole) and cause of death. Our main goal was to produce new data, on the welfare impact of kill-trapping in the field, which might inform decisions on the inclusion of mole traps in the welfare approval system established under the 1954 Pests Act.

Materials and methods

Carcase sourcing

We aimed to source mole carcases trapped by a range of trappers using scissor or Duffus traps. During autumn/winter 2008/2009, we contacted 15 professional pest controllers, 24 golf courses, 15 ornamental parks or gardens, and 180 farmers, in an effort to identify people planning to trap moles in the subsequent few months, and prepared to supply carcases for the study. We telephoned potential participants in southern England (Oxfordshire, Buckinghamshire, Berkshire, Warwickshire and Northamptonshire), briefly explained the background and purpose of the study, and asked the following questions: whether they trapped moles, and if so, which kind of traps they used and when they planned to trap moles in the coming season. Twenty-eight potential candidates agreed to take part, those declining either having no moles (24% of farmers), not routinely trapping their moles (43% for farmers), only carrying out sporadic control of any kind (13% of farmers), or not wishing to take part (7% of farmers). One pest controller contacted expressed concern that the study would be used by animal welfare organisations. We planned to collect a balanced number of moles from each source, to minimise the possible effects of any variation between trappers, but contributions were fewer than expected and so we accepted all moles available.

Ideally, we would have accompanied trappers during trap-checking but this proved impractical as they visited traps at unpredictable times and, in general, trapping success rates were low. Participants were asked to retain all trapped moles for the study and to contact us when they had a carcase for collection. They were asked not to freeze carcases unless absolutely necessary and to keep individual carcases separately and to record capture information at the individual level.

Carcase collection and mole controller interviews

Where possible, trapped moles were photographed and examined at the capture site, while still in traps, and after removal from traps, for corroboration of pathological investigation. Carcases were individually labelled and bagged, and handled with care to avoid them becoming damaged.

Table 1 Number of trappers using traps of each type and number of moles caught in traps of each type between November 2008 and March 2009 and between April and August 2009.

		Trappers (n)	Moles (n)
November–March	Duffus	5	24
	Scissor	4	5
April–August	Duffus	1	2
	Scissor	3	19

Mole controllers were asked questions relating to each capture, including the type of trap used, and the condition of the mole when found. We explained to participants that all data collected would be treated confidentially, and asked them to sign a form providing their consent for using their data in the study; their involvement was approved by the University of Oxford's ethical review process.

Post mortem and x-ray examinations

Carcases were collected fresh and subjected to complete necropsy and x-ray examination within three days of capture wherever possible. Pathologists examined each carcase externally, and then dissected and examined it internally, for evidence of disease and trauma. A standard post mortem examination report was produced for each carcase. Capture point, primary cause of death and mole sex were categorised and bodyweight recorded. Digital laboratory photographs were taken during the examination. After post mortem examination, carcases were frozen and x-rayed (ventro-dorsally and laterally), three moles per plate (24 × 30 cm), using a Hunter X-Ograph veterinary x-ray set (Xograph Healthcare, UK), at 40 kV and 20 mAs (50 mA × 0.4 s) exposure, and digital x-rays were produced.

Statistical analysis

Interview data, post mortem examination results and anonymised site details were stored in separate tables in an Access database (Microsoft Office 2003). Data were extracted for manipulation and analysis using SAS software (SAS/STAT 2002-8). We used χ^2 to test the effect of trap type on the sex of mole caught, and a general linear model to examine the relationship between mole bodyweight, mole sex and trap type. Scrutiny of the appropriate plots showed no evidence for problems with non-normality or heterogeneity of variance. We used Fisher's Exact test to examine seasonal patterns in the sex ratio of moles trapped. We conducted χ^2 tests (and, where sample sizes were small, Fisher's Exact tests) to examine relationships between categorical variables including trap type, mole sex, capture point, and cause of death. There were insufficient data to analyse three-way interactions among categorical variables prior to conducting χ^2 tests.

Results

Carcases collected

Between 27th November 2008 and 10th August 2009 50 mole carcases were collected from 13 sources (Table 1), including seven amenity managers, five farmers and one professional pest controller. Each provided between one and eleven trapped carcases (mean [± SEM]: 3.9 [± 0.8]). Nearly equal numbers of moles were caught in each type of trap (26 in Duffus traps, 24 in scissor traps). Trappers used either scissor (n = 7 trappers) or Duffus traps (n = 6 trappers), but not both, so we were unable to examine any potential interaction between trap type and controller (and hence source site). Moles supplied by the same controllers may conceivably have been caught with the same individual trap, so these carcases may not be entirely independent. Of the 50 trapped moles available for analysis, 42 were dead on discovery in the trap, one (caught in a scissor trap) was alive, and we do not know whether the other seven were dead or alive when found. The mean (± SEM) time that traps catching moles had been checked after being set was 32.2 (± 2.4) h (range 5–67 h) and the trap in which the live mole was found had been checked after 24 h.

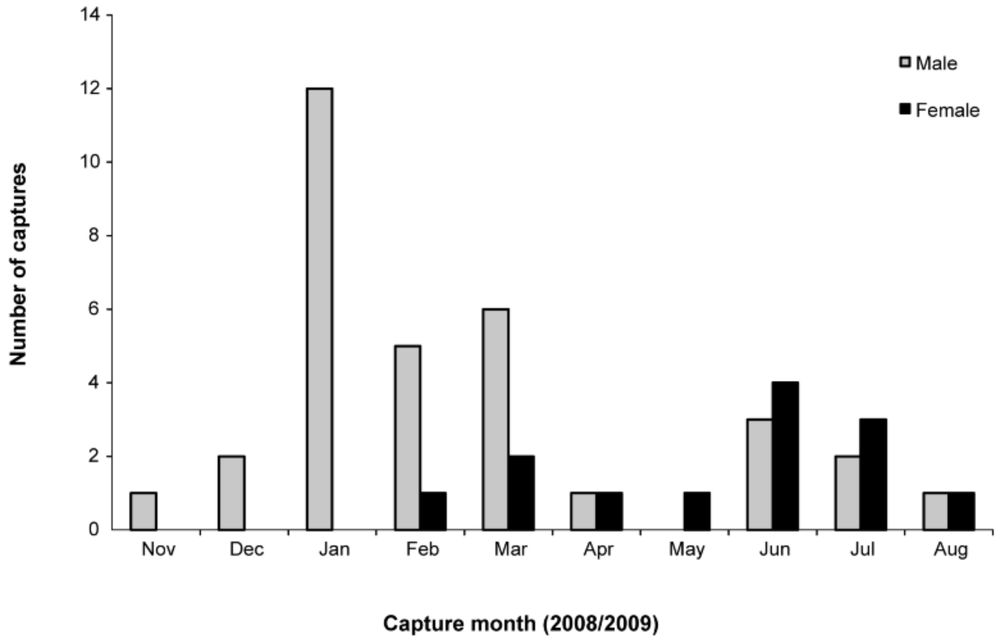
The majority of carcases (48/50) were collected and examined fresh, but two (both scissor trap captures) had been frozen by controllers before collection (they were caught over the Christmas period when the laboratory was closed). Most carcases were assessed as being in good condition for necropsy prior to post mortem examination (47/50), two (scissor trap captures) as being in fair condition and no condition was recorded for the remaining carcase (a scissor trap capture). Based on palpation and visual inspection, all moles were judged to have either a full (n = 49) or a moderately full (n = 1) gastrointestinal tract (stomach to rectum).

Seasonal patterns in sex ratio

Trapped moles included 33 males and 13 females, a sex ratio of 2.5:1 (Figure 2), and four animals for which sex was not recorded. These four were not included in the following sex and bodyweight analyses. All females and all but one male were considered to be adults, on the grounds that their reproductive organs were fully developed. The age of the other male could not be established but its bodyweight lay within the range of the other males. One female, trapped on 12/13th March, was pregnant with three young. The sex of moles caught differed over the months of the study (November 2008–August 2009) (Fisher's Exact: $P = 0.022$, n = 46). Almost all moles caught during winter and early spring were males, while from April onwards males and females were approximately equally likely to be caught (Figure 2). This had the overall effect that males tended to be caught during winter and early spring, and females later on.

https://doi.org/10.7120/09627286.24.1.001 Published online by Cambridge University Press

Figure 2



Number of male and female moles caught during each month of the study (male; n = 33, female; n = 13).

Trap type and mole bodyweight and sex

Trap type did not affect whether heavier or lighter moles were caught ($F_{1,42}$ = 0.29, P = 0.60) and there was no evidence that the effect of trap type on bodyweight differed between the sexes ($F_{1,42}$ = 0.04, P = 0.84). Sex, trap type and month of capture were confounded to some extent, but this did not affect the conclusions based on the general linear model on trap type, mole sex and mole bodyweight, because results were sufficiently clear anyway. Sex ratio differed significantly between trap types, with a higher proportion of males caught using Duffus (88%) than scissor traps (50%) (χ^2 = 8.25, P = 0.004, df = 1, n = 46). Most moles caught between November and March were caught in Duffus traps, and were male, while most caught between April and August were in scissor traps, with no particular sex bias between trap types (see Table 2). These results arose because individual trappers used either Duffus or scissor traps (but not both) and contributed carcases at different times of the year, eg trappers 1–9 provided carcases exclusively between November 2008 and March 2009 (n = 29) and trappers 10–13 supplied them between April and August 2009 (n = 21) (Fisher's Exact: P < 0.001, n = 50) (see Table 1). However we do not know how many traps any trapper used.

Capture point

Moles were caught at one of the following points on their body: shoulder (shoulder blades 4%), thorax (rib-cage behind shoulder blades 24%), thorax-abdomen (junction between thorax and abdomen 14%), abdomen (soft body between ribs and pelvis 56%) or hips (pelvic bones 2%) (n = 50). Capture point differed marginally significantly between Duffus (n = 29) and scissor traps (n = 21) (Fisher's Exact: P = 0.054). Moles caught in Duffus traps were caught primarily at the abdomen or further forward (Figures 3 and 4), whereas most in scissor traps were caught at the thorax, thorax-abdomen, or abdomen, with small numbers caught at the shoulders and the hip (Figure 4). The mole found alive in a scissor trap was caught at the thorax. Capture point did not differ significantly between the sexes (Fisher's Exact: P = 0.579; males; n = 33, females; n = 13).

Table 2 Number of moles of each sex caught in traps of each type between November 2008 and March 2009 and between April and August 2009.

		Male (n)	Female (n)
November–March	Duffus	22	2
	Scissor	4	1
April–August	Duffus	1	1
	Scissor	6	9

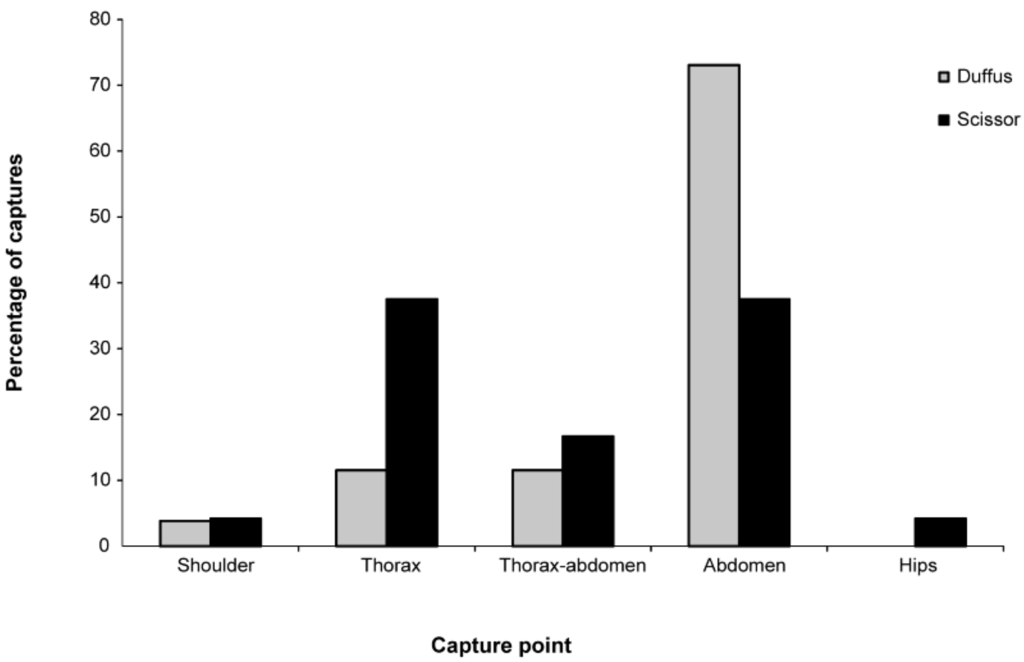
Injuries and primary identifiable cause of death

Visual inspection in the field, and palpation of carcases during post mortem examination, suggested that some had a broken spine at the capture point (eg Figure 5). However, x-rays revealed that none of the 50 trapped moles had any damage to their vertebrae (see Figure 6, which includes the animal shown in Figure 5). One animal that had been captured diagonally around the thorax-abdomen, and had acute haemorrhage in both those areas, also sustained nine fractured ribs in the thoracic region (T5–11 on the left and T4–5 on the right).

Figure 3

Trapped carcase 12, photographed captured at the abdomen by a Duffus trap.

Figure 4



Capture point by trap type: Duffus, n = 26; scissor, n = 24.

All trapped moles had obvious evidence of crush injuries and most had associated internal haemorrhage. During the post mortem examinations, each trapped carcase was ascribed a primary cause of death; these included acute haemorrhage in the thorax (36.7%), abdomen (14.3%), or both (46.9%), and interruption of venous return to the heart (2%) (n = 49). One carcase was very autolysed with no obvious sign of haemorrhage, and no specific cause of death could be inferred (2%); this was not one of the frozen carcases, both of which showed clear evidence of acute haemorrhage in the abdomen.

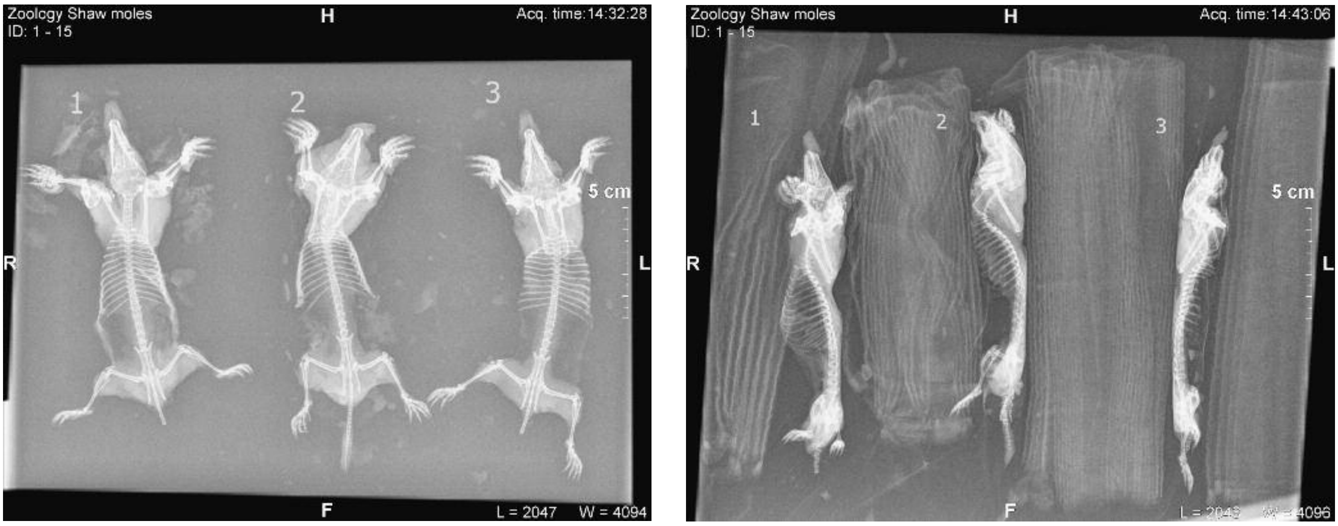
Cause of death varied with both trap type (Fisher's Exact: $P < 0.001$, n = 49) and capture point (Fisher's Exact: $P < 0.001$, n = 49). The majority of moles killed in Duffus traps had acute haemorrhage in the thorax and abdomen or the thorax (Figures 7 and 8). Most caught in scissor traps had acute haemorrhage in the thorax, abdomen, or both

https://doi.org/10.7120/09627286.24.1.001 Published online by Cambridge University Press

Figure 5

Trapped carcase 2, photographed following capture at the thorax by a scissor trap. None of the moles examined had broken vertebrae, despite some (as here) having a bent spine.

Figure 6

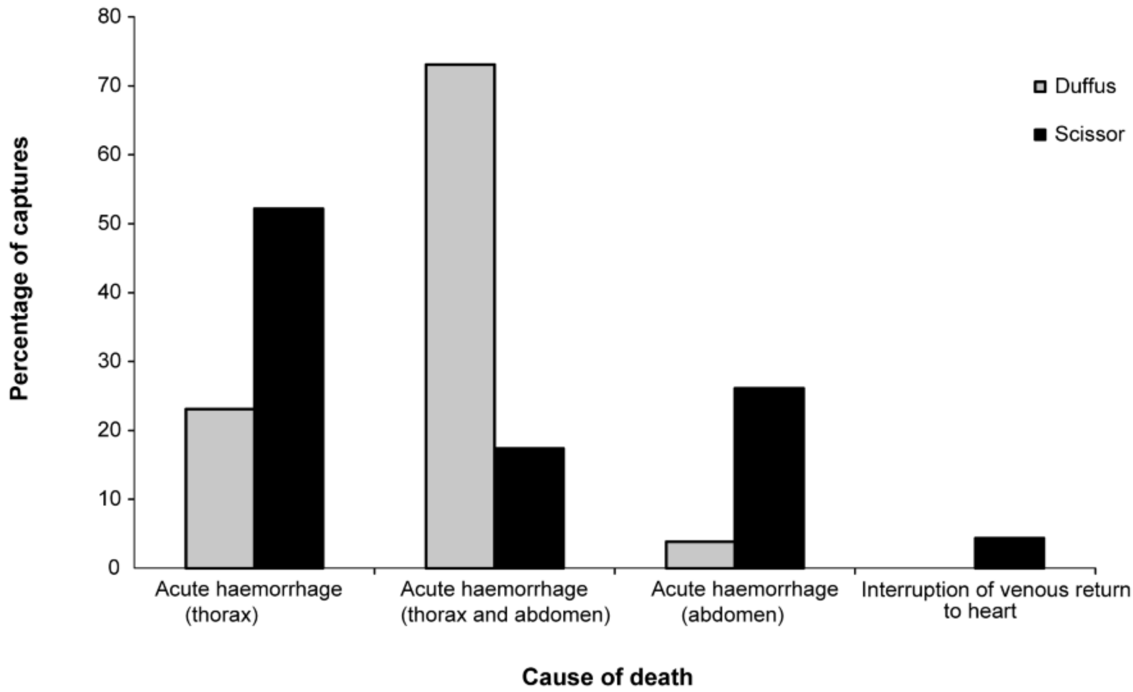


X-ray (radiograph) of trapped carcases 1, 2 and 3 showing ventro-dorsal (left) and lateral (right) views .

(Figure 7). Acute haemorrhage in the thorax was the primary injury observed in the mole found alive in a scissor trap, and it also had an enlarged spleen with lesions but this was a pre-existing condition, not related to trapping.

In general, injury occurred at and/or forward of the capture point. Those caught at the shoulder (n = 2), thorax (n = 11) or hips (n = 1) had acute haemorrhage in the thorax. Those caught at the thorax-abdomen had acute haemorrhage either in the thorax (3/7), or thorax and abdomen (3/7), or they had interruption of venous return to the heart (1/7). Moles caught at the abdomen had acute haemorrhage in the thorax (1/28), abdomen (7/28), or both (20/28). Subsidiary injuries included blood clots on the heart, and haemorrhagic lungs. Other damage included three cases of haemorrhagic testes and/or seminal vesicles (one of these moles also had bruised kidneys) and a fourth where the testes contained a bloody pulp and major organs had been pushed cranially. These damaged testes and seminal vesicles occurred in cases where the primary cause of death was acute haemorrhage in either the abdomen, or both the thorax and abdomen.

Figure 7



Primary identifiable cause of death by trap type (Duffus; n = 26, scissor; n = 23).

Figure 8

Trapped carcase 21 during post mortem examination, showing severe haemorrhaging throughout the thoracic and abdominal cavities as a result of Duffus trapping.

https://doi.org/10.7120/09627286.24.1.001 Published online by Cambridge University Press

Discussion

Our results were extremely consistent, indicating that no trapped moles died immediately as a result of damage to the cranium or vertebral column, with the primary identifiable cause of death in all but one case being acute haemorrhage, and most likely associated haemorrhagic shock. In a minority of cases, asphyxiation may have been the primary cause of death, but this may not be detectable at post mortem (although asphyxiation could potentially be inferred depending on other findings at post mortem; see later in *Injuries and cause of death*). We detected a seasonal sex bias among trapped moles which has consequences for mole management and welfare.

Sex and seasonality

We discovered a sex bias among trapped moles, with 2.5 males caught for every female over the whole period of study (November–August). There was a strong seasonal sex bias, with almost all moles caught between November and March being male, and those caught between April and August being approximately equally likely to be male or female. Because trap type, sex and month of capture were confounded, it could be possible, hypothetically, that (earlier in the study period) females were detecting and avoiding Duffus traps more effectively than males, but this seems highly unlikely. However, while moles are thought to maintain individual territories for most of the year, during the breeding season males leave their normal ranges in search of mating opportunities, and have been known to more than double their territory size at this time. Females do not seem to leave their normal range in this way. During this time males also sleep for short periods in tunnels rather than returning regularly to their nest chambers to sleep (Gorman & Stone 1990). Such changes in behaviour among breeding males are likely to increase their chance of capture at this time. Breeding time among moles depends on geographical location, becoming later with increasing latitude (Gorman & Stone 1990). Male breeding activity and associated molehill activity in southern England are likely to peak between January and March (Godfrey & Crowcroft 1960; Hartman 1995). This corresponds with our observations that more males than females were caught during this period, and that a female in our study was pregnant when trapped in March. The three moles caught in November and December were all male, but this may have occurred by chance, given the small numbers concerned.

In 1960, Godfrey and Crowcroft observed that trapping moles in Suffolk, south-east England, UK, produced an excess of males. They attributed this to greater activity among males, particularly in the breeding season, as well as failure to trap for sufficient time. Hartman (1995) re-analysed Godfrey and Crowcroft's data and demonstrated that they had caught significantly more males than females in each month between January and April, but found no significant sex bias in captures during other months of the year. Our observation closely matched that of Hartman (1995), who attributed his observed seasonal changes in the sex ratio of trapped moles to behavioural changes, related to variation in hormone levels, and suggested that males move more, and females less, during the breeding season.

The timing of mole trapping should depend on the desired outcome. If the aim is to reduce current short-term activity, eg for aesthetic or functional reasons on a golf course, or to reduce molehill production on farm grassland immediately before silage cutting, then trapping can be conducted whenever considered necessary, since active moles (whether male or female) are more likely both to be creating the unwelcome molehills and tunnels, and to be caught. However, if the goal is long-term population reduction, then because reproduction in mammals is generally limited by the number of breeding females, trapping should logically target this group.

Of course, there are welfare implications of trapping while females have dependent young (Lodal 1999), unless (in the highly unlikely event that nests can be found) the young moles are humanely destroyed (see Sharp & Saunders 2005, regarding rabbits), because this would result in young moles being left to die of starvation or hypothermia. It has been suggested that the welfare impact of lethal mole control could be reduced by implementing a close season of 2–3 months during which mole control was banned to protect breeding females and their dependent young (Lodal 1999). However, such a ban could be unpopular given that it would effectively mean an embargo on control at what might be the most effective time of year for long-term population reduction. Furthermore, because the timing of breeding in the European mole varies with latitude (Gorman & Stone 1990; Lodal 1999), it might be difficult to devise and police a suitable system. If a close season was introduced there may be a demand for licensed control during the close season for certain purposes.

In our study, most moles were caught between January and March, and very few in April and May, and overall females tended to be caught in summer after the breeding period (Figure 2). Without information on trapping effort it is difficult to interpret monthly patterns in the number of moles killed, but our data suggest that trappers were not killing moles (or perhaps even targeting them) effectively for long-term population reduction. This is supported partly by data from questionnaire surveys of British farmers and amenity managers who reported that mole activity and control on their land peaked in March/April (Atkinson *et al* 1994; Sandra Baker, unpublished data 2007). In contrast, data from a small sample of householders reveal that reported mole activity and control in domestic gardens peaked in the summer and early autumn (Sandra Baker, unpublished data 2007). These seasonal differences in reported mole activity and control among different stakeholder groups may result from a combination of factors including differences in the visibility of molehills on different enterprise types, and farmers and amenity managers being less busy, and gardeners more interested, at certain times of year. As a consequence, none of these groups might be targeting moles effectively for long-term population management. Instead, their control efforts may be responding to damage as it becomes conspicuous or a nuisance. The apparent focus in this study of trapping efforts during the peak in male breeding activity suggests that trappers were targeting problem animals as they appear, probably to reduce the short-term impacts of tunnelling and molehill production. However, even if the effort is worthwhile, ethical questions remain regarding whether the killing of primarily male moles during the breeding period is justified (eg see Warburton & Norton 2009).

Capture and capture point

Of the 50 trapped moles available for analysis in this study, 42 were reported to be dead on discovery in the trap (all 26 Duffus and 16 scissor trap captures), one (caught in a scissor trap) was alive, and we do not know whether the other seven (all scissor trap captures) were dead or alive when found. The majority of captures with both trap types occurred either at the thorax, abdomen or thorax-abdomen (Duffus 96%; scissor 92%), but capture point differed marginally significantly with trap type. Around three-quarters of moles trapped in Duffus traps were caught round the abdomen, while scissor trap captures were more evenly spread between the thorax, thorax-abdomen and abdomen. This variation in the pattern of capture points between trap types could be related to differences in trap features and function. Although Duffus and scissor traps are very different in design, the trigger and the capture components in both types are a similar distance apart (approximately 4 cm) and both might therefore be expected to capture moles at a similar point on their body. However, it may be that the different mechanisms influence capture point differently, eg Duffus traps feature a smooth garrotting wire, rather than opposing jaws, so when the trap is sprung, the wire — if striking the thorax of a mole — may tend to slip towards the softer/narrower abdomen. Also, Baker *et al* (2012) demonstrated that different spring types and trap designs can influence the impact momentum and clamping force produced by break-back traps for rats or mice. Duffus traps tend to have a standard spiral spring while scissor traps generally have a leaf-style spring (and both types may vary in quality among manufacturers), and it may be that any consequent differences in impact momentum or clamping force (Baker *et al* 2012) influenced the capture point in this study.

Of the 22 mole carcases examined by Atkinson *et al* (1994), the two caught in Duffus traps had, like most of our Duffus trap captures, been caught at the abdomen, while the majority caught in scissor traps (17/20) had been captured around the shoulders (this may equate at least partially to 'thorax' in our study), and one each was caught at the abdomen, the hip and the skin of the flank. All moles in that study were found dead on inspection 24 h after setting the traps. In Rudge's (1963) kill-trapping study, 26 moles were caught in Duffus traps and 32 in scissor traps, and it is implied that Duffus trap capture points were limited to forelimbs, thorax and abdomen, and scissor trap capture points to thorax and abdomen. Given that Rudge (1963) and Atkinson *et al* (1994), respectively, reported six of 60 trapped moles caught by forelimbs, and one of 22 caught by the skin of its flank, we might have expected at least some of our 50 to have been caught by an extremity. While we asked trappers to supply us with all moles trapped during the study period, it is possible that they did not, potentially omitting carcases that had not been trapped cleanly.

Injuries and cause of death

A spring trap can directly kill a target animal in three main ways (Parrott *et al* 2009). Ideally, it will strike the correct anatomical location with enough impact momentum to cause cranial or upper vertebrae fracturing, rendering the animal immediately insensible before death. Alternatively, the clamping force of the trap may cause death in one of two ways. If the striking bar falls across the neck it can cause occlusion of blood vessels supplying the brain. If it falls across the body, thoracic compression can cause hypoxia as a result of asphyxiation. There is evidence from a number of animal species of a synergistic relationship between impact momentum and clamping force in causing death (Warburton & Hall 1995 and Benn *et al* 1980, cited therein). The impact momentum generated by a trap will also cause physical damage, eg to the nervous system, blood vessels and organs. Parrott *et al* (2009) summarise some of the other impacts that can occur when an animal is wounded but not killed immediately by a trap. For example, haemorrhaging and swelling may occur. These result in pain through the accumulation of pressure or restricted venous return, where pain-provoking substances cannot be eliminated from the damaged area. If an animal is caught by an extremity, it experiences pain instantly, followed by passing numbness and increasing aching resulting from occlusion or injury of major blood vessels and nerve depression (Gregory 2004). Deep tissue trauma, eg bone fracture, is generally accompanied either by immediate pain or by numbness and then pain. Trapped animals are also likely to experience fear and possibly cardiogenic shock (due to heart failure) and haemorrhagic shock (Gregory 2004). Being trapped but not killed can cause severe distress (Parrott *et al* 2009).

Spring traps that crush the skull are considered to be the most efficient and humane (Proulx & Barrett 1991; Mason & Littin 2003). No moles in our study had damage to the cranium or vertebrae, or any other skeletal damage, apart from one animal that sustained broken ribs. In no cases had the striking bar landed across the mole's neck. No carcases presented by trappers had been caught by extremities. One mole in our study experienced interruption of venous return to the heart. The primary identifiable cause of death in the remaining 48 (98%) of those 49 moles that could be assessed was acute haemorrhage in the thorax, abdomen, or both. No cause of death could be inferred in the remaining (autolysed) carcase.

Haemorrhaging occurs when blood vessels are ruptured; because the circulation is a pressurised system, blood vessels are easily damaged. Which vessels are damaged in trapped moles will depend on the point of capture, but they would tend to be major internal vessels such as splenic vessels or vena cavae (arteries have thicker walls than veins and are generally stronger, while the aorta in particular is well protected by the muscles of the back). Acute haemorrhage in

https://doi.org/10.7120/09627286.24.1.001 Published online by Cambridge University Press

the moles examined most likely led to acute haemorrhagic shock (Gutierrez *et al* 2004), a severe clinical condition in which a sharp drop in blood pressure occurs following traumatic and haemorrhagic bleeding. Because of reduced O_2 supply, ischaemia (local anaemia) may occur in vital organs and irreversible change or death may result (Xu *et al* 2011). Haemorrhagic shock affects the central nervous, cardiac, and renal systems (Falk *et al* 1992) and symptoms will depend on the volume and rate of blood loss (Smith 1997). In humans, severe haemorrhagic shock involves rapid blood loss, increased heart rate, a profound drop in blood pressure, delayed capillary refill, tachypnoea (rapid breathing) and respiratory collapse, anuria (no urine output) and the patient is lethargic and obtunded (dulled reflexes) (Martel *et al* 2002).

A possible alternative cause of death for those moles trapped at the shoulder, thorax, or thorax-abdomen (42%, n = 50) was asphyxia, but this would be difficult to identify grossly at post mortem examination unless there was an obstruction of the airway. However, if asphyxiation had been a major factor we may have found more evidence of this, eg more animals with fractured ribs, damage to the trachea or larynx, haemorrhage in the respiratory tract etc. Asphyxia could occur if there was mechanical interference either with lung function (through damage or constriction by a trap), or with movement of air through the trachea, causing reduced oxygen levels (hypoxia), anoxia in the brain and then unconsciousness (Talling & Inglis 2009). It is also possible, but probably less likely, that some moles captured at the abdomen may have asphyxiated, given that in one mole the internal organs had been pushed cranially. If some moles did die primarily of asphyxiation, then the acute haemorrhaging identified in these particular animals could have been a secondary feature of crushing by the trap.

The welfare impact of a trap depends on the time from the beginning of the killing process to the point where irreversible unconsciousness occurs. Ideally, in welfare terms, a trapped animal would die without experiencing any pain or suffering, because it either dies, or becomes irreversibly unconscious, immediately (Talling & Inglis 2009). To render an animal unconscious, a trap needs to cause brain malfunction; this may be achieved by direct physical destruction of the brain, cervical dislocation, a significant decrease in blood supply to the brain (including by cardiac arrest, haemorrhage and haemorrhagic shock or constriction of blood vessels supplying the brain) or by sufficient interference with the respiratory system (Talling & Inglis 2009). In England, the approval of those new spring traps that are not exempt from approval is usually based on killing tests on free-moving animals in captivity, and a trap is recommended for approval if at least 80% of 12 tests result in irreversible unconsciousness within 5 min (Defra, personal communication 2012; Welsh Environment and Agriculture Team, personal communication 2012). In their 2009 report to the EU, the Food and Environment Research Agency (FERA) suggested that a tiered system, including additional, shorter thresholds of 3 min and 30 s, would encourage the improvement of spring traps (Talling & Inglis 2009). The time to irreversible unconsciousness from initial strike is determined by loss of palpebral and corneal reflexes as described by the ISO (International Organization for Standardization) trap-testing standards (ISO 1999). There is extensive literature, particularly from Canada and New Zealand, on trap-welfare testing. See, for example, papers by Gilbert Proulx (Proulx *et al* 1994, 1995) and Bruce Warburton (Warburton & Hall 1995; Warburton *et al* 2008).

Neither time to death nor time to unconsciousness may be determined for moles in this study, on the grounds either that they: i) died as a result of acute haemorrhaging, because both times would depend on the quantity and rate of blood loss (eg, see Gregory 2004); or ii) that they died of asphyxiation, because both times would depend on the extent of obstruction or constriction (Talling & Inglis 2009), and none of these were known. Baker *et al* (2012) demonstrated differences in mechanical (and potentially welfare) performance both between Duffus and scissor traps, and among different brands of the same type of trap. This may have been related to differences among trap features (eg spring strength or type, the location of triggers and capture components, the sensitivity of triggers) or the quality of components. Therefore, it is possible that moles in this study, that died of the same broad primary cause (eg haemorrhage or asphyxiation), may have taken different times to become unconscious or to die, but this would not be detectable or measurable through post mortem examination. Also, differences in the impact momentum or clamping force produced by traps may have affected whether moles died of haemorrhage or asphyxiation. In their report, Talling and Inglis (2009) said that a trap that prevents the supply of blood to the brain is thought to cause unconsciousness more quickly than one that kills by asphyxiation. However, whether or not a mole with acute haemorrhaging would become unconscious more quickly than one that is asphyxiated is a matter of degree. If the blood or oxygen supply to the brain was cut off completely the mole would die very quickly. If blood pressure was reduced or the level of oxygen in the blood changed then the time to unconsciousness and death would be very unpredictable. Experience of death among moles in this study is likely to have fallen somewhere on a spectrum between two extremes of acute haemorrhaging: i) where a major blood vessel is severed the animal might lose consciousness, and die, very quickly, through exsanguination and haemorrhagic shock; and ii) where a minor blood vessel is severed the animal could take longer to die, but would nevertheless most likely become unconscious before death occurred. If the moles died of acute haemorrhaging, they are unlikely to have bled to death over several hours because, if bleeding was that slow, clotting mechanisms would have come into play and the moles would have been found to have died of other causes, such as dehydration or starvation. If some of the moles asphyxiated, their experiences could vary between extremes of complete obstruction of the airways and a slight compression of the ribcage reducing the amount of oxygen entering the bloodstream.

All trapped moles had either full or moderately full gastrointestinal tracts at post mortem examination. Gorman and Stone (1990) reported that moles need to fill their stomachs three times in a 24-h period. Mellanby (1971) fed moles on earthworms containing barium and used x-ray examination to demonstrate that food can pass through a mole's gut, from ingestion to defaecation, in the space of 3.5 h. Superficially, this might seem to suggest that full gastrointestinal tracts at death indicate that moles died relatively quickly, before any food (ingested prior to trapping) could be processed and expelled as faeces. However, ilieus (decreased gut transit) can occur following traumatic injury and haemorrhagic shock (Moore-Olufemi *et al* 2005), and so it is unlikely that anything can be inferred, from the presence of food in the stomachs of trapped moles, regarding the time to death.

Our findings regarding cause of death contrast with those of Atkinson *et al*'s study (1994), in which only one of 13 moles examined, post mortem, was certain to have experienced internal haemorrhage; this animal had been caught at the shoulder in a scissor trap. However, in common with our study, Atkinson *et al*'s x-rays (1994) showed no evidence of broken skulls, vertebrae, or other bones (except one animal that sustained broken ribs in our study), and the authors suggested that the muscles and bones of the shoulder region may have protected the trachea, nerves and blood vessels underneath from damage by the trap. Atkinson *et al* (1994) concluded that their trapped moles may have gone into shock, as a result of pressure applied by the trap, and then became unconscious and died of circulatory failure or asphyxia, or that they may not have gone into shock, instead starving or asphyxiating while conscious; their study was inconclusive as a result. While our moles also did not have any broken skulls or vertebrae, some carcases had experienced sufficient soft tissue damage around the capture point that their spine appeared broken both upon initial external visual inspection and during post mortem examination. It is possible that the spinal cord may have been damaged in such circumstances, despite the intact vertebrae. However, spinal cord damage is unlikely to cause unconsciousness in a short time-frame. For an animal to die from such an injury, the brainstem would have to be involved, eg as would occur through cervical dislocation or a direct, severe blow to the cranium.

It is impossible to determine the reason for the difference between the outcomes of Atkinson *et al*'s (1994) study and ours. However, one potential explanation is that Atkinson *et al* (1994) stored all thirteen of their carcases in a freezer, before post mortem examination, whereas only two of our fifty carcases had been frozen. While both studies detected haemorrhage in carcases that had been frozen (1/13 of Atkinson *et al*'s [1994] and both of ours), freezing and defrosting carcases before post mortem examination is not recommended because soft tissues are damaged in the process. This, combined with autolysis (where cells are destroyed by the action of their own enzymes) makes the interpretation of any findings and histopathology less reliable than when fresh carcases are used, increasing the likelihood of missing any evidence of haemorrhaging (Nicholls *et al* 2008). A second possible explanation for the discrepancy may lie with trap quality. While information regarding trap brands was not available in either study, it is possible that traps of different quality were used in the two studies and that these produced different welfare impacts. This is quite conceivable given that the studies occurred more than 15 years apart and that traps of widely varying price and quality are available on the market now (Baker *et al* 2012). Baker *et al* (2012) demonstrated wide variation in mechanical trap performance among different, currently available, mole trap brands among both Duffus and scissor traps. They suggested that different brands of mole trap could produce different welfare impacts as a result. Lodal (1999) made the point that the quality of mole traps available then may have varied between brands, so it is likely that the quality of some traps available today will vary from that of some available in the 1990s. A third potential factor is that the suppliers of carcases for this study may have withheld some moles that they thought had not been trapped humanely, eg those caught by extremities, whereas all the moles caught in Atkinson *et al*'s (1994) study were trapped by the authors themselves and delivered for post mortem examination. In this regard and in contrast, our study may be skewed towards 'cleaner' kills. In support of this, we note that both Rudge (1963) and Atkinson *et al* (1994) reported moles caught by extremities (see also Gorman & Stone 1990), whereas none of the fifty moles presented for our study were reported to have been caught by extremities.

There are no data to relate mechanical performance of mole traps with welfare impact. Also, other trap-testing studies have revealed that acceptable thresholds for impact momentum or clamping force are not directly related to target species' bodyweight and that these thresholds tend to vary between strike locations within species (Zelin *et al* 1983; Warburton & Hall 1995). Therefore, the actual welfare impact of mole spring traps cannot be extrapolated from other trapped species and may be determined only by killing trials on moles to assess time to irreversible unconsciousness, as in the spring traps approval process (Baker *et al* 2012). We believe that mole traps should no longer be exempt from approval for this reason. Of course, it may be that all currently available mole traps would meet the UK's current welfare standards, but this needs to be tested, as illustrated by the case of the Fenn trap, which was long-accepted in New Zealand for controlling stoats (*Mustela erminea*), but which dramatically failed the country's new approval standards (Warburton *et al* 2008).

Animal welfare implications and conclusion

The need for mole control may be questionable in some scenarios (Atkinson *et al* 1994). However, moles are commonly killed in Britain and, in the absence of strychnine, spring traps are likely to remain the favoured method of control. Nevertheless, mole traps have always been exempt from the UK spring traps approval process and, until recently (Baker *et al* 2012), the humaneness of mole traps had rarely been questioned in Britain (Atkinson *et al* 1994).

Our results were extremely consistent, with no moles sustaining broken skulls or upper cervical vertebrae (either of which could cause immediate unconsciousness; Parrott

https://doi.org/10.7120/09627286.24.1.001 Published online by Cambridge University Press

et al 2009), and all but one having evidence of acute haemorrhage. While haemorrhage may have been the primary cause of death for most moles, we cannot rule out the possibility that at least some asphyxiated. Whether they died of haemorrhage or asphyxiation, moles most likely became unconscious before they died, but neither time to unconsciousness, nor time to death, can be determined through post mortem examination. When welfare approval of spring traps was introduced in the UK, mole traps were exempted, on the grounds that they were not thought to cause unnecessary suffering (Scott Henderson 1951). It is probably assumed that mole traps kill quickly by breaking skulls or vertebrae, and this belief may be bolstered by the facts that moles die out of sight, underground, and that some trapped moles appear to have broken spines, when — as we discovered — they do not. Mole traps of varying quality, mechanical performance and potentially welfare performance are widely available in the UK (Baker *et al* 2012) and, while some or all might meet the UK approval criteria, this can only be tested using killing trials and further investigation is urgently needed. This should be done as it is for other species in the UK, through the spring traps approval process, and the exemption of moles under the Small Ground Vermin Traps Order (1958) should therefore be lifted. The Law Commission review of UK wildlife law may be a potential vehicle for this. Alternatively, a new EU Trapping Directive could specify that traps for all species should require welfare approval (Talling & Inglis 2009). This could improve the welfare standards of mole trapping in Britain, potentially impacting many thousands of animals each year.

The introduction of a close season of 2–3 months during the breeding period could improve the welfare of breeding females and their dependent young. However, this would mean an embargo on mole control at what might arguably be the most effective time of year to attempt population reduction. The current focus of trapping efforts during the peak in male mole breeding activity, as observed here, may result in sub-optimal population control.

Acknowledgements

This research was funded by the Royal Society for the Prevention of Cruelty to Animals (RSPCA). SB was supported by the Humane Society International, UK and The Baker Trust during preparation of this manuscript. The work would not have been possible without the generous help of the mole controllers who provided us with carcases and capture information. Members of the Biomedical Services Department at Oxford University were tirelessly helpful and enthusiastic regarding the project and we are extremely grateful for their work; Marc Martin and Edmarcia A de Araujo conducted and interpreted post mortem examinations, and Sarah Wolfensohn provided the resources to undertake the project. Dr Paul Johnson of the Wildlife Conservation Research Unit, Department of Zoology, Oxford, advised on statistics. Colin Booty, previously of the RSPCA, made helpful comments on an earlier version of this paper.

References

Atkinson RPD, Macdonald DW and Johnson PJ 1994 The status of the European mole *Talpa europaea* L as an agricultural pest and its management. *Mammal Review 24*: 73-90. http://dx.doi.org/10.1111/j.1365-2907.1994.tb00136.x

Baker SE, Ellwood SA, Tagarielli VL and Macdonald DW 2012 Mechanical performance of rat, mouse and mole spring traps, and possible implications for welfare performance. *PLoS One 7(6)*: e39334. http://dx.doi.org/10.1371/journal.pone.0039334

Barrett MW, Proulx G, Hobson D, Nelson D and Nolan JW 1989 Field evaluation of the C120 Magnum Trap for marten. *Wildlife Society Bulletin 17(3)*: 299-306

Benn DM, Zelin S, Lee E and Archibald J 1980 The effects of clamping force upon impact threshold values. *A report submitted to the Federal Provincial Committee for Humane Trapping* pp 206. University of Guelph: Guelph, Ontario, Canada

Broom D 1999 The welfare of vertebrate pests in relation to their management. In: Cowan PD and Feare CJ (eds) *Advances in Vertebrate Pest Management* pp 309-329. Filander Verlag: Furth, Germany

Falk JL, O'Brien JF and Kerr R 1992 Fluid resuscitation in traumatic hemorrhagic shock. *Critical Care Clinics 8*: 323-340

Godfrey G and Crowcroft P 1960 *The Life of the Mole*. Museum Press: London, UK

Gorman ML and Stone RD 1990 *The Natural History of Moles*. Christopher Helm: London, UK

Gregory N 2004 *Physiology and Behaviour of Animal Suffering*. Blackwell: Oxford, UK. http://dx.doi.org/10.1002/9780470752494

Gutierrez G, Reines HD and Wolf-Gutierrez ME 2004 Clinical review: hemorrhagic shock. *Critical Care 8(5)*: 373-381. http://dx.doi.org/10.1186/cc2851

Hartman GD 1995 Seasonal effects on sex ratios in moles collected by trapping. *American Midland Naturalist 133*: 298-303. http://dx.doi.org/10.2307/2426394

ISO (International Organization for Standardization) 1999 *ISO 10990-4 Animal (Mammal) Traps, Part 4: Methods for Testing Killing-trap Systems used on Land or Underwater. First edition*. International Standards Office: Geneva, Switzerland

Lodal J 1999 The mole: a matter of control or conservation. In: Cowan DP and Feare CJ (eds) *Advances in Vertebrate Pest Management* pp 43-55. Filander-Verlag: Furth, Germany

Martel MJ, MacKinnon KJ, Arsenault MY, Bartellas E, Klein MC, Lane CA, Sprague AE and Wilson AK 2002 Hemorrhagic shock. *Journal of Obstetrics and Gynaecology Canada 24*: 504-511

Mason G and Littin K 2003 The humaneness of rodent pest control. *Animal Welfare 12*: 1-38

Mellanby K 1971 *The Mole*. William Collins Sons & Co: Newton Abbot, UK

Moore-Olufemi MD, Xue H, Allen SJ, Moore FA, Stewart RH, Laine GA and Cox CS 2005 Inhibition of intestinal transit by resuscitation-induce gut edema is reversed by L-NIL. *Journal of Surgical Research 129(1)*: 1-5. http://dx.doi.org/10.1016/j.jss.2005.04.041

Natural England 2011 Moles: options for management and control. *Technical Information Note TIN033*. Natural England: Bristol, UK. http://publications.naturalengland.org.uk/publication/34015?category=23035

Nicholls J 2010 *Mole-catching: A Practical Guide*. Crowood: Marlborough, UK

Nicholls P, Bailey T and Lampen F 2008 Post-mortem examination and biomedical reference collections. In: Bailey TA (ed) *Diseases and Medical Management of Houbara Bustards and other Otidae* pp 171-184. Emirates Printing Press LLC: Dubai, United Arab Emirates. http://researchrepository.murdoch.edu.au /668/1/Chapter.pdf

Parrott D, Quy R, Van Driel K, Lurz P, Rushton S, Gurnell J, Aebischer N and Reynolds J 2009 Review of red squirrel conservation activity in northern England. *A Report by Fera to Natural England (NECR019)*. Natural England: Sheffield, UK. http://publications.naturalengland.org.uk/publication/46008

Proulx G and Barrett MW 1991 Evaluation of the Bionic trap to quickly kill mink (*Mustela vison*) in simulated natural environments. *Journal of Wildlife Diseases 27(2)*: 276-280. http://dx.doi.org/10.7589/0090-3558-27.2.276

Proulx G, Kolenosky AJ, Cole PJ and Drescher RK 1995 A humane killing trap for lynx (*Felis lynx*): the conibear 330™ with clamping bars. *Journal of Wildlife Diseases 31(1)*: 57-61. http://dx.doi.org/10.7589/0090-3558-31.1.57

Proulx G, Pawlina IM, Onderka DK, Badry MJ and Seidel K 1994 Field evaluation of the number 1½ steel-jawed leghold and the sauvageau 2001-8 traps to humanely capture arctic fox. *Wildlife Society Bulletin 22*: 179-183

Quy R and Poole D 2004 *A Review of Methods used Within the European Union to Control the European Mole,* Talpa euroaea. DEFRA: London, UK

Rudge AJB 1963 A study of mole-trapping. *Proceedings of the Zoological Society of London 149*: 330-334

Scott Henderson J 1951 *Report of the Committee on Cruelty to Wild Animals, Home Office/Scottish Home Department, Cmd 8266, June 1951*. Her Majesty's Stationery Office: London, UK

Sharp T and Saunders G 2005 *RAB009 Ground Shooting of Rabbits: Standard Operating Procedure*. NSW Department of Primary Industries: NSW, Australia. http://www.feral.org.au/wp-content/uploads/2012/07/rab-009_SOP2005.pdf

Smith HO 1997 Shock in the gynecologic patient. In: Rock JA and Thomson JD (eds) *Te Linde's Operative Gynecology, Eighth Edition* pp 245-261. Lippincott-Raven: Philadelphia, USA

Talling JC and Inglis IR 2009 *Improvements to trapping standards*. DG ENV. http://ec.europa.eu/environment/biodiversity/animal_welfare/hts/pdf/final_report.pdf

Warburton B and Hall JV 1995 Impact momentum and clamping force thresholds for developing standards for possum kill traps. *New Zealand Journal of Zoology 22(1)*: 39-44. http://dx.doi.org/10.1080/03014223.1995.9518022

Warburton B and Norton BG 2009 Towards a knowledge-based ethic for lethal control of nuisance wildlife. *Journal of Wildlife Management 73(1)*: 158-164. http://dx.doi.org/10.2193/2007-313

Warburton B, Poutu N, Peters D and Waddington P 2008 Traps for killing stoats (*Mustela erminea*): improving welfare performance. *Animal Welfare 17(2)*: 111-116(6)

Xu H, Han LC, Gao W, Sun XX, Zhou Y, Meng XZ, Zhang H and Xu LX 2011 Therapeutic effects of intravenous infusion of hyper-oxygenated solution on acute haemorrhagic shock in rabbits. *The Journal of International Medical Research 39:* 1843-1851. http://dx.doi.org/10.1177/147323001103900527

Zelin S, Jofriet JC, Percival K and Abdinoor DJ 1983 Evaluation of humane traps: momentum thresholds for furbearers. *Journal of Wildlife Management 47(3)*: 863-868. http://dx.doi.org/10.2307/3808628

https://doi.org/10.7120/09627286.24.1.001 Published online by Cambridge University Press