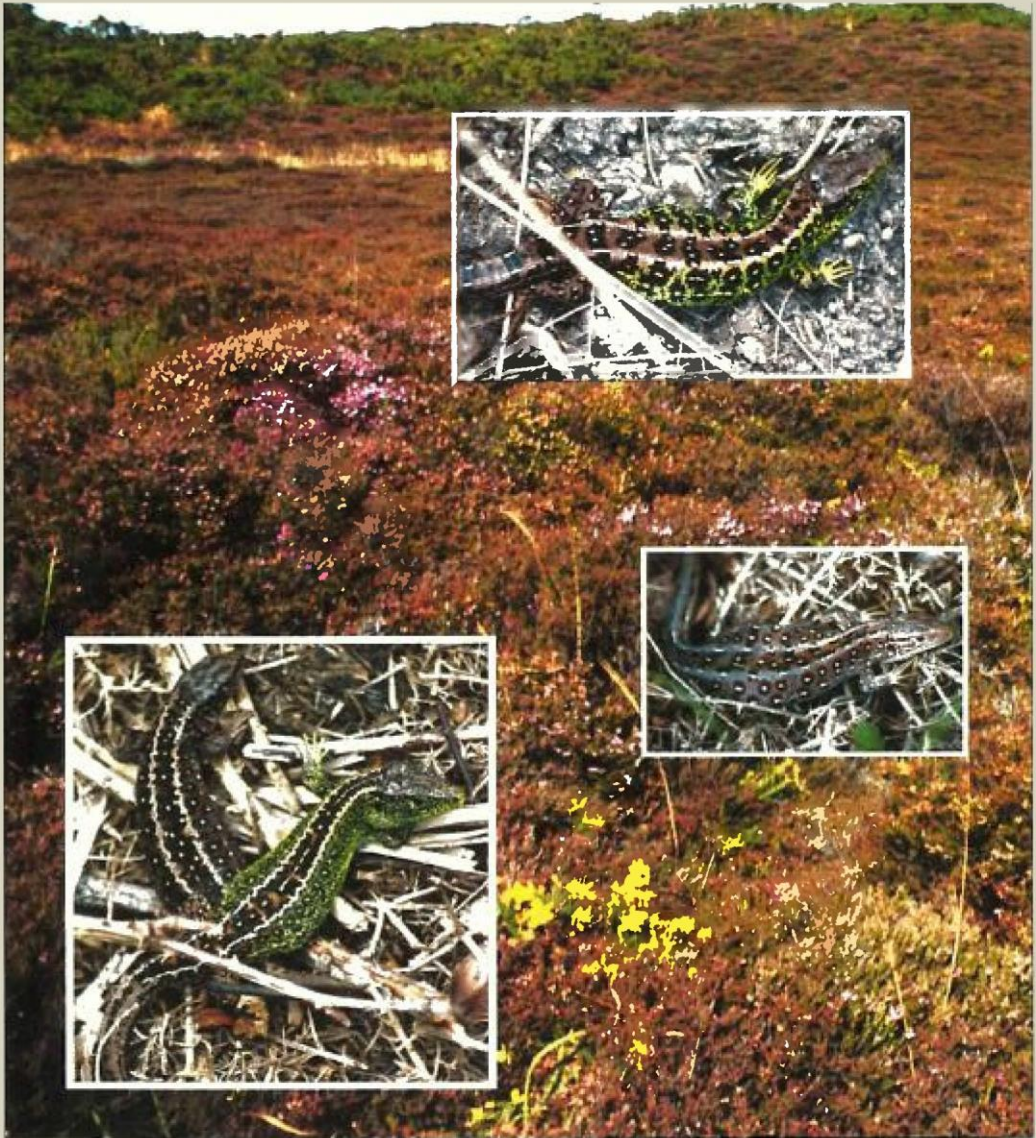


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A photographic study of reproductive behaviour in the Sand Lizard, *Lacerta agilis*, on a Dorset nature reserve

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THIS report presents the results of extensive behavioural monitoring of populations and individuals of *Lacerta agilis* on a Dorset nature reserve during the spring, summer and autumn of 2001. The objective of the study was to provide a detailed photographic record of breeding behaviour for one of Britain's rarest reptiles.

Lacerta agilis is the largest of the United Kingdom's two native lacertids. At present the species persists only in Surrey, Dorset and Merseyside (Corbett, 1988), although introduced populations may also survive in Sussex, Devon and Wales following a program of recovery. Dorset is undoubtedly the stronghold and the overwhelming majority are to be found on the remaining heathlands within this county (Beebee & Griffiths, 2000). The continued destruction and fragmentation of Dorset's heaths combined with the effects of uncontrolled fires has resulted in the extinction of many local populations. Currently, *L. agilis* is an endangered species and is nationally protected under schedule 2 of the UK Conservation (Natural Habitats etc.) Regulations 1992, and internationally protected under the Council of Europe's Convention of European Wildlife and Natural Habitats and Species Directive (1992).

Lacerta agilis has a wide European range extending from western France across the European continent and into central Asia. In Britain, it is an animal of lowland heaths and occasionally of coastal sand dunes and thrives only where there is dense dwarf-shrub or similar vegetation at ground level. They also require areas of open exposed sand in which to lay their eggs. Optimum Sand Lizard habitat is a southern heathland with a south-facing sandy bank and extensive stands of mature ling or bell heathers, interspersed with open patches of track or sand (Beebee & Griffiths, 2000).

Lacerta agilis in Britain emerge from hibernation during February and March, though the males in general appear a couple of weeks before the females. As the sun strengthens, activity increases and after a spring moult males begin to acquire their greenish breeding colours. By mid to late April the time spent basking declines and the lizards become preoccupied with mating and feeding. In the summer when the sun is at its height, the lizards are seldom seen and much of their time is spent underground or foraging in vegetation (Beebee & Griffiths, 2000). *Lacerta agilis* mate between April and early May (mating was observed on the Dorset site in early May), lay their eggs between late May and June, which then hatch between August and September. The lizards then return to hibernation late September to October (although the exact time is dependent on the weather).

The diet of *L. agilis* consists of a wide range of invertebrates and they can be seen chasing bumble bees, butterflies and moths, spiders, crickets, harvestmen, flying ants and beetles (Beebee & Griffiths, 2000). The intelligence of *L. agilis* has been documented and recognised notably by Rollinat over a century ago (Smith, 1951).

Site Description

The lizards were observed at a small 5 ha Local Nature Reserve, which has been designated as a Site of Special Scientific Interest (SSSI) in Dorset, managed and maintained by Poole Borough Council. It is a mosaic of several habitats including secondary woodland with stands of willow, birch and oak, scrub areas dominated by gorse and bramble, acidic grassland varying in maritime influence and wetness, remnant heath, reed-bed, ditches, banks and ponds. The site is



Plate 1. Area of site in which the lizards were observed basking and displaying territorial behaviour for the 2001 season. The habitat here is characterised by reed, bramble, silt, bare ground and gorse.

adjacent to urban areas on three sides with a golf course containing heathland to the North. Approximately 0.5 ha of the site is occupied by the lizards.

The lizards observed prior to 1996 have been present on only two areas of the site, and it is believed that at this time the populations were isolated. Habitats in these areas differ significantly from one another and from the expected and typical Sand Lizard habitat. The areas that are known to contain historical populations of lizards consist of gorse, bramble, scrub and silt banks, and the other of low mixed vegetation, reeds, bramble and grasses (Plates 1 and 2).

The majority of the lizard activity observed during this study has occurred on these silt banks or in the low mixed vegetation surrounding them. These habitat types have been encouraged in the management regime of the site by maintaining and providing open sunny areas with low vegetation, areas of open sand and wind breaks of taller scrub.

Population status and response to active management

Sand Lizards have been seen on the site prior to 1996 but not regularly recorded. From 1996 onwards surveys have been conducted each year and the results of these fed back into active management of the site for reptiles. In 1996 only eight individuals were recorded, found on the two



Plate 2. One of the many silty banks created and encouraged by the site managers. This photograph was taken year beginning 2002, after the activity in this study was recorded.

main silt banks and in mixed vegetation to the North of the site, which probably represents an underestimate. From 1997 onwards recording appears to have continued at much the same level. Twenty individuals were recorded in 1997 and this is thought to be a reasonable estimate of the population size at that time. Active management started in 1995 has steadily improved the habitat available. The number of individuals recorded has steadily increased from 30 in 1998, to 48 in 1999, and 55 in 2000. In 2001, 90 individuals were recorded, of which 15 were confirmed new sightings. Few young animals are seen in the open until later in the year unless disturbed by adults and are likely to be very under-recorded.

The total number of Sand Lizards currently present at this site is difficult to determine, but the population appears to be thriving and responding well to active management. The density of individuals appears to be significantly higher than the expected density quoted in recent literature (e.g. Beebee & Griffiths, 2000). It is probable that the populations here are less isolated than they were in 1996. In particular, movement of animals between ancillary colonies at the site may have increased, and movement may have also occurred to and from the adjacent golf course, on which recent management has created additional areas of open heathland.

METHODOLOGY

Lizards at this site were recorded on detailed maps of the reserve with each individual given a number. Each animal was numbered when first observed and its location accurately recorded on a detailed site map. This data was used as a baseline for the survey to determine the expansion of the populations and where possible, to obtain a photographic record of the back pattern for each numbered individual (for future identification purposes). It was important that each individual lizard kept its original number. This was ensured by use of the detailed reserve maps during recording. It should be recognised that surveying for this study started late in the season.

Surveys were conducted by walking a set route through the site and across the occupied bank habitats without interfering with the lizards or degrading the area.

Following several unsuccessful survey days from the end of April, five continuous full days were spent on site when all the observations noted in this study were recorded. These observations were recorded between 10th and 14th May 2001.

When a lizard was observed the following was noted:

- * Date and time of sighting
- * Weather conditions
- * Sex
- * Whether adult or juvenile
- * Location on the site map

- * Presence of other lizards
- * Behaviour at time of sighting (basking/mating)
- * Lizard number
- * Whether a new sighting
- * Where possible a photograph of the back pattern or behavioural activity was taken

FIELD OBSERVATIONS AND RESULTS

It is of great importance to stress that all the behaviour displayed by the lizards was completely natural. There were no human pressures or influences governing the behaviour of the animals during and after this study.

Three distinctive and eventful sequences were chosen from the field observations. Each photograph in this article has been selected as it displays either a typically observed and well documented aspect of behaviour or, more interestingly a type of behaviour not noted or observed in either wild or captive populations of sand lizards. Each sequence is described in its entirety and each interesting observation or aspect of behaviour is cross-referenced to the corresponding photograph.

Sequence 1

Behaviour noted

- Female approaching male
- Biting
- Circling

Date and time

~11:00 hrs, 11th May 2001

Weather conditions

Lots of cloud cover, humid and warm.

Duration of display

~2 minutes.

Size and Age of lizards

Not noted

Notable points

Observations 4 and 6 have not been documented in previously published research.



Plate 3.



Plate 4.



Plate 5.



Plate 6.



Plate 7.

Sequence 1. Summary: male 66 and female 67.

1. Male moves towards female tasting the air as he moves.
2. Male approaches female almost cautiously and makes eye contact; he then begins to circle female (Plate 3).

3. Female changes body posture and her behaviour begins to resemble that of agitation (shaking of front foot, flicking of tail) as male approaches.
4. Female approaches male in an almost aggressive manner and moves forward with mouth slightly open towards his head (Plate 4).
5. Male continues to circle female, then starts to bite her tail (Plate 5).
6. Female maintains eye contact with male and moves towards his head with mouth open (Plate 6).
7. Male and female begin circling each other with female gradually becoming more flattened and widened; the pair are continuously moving closer together (Plate 7).
8. Female leads male into surrounding vegetation.



Plate 8.



Plate 9.

Sequence 2

Behaviour noted

- Guarding
- Biting
- Female agitation
- Territorial

Date and time

~10:00 hrs, 10th May 2001

Weather conditions

Lots of cloud cover, humid and warm.

Approximate age and size of individuals

Age unknown, male ~26cm, female ~26cm.

Duration of sequence

Approximately 30 minutes.

Notable points

This pair of lizards was seen regularly on site in the same area and consequently their behaviour has been extensively documented.

It is not known whether the couple had mated prior to this sequence.

Sequence 2. Summary - male 52 and female 53.

1. Male guards female.
2. Female displays agitation by shaking front foot and flicking tail.
3. Male and female circle each other.
4. Male guards female (Plate 8).
5. Male aligns himself with agitated female where eye contact is made and maintained (Plate 9).

6. Male runs away at speed and begins to circle territory; this lasts approx. 5 minutes (after sequence, male 89 observed nearby, where male 52 was circling territory).

7. During this time female returns to favourite basking spot (identified from previous observations), catches and eats a fly, then continues to bask.

8. Male returns to female, tasting air as he moves.

9. Female responds by displaying agitation.

10. Male guards agitated female.

11. Male and female circle each other.

12. Male bites female; she responds by biting him.

13. Activity in steps 11 and 12 continue for approximately 10 minutes.

14. Site of activity is left for 5 minutes; on return, female is displaying a sizeable mating wound on her right flank. It is not known whether this pair of lizards actually mated.

Sequence 3

Behaviour observed

Mating, territorial and guarding.

Date and time

~12:00 hrs, 11th May 2001

Weather conditions

Lots of cloud cover, humid and warm.

Approximate age and size of individuals

Age unknown, male ~25cm, female ~25cm.

Duration of sequence

Approximately 10 minutes.



Plate 10.



Plate 11.



Plate 12.



Plate 13.

Notable Points

Prior to copulation, the mating pair moved to denser lower vegetation where they were more camouflaged.

Sequence 3. Summary - male 56 and female 63.

1. Male bites female continually, gradually moving up her body.
2. Male curls around female and exhibits guarding behaviour.
3. Male begins biting female directly below her hind legs (Plate 10).
4. Male mates with female (Plate 11).
5. Male circles female post copulation and eye contact is made (Plate 12).
6. Male guards female directly after mating (Plate 13).
7. New male (male 64) approaches mated pair and mated male (male 56) 'tastes' air whilst guarding female.

8. Mated male 56 chases new male 64 off at speed, whilst female remains under cover of vegetation.

9. Female basks.

10. Mated male basks exactly where male 64 was observed after mating.

DISCUSSION

The close monitoring and photography of these lizards has created the opportunity to detail and analyse their movements, postures, interactions and behaviour at a level not previously investigated in wild *L. agilis*. Outlined in this discussion are four main points of interest.

- Timing of activity
- Dorsal pattern Variation
- Behaviour
- Areas for Further Study

The Timing of the Activity Recorded

'The duration of the period of seasonal activity substantially varies among populations of *L. agilis*

... which seems to be primarily a consequence of geographical variation in environmental temperatures (Adolph & Porter, 1993; in Gvozdik, 2000). The timing of the mating behaviour observed this season occurred at the same time of year as previous site records for this behaviour.

During the study period the weather was extremely humid. All aspects of the observed activity were recorded between 10:00 and 19:00 hrs; due to time constraints it was not possible to observe the lizards at other times. Most of the mating activity observed was seen at 11:00, 12:00 and 15:00 hrs, even with the same pairs of lizards, over a couple of days. Generally speaking, each lizard was seen in the same area of the site at roughly the same time each day. To observe as many individuals and mating pairs as possible, areas of the site were visited at different times of the day. This provided time variation and increased the opportunity to see more individuals.

The mating display for male 52 and female 53 was observed and their full sequence is included in the field observations. Their mating display combined with basking time occurred over a period of approximately 2 hours. During this time numerous other lizards were observed in the area.

Dorsal Pattern Variation

As noted previously, the dorsal pattern of the Sand Lizard is unique to each individual. It was observed that in both sexes the colour intensity, markings, spots and the dorsal stripes vary significantly between individuals, aiding recognition.

With male lizards it was evident that not only the markings and spots on their back differ significantly but also the shade, brightness and extent of colouration on their flanks. The dorsal stripes vary in colour (from cream to brown), intensity, continuity and width. The intensity of the male flank colouration increases after emergence from hibernation. This distinctive colouration is visible before the first skin moult. The colouration continues to increase with time and male condition until the males have mated, after which it gradually starts to fade.

Olsson (1993) states that green colouration in males is allometrically related to body size, which suggests that the larger the males the more vibrant the colour. Beebee & Griffiths (2000) concurred with this and further stated that 'the largest males are the greenest', this study found no evidence to support this claim. It appeared that the males frequently observed basking and feeding were notably greener than males which did not display this behaviour. It has been suggested (D. Bird & D. Hurst, pers. comm.) that really bright males appear to be out basking where they can be seen and hence approached by females, whereas the less bright males need to look for females with which to mate. Olsson et. al. (1995) state that a male's mating success depends primarily on his ability to encounter receptive females and achieve mating in competition with other males. The female dorsal pattern is also subject to natural variation. The female back pattern varies between the spots and marking on the back and the shade of brown on the flanks.

There is no evidence to suggest that the male lizard selectively chooses females based solely on their lightness or darkness of their back pattern. Olsson (1993) and Olsson & Madsen (1995), claim that males prefer the larger more fecund females where a choice is available. From the monitoring at this site, our observations indicate that the younger the female the lighter brown the back pattern, and the older the female the darker the back pattern. However, this can not be confirmed as the sample size was too limited. It is expected that this observation is highly site specific and could be partly be explained by inbreeding of the populations.

Behaviour

From the observations recorded it can be concluded that the mating behaviour in this population of *L. agilis* can be divided into the following categories of activity:

- * Agitation of the female
- * 'Circling'
- * Biting
- * Copulation
- * Guarding
- * Basking



Plate 14.

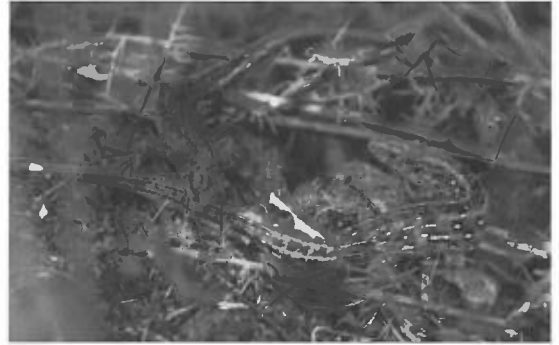


Plate 15.



Plate 16.



Plate 17.



Plate 18.

Agitation of the female

This is the first display in the mating sequence. When a male Sand Lizard approaches a female she appears very agitated. This agitation is displayed by the female shaking vigorously one of her front feet whilst flicking her tail. Eye contact is made and kept with the male throughout (Plate 14; part of sequence 1). This contradicts Beebee & Griffiths (2000), in which it is suggested that the female shakes her front foot to discourage the males.

'Circling'

When the female and male have accepted each other as a mate, and the female has performed her agitation display, the lizards start to circle each other simultaneously (Plate 15). Whilst circling, it appears the lizards gradually move closer together and the female then starts to flatten herself out. Circling was observed in all mating pairs of Sand Lizards during the course of this study.

Biting

The male, after circling the female clamps her tail in his mouth, then gradually in stages moves further up her tail, clamps her upper tail, then above her back legs and then her stomach area. This display occurs very quickly, although the male may hold the female in a clamped position for up to 30 seconds at a time. The lizards may start to circle each other again after completing the biting sequence. This can happen several times before the female and male are ready to mate (Plate 16).

Copulation

The male and female in sequence 3 were photographed during copulation (Plate 11). It appears that when the Sand Lizards decide to mate, they prefer a slightly vegetated area with some cover. No copulating lizards were observed out in the open. It should be noted that there were always 'single' males nearby a mating pair. The 'single' male always approached the mating pair just after copulation and on every occasion was chased off by the newly mated male.

Guarding

At the start of this study the term guarding was used to describe how the male appears to protect/watch over the female after copulation. A year on, different types of 'guarding' behaviour have been demonstrated by males towards females. The subtle differences in behaviour differed between pairs of lizards that were known to have mated and pairs which had not yet mated. Thus, prior to copulation the male and female lizards display pair bonding behaviour and after copulation true 'guarding' behaviour is exhibited (Plate 17). In this article all reference to the term 'guarding' refers to post copulation guarding. Guarding behaviour was observed in all mated pairs of lizards. The amount of time the female was guarded after mating varied between an hour and 5 days.

There is published literature detailing mate guarding post-copulation, both in captive and wild populations. Olsson (1992) commented that 'After mating the male stayed near the female, generally resting his chin and forelimb on top of her. This behaviour is commonly observed in natural conditions'.

Olsson et al. (1995) also comment that 'larger males guarded females longer and were more likely to mate guard a female of a similar age' the observations noted during this season of monitoring found no conclusive evidence to support this statement. However, Olsson (1992), clearly states that mating motivates a male to defend the newly mated female'. This behaviour was frequently observed in several different pairs of mated lizards whereby the guarded female was approached by a 'new male' only to be aggressively chased off by the recently mated male.

One other guarding position that the mated pairs adopted is illustrated in Plate 18.

Basking

After post-copulation guarding, the male and female basked in the area close to where they mated and within close proximity to each other. The female was very flattened and especially well camouflaged.

Areas for future study

This study of one population of Sand Lizards has recorded and briefly discussed three main areas of interest: the timing of activity, dorsal back pattern variation, and mating behaviour. In addition, the results have highlighted some areas requiring further clarification. There is a particular need to evaluate and review the current recommended survey techniques for this species and it is encouraged that the success of recent habitat management on the site is evaluated. Additional proposals for further research ideas are outlined below.

Timing of activity

- Investigation of the emergence of Sand Lizards from hibernation.
- Evaluation of the importance of early emergence from hibernation with respect to creating territories.

Dorsal Back Pattern Variation

- Clarification of the rate of development of greenness in the flanks of the males after emergence from hibernation (currently in progress).

- Determination of the importance of male greenness in mate ranking order.
- Establishment and development of a dorsal back pattern database to enable accurate identification of individuals and to monitor movement and distribution around the site (currently in progress).
- Clarify and further investigate the increasing darkness in colour of females with age.

Behaviour

- Comparison of the mating behaviour of this wild population to that of captive populations.
- Comparison of the behaviour observed with that of published literature.
- Analysis of the decrease in male tolerance level after emergence from hibernation to their tolerance level prior to mating.
- Quantitative analysis of the competition for withholding territories.
- Investigation to determine the extent of male dominance.
- Investigation into the importance in early establishment of territory and mating success.
- Investigation of the displacement of males from territories.
- Investigation of pair bonding behaviour.
- Clarification of the term 'guarding'.

Surveying Techniques

- Critically evaluate the current techniques for surveying this species.
- Accurately establish the male:female ratio at this site.

Habitat management and Population Size

- Investigation into what constitutes a good basking spot.
- Analysis of habitat within which mating occurs.
- Review and evaluation of recent site management.
- Determination of the actual population size and structure based on knowledge of current under recording.
- Review of the 'typical' lizard habitat.
- Impact of amenity use of the reserve on the lizard populations.

Studying this population of Sand Lizards uncovered some new aspects of behaviour not previously documented. To quote Nijam (1996) 'more research into small isolated populations, fragmentation and isolation is needed'. This will at

least help maintain and preserve the current stability of *L. agilis* populations in this area and provide valuable data for optimal habitat management.

ACKNOWLEDGEMENTS

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