ENGLISH NATURE

The hornet robber fly *Asilus crabroniformis* Linnaeus

Adult behaviour at selected sites in Dorset, Hampshire and Surrey in 1997

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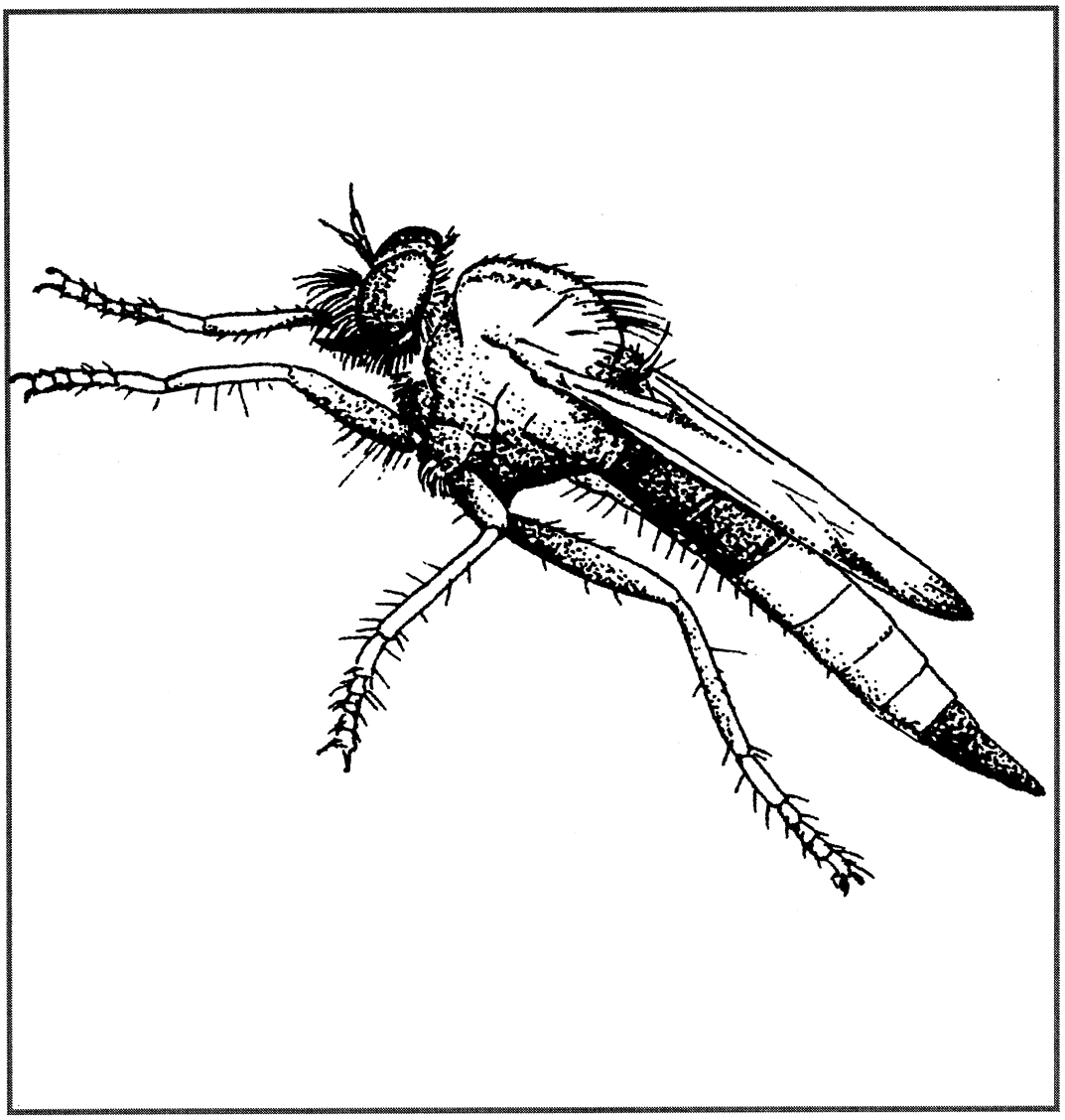

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Number 274

Species Recovery

The hornet robberfly *Asilus crabroniformis* Linnaeus - adult behaviour at selected sites in Dorset, Hampshire and Surrey in 1997

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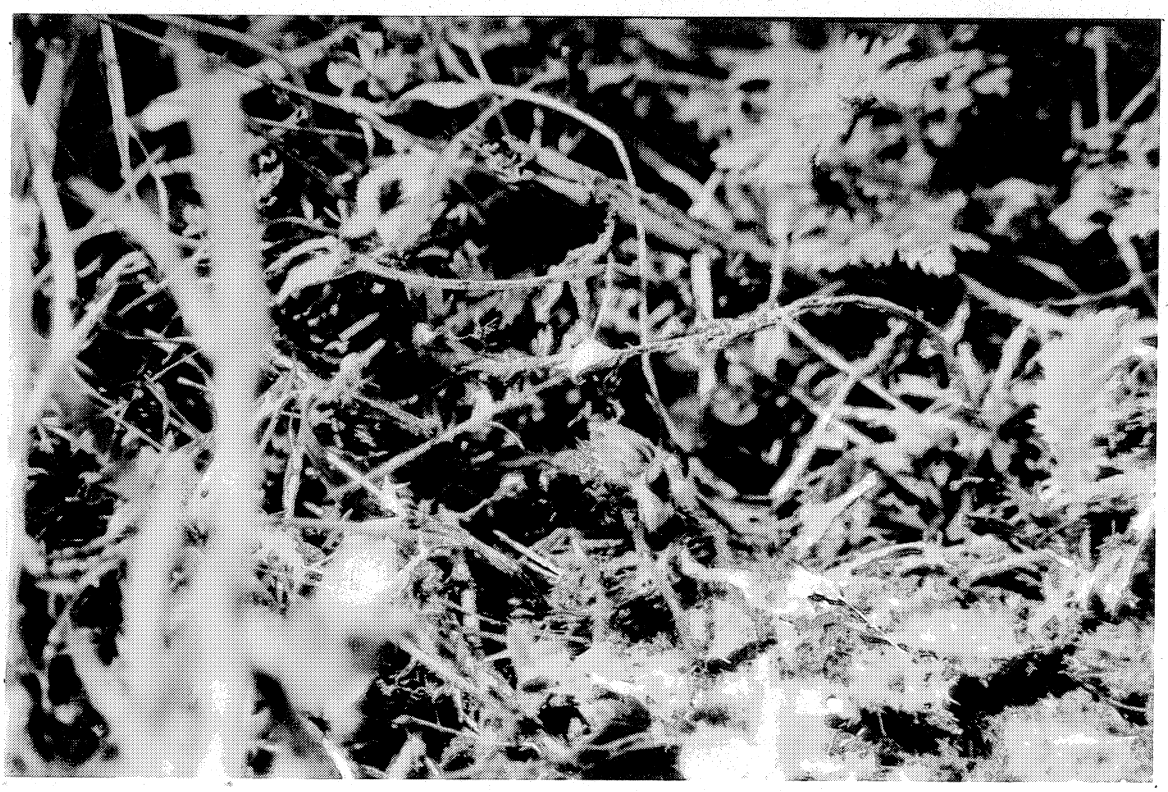


Female Ovipositing in Cow Pat, Jugglers Moor.

1. Summary

This report summarizes survey work relating to adult behaviour of the Hornet Robberfly *Asilus crabroniformis* at Worgret Heath SSSI, Dorset, North Solent National Nature Reserve, Hampshire, and Thursley Common National Nature Reserve, Surrey, in 1997.

The size of the colonies studied are recorded, along with the habitats where they are present, and the climatic conditions during each survey period.

At each of the sites attempts to assess territory size of both the males and females was recorded, along with courtship and copulation behaviour.

Adults were marked and their apparent territory sizes were recorded at the Dorset and Hampshire sites. The size of territories of males were approximately 25 m radius and those of females similar or smaller. The maximum distance travelled by a marked individual was 400 m.

Females were observed ovipositing in and around the margins of moderately dry dung of domestic cattle and under dry pellets of rabbits.

Rabbit latrines appear to be important for *Asilus* on heathland sites. A strong co-occurrence with *Typhaeus* beetles suggests that they may be a possible prey of *Asilus* larvae.

Horse and dog dung on heathland sites appeared to be used only as hunting perches, not as oviposition sites.

Prey items caught and eaten by the adults are recorded for each site.

Larvae were searched for at the colonies in Dorset and Hampshire, but none were found.

Locations where *Asilus* has been reported are listed.

Suggestions for future research and monitoring are given.

A list of papers relating to *Asilus* is included.

2. Introduction

The hornet robberfly *Asilus crabroniformis* is a nationally scarce fly that appears to have undergone a contraction in range this century. It is strongly associated with the dung of large herbivores, mainly cattle, and changes in patterns of grazing, the use of antihelminthid chemicals, and fragmentation and degradation of the countryside are among the possible reasons for this decline. It typically occurs on heathland and downland but adults have been recorded from other habitats including marshland and woodland clearings.

As *Asilus* is large and spectacular and its ecology is probably intimatedly bound up with the dung fauna, it was included in the short list of the Biodiversity Action Plan as a

flagship species to address a range of issues. *Asilus* has been recorded in about 40 ten km squares in southern England and Wales since 1970. It is therefore sufficiently widespread that the results of any work are likely to have broad implications for grazing management.

The principal aim of the study was to observe oviposition behaviour of females as current knowledge of the fly's association with different types of dung is still poorly understood. This information will improve our understanding of the relationship with livestock and other grazing animals, and may help identify potential prey of *Asilus* larvae. A second aim of the study was to obtain a crude measure of the size of the area used by individual flies. These aims fulfill part of the published action plan to 'research the fly's ecology, especially its habitat requirements' (UK Steering Group, 1995).

During the period of the present study, a parallel study into the autecology of *Asilus* has been carried out on various sites in Wales, and preliminary findings from the Welsh study have been included in the present account where relevant (Clements & Skidmore, 1998).

3. Location and description of survey sites

3.1 Worgret Heath SSSI, Dorset

The colony studied in Dorset occurs at Worgret Heath SSSI, at a site managed by the Herpetological Conservation Trust primarily for reptiles. The colony was first discovered by the surveyor for this contract, Mr D.R.Bird, during July 1996. The site is located approximately one and a half miles West of Wareham, Dorset, and lies between the A352 road and the River Piddle (Trent), at SY895869 (Map 1).

Worgret Heath SSSI is an open sunny south-facing slope with a mixture of heathland species present. The ground flora comprises chiefly short grazed ling *Calluna vulgaris*, bell heather *Erica cinerea*, bristle-leaved bent *Agrostis setacea* and wood sage *Teucrium scorodonia*. Scrubby species, birch *Betula pendula*, gorse *Ulex europaeus* and bracken *Pteridium aquilinium* are also present and patches of bryophytes and open sandy soil, which provide ideal resting and ovipositing sites for *Asilus*. Heights of the different flora species were measured and their average heights are shown on Map 2 (see legend). Bracken was sprayed on the site during 1996 in efforts to reduce its dominance, and gorse was cleared from some of the site in 1987 and 1992. No grazing by domestic livestock takes place on the site, but rabbits and deer do use the site regularly. The soil is a coarse sand, which is organically poor, with a covering of gorse needle litter and bracken litter in places.

Maps 2 and 3 show a plan of the habitat at this site and the locations of the colonies studied.

Photographs of the site and its habitat are held by D.R.Bird.

3.2 Jugglers Moor, North Solent National Nature Reserve, Hampshire

The colony studied in Hampshire is located on the North Solent National Nature Reserve, in an area known as Jugglers Moor. The site is managed under management agreement with the owners, the Manor of Cadland Estate. The colony was first discovered by B.J. Pinchen in September 1996, when six individuals were found. The site is approximately one mile south of Fawley Oil Refinery and 5 miles east of Beaulieu and borders the shore of the Solent at SU469005 (Map 1).

Jugglers Moor is a small complex of low lying unimproved wet grazing meadows divided by a stream. The ground flora mainly comprises dense grass spp, with *Juncus* dominant in many places. Across the whole of the 'moor' only six of the meadows were used by *Asilus*. Birch, willow *Salix* spp, alder *Alnus glutinosa* and bramble *Rubus fruticosus* agg. are the dominant woody species present. The meadows run roughly north to south, and are south-facing. To the east they are bordered by conifer plantation, and to the west by a small belt of mixed deciduous woodland and arable fields. Willow scrub was cleared from the eastern side of the stream during 1996, and the ditch was cleaned out during the winter period 1996/7. The *Juncus* was mown in meadow 1 in October 1997. Grazing by domestic cattle begins in the meadows in July with approximately thirty cattle, including calves, and the livestock is taken off the meadows in September. This nicely fits in with the flight period of the adult flies. Only the bull is treated with Ivermectin, the rest of the cattle are Ivermectin free. Rabbits and roe deer *Capreolus capreolus* have been seen grazing/browsing in the meadows. The soil is an open, free draining, organically rich coarse loam which floods and becomes waterlogged during the winter, and indeed in September there were numerous pockets of standing water across the study area. Map 4 shows the extent of the *Asilus* colony.

Drop disc measurements of the vegetation height were taken across all six of the meadows at Jugglers Moor where *Asilus* was present. The measurements were made at five metre intervals across each meadow, in a diagonal line which was roughly northeast to southwest. All measurements given are in metres (Table 1., Map 4).

Photographs of the site and its habitat are held by B.J.Pinchen. Aerial photographs at 1:5000 scale taken in 1996 are held by the English Nature Lyndhurst Office.

3.3 Thursley Common National Nature Reserve

The colony studied in Surrey is located on Thursley Common National Nature Reserve, a large heathland reserve which is owned and managed by English Nature. The colony has been present for many years, and has been the object of some survey work in the past by the surveyor for this contract, Dr J.S.Denton. The site lies approximately one mile west of Milford, Surrey, and is bordered on one side by the A3 road, at SU910401 (Map 1).

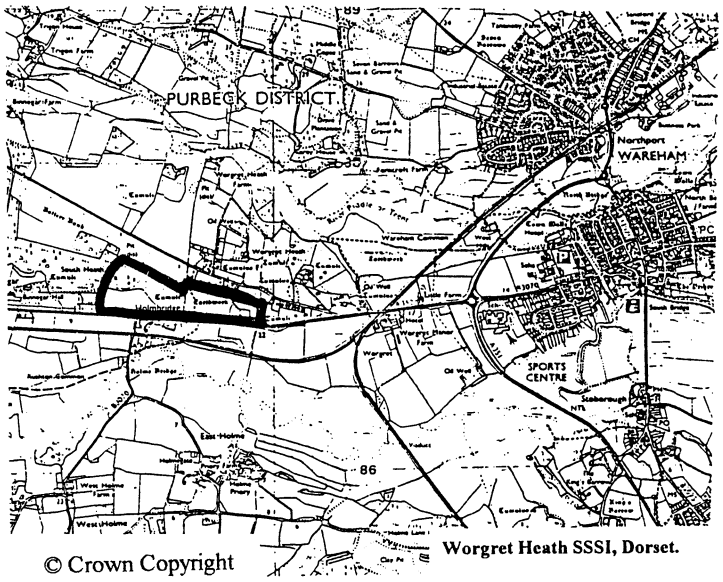
Thursley Common NNR is a large heathland block, comprising areas of both wet heath and dry heath. The main area where *Asilus* was recorded is an area of the dry heath on the southeastern corner of the reserve. Much of this area is matrix of open dry heath with ling, bell heather, and bryophyte including the alien moss *Campylopus intraflexus*. Bracken is also present in small quantities. The heather spp were scattered in their distribution and typically only 5-20 cm tall. The adult flies were almost exclusively

associated with the most open areas of heathland. Rabbits are frequent in the areas where *Asilus* was most frequently recorded and are instrumental in keeping conditions open, while roe deer, domestic horses and dogs also use the site.

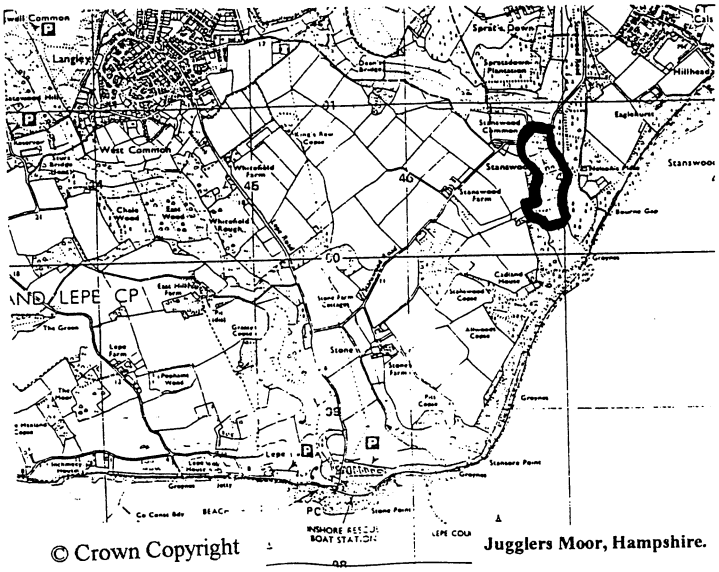
In recent years heath fires on the reserve have proved to be beneficial to *Asilus* by increasing the amount of open semi-bare ground available to the species. The soil is an organically poor, coarse, open free-draining peaty sand, which does not waterlog after heavy and prolonged rain.

Map 5 shows where sightings of *Asilus* were made.

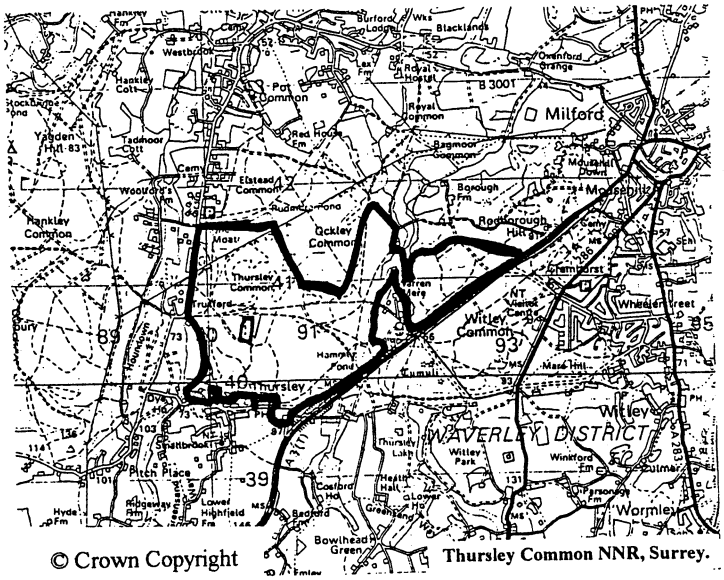
Photographs of the site and its habitat are held by Dr J.S.Denton.



 Worgret Heath SSSI, Dorset.



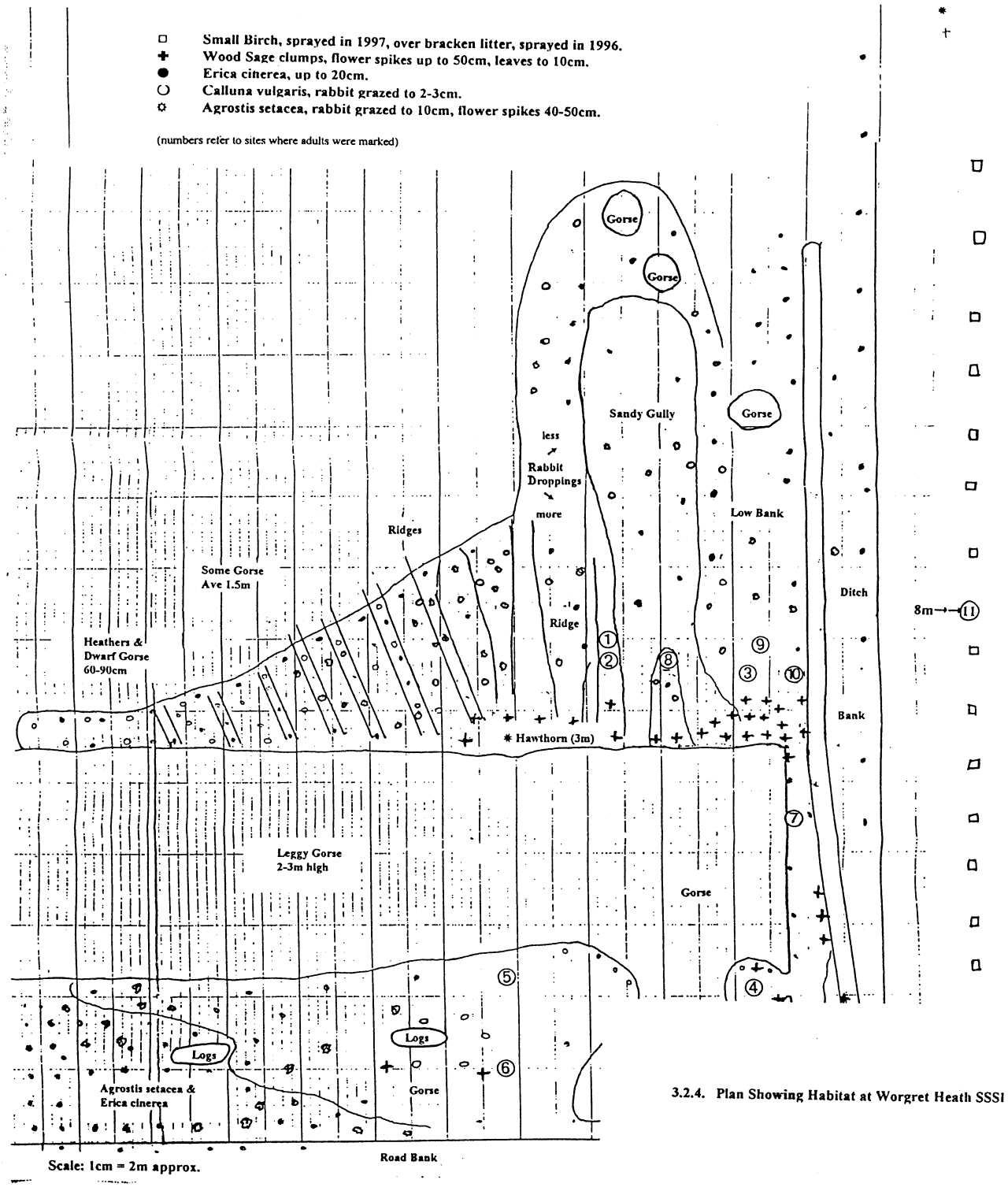
 Jugglers Moor, Hampshire.



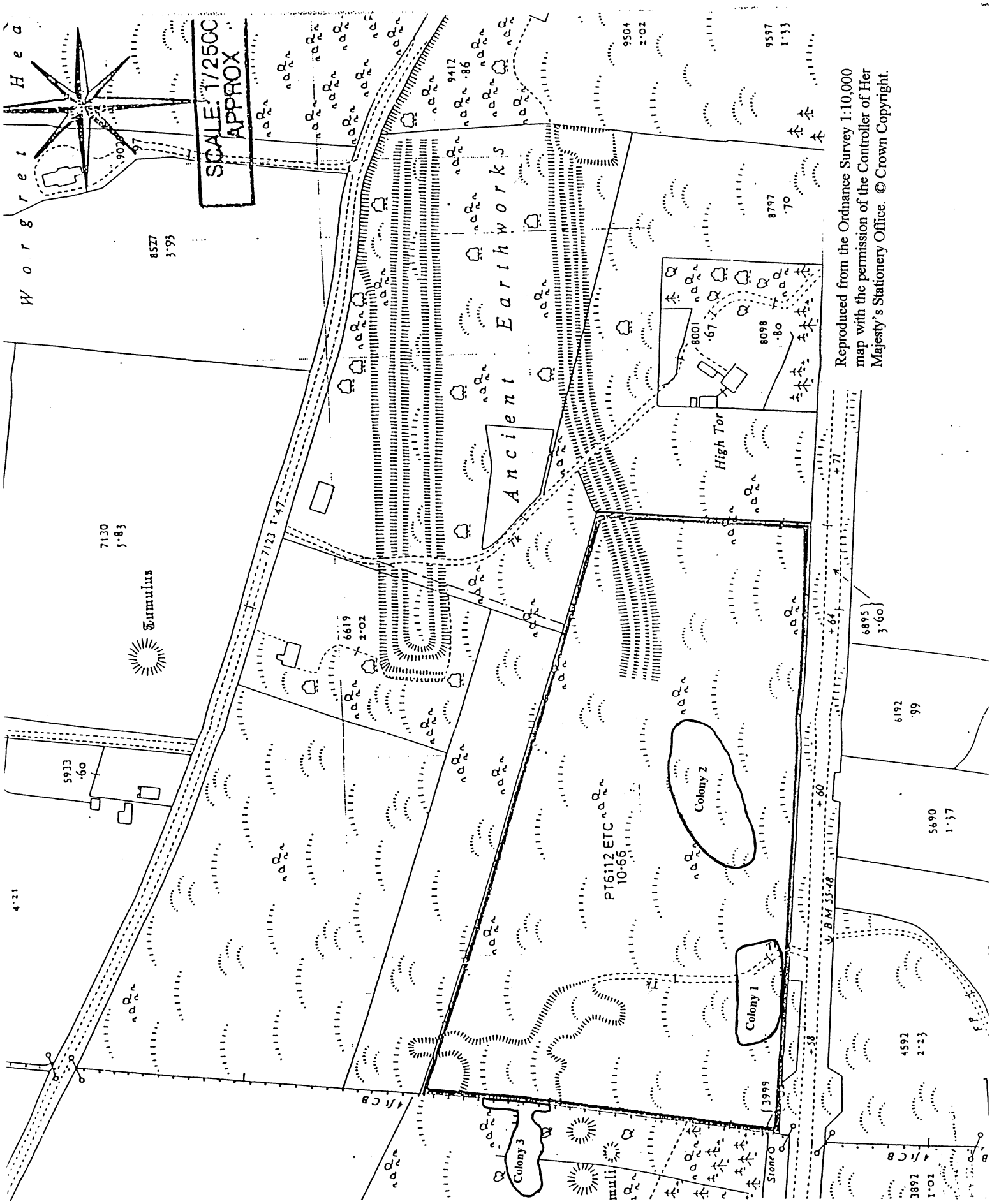
 Thursley Common NNR, Surrey.

Map 1. **Locations of Worgret Heath SSSI, Jugglers Moor and Thursley Common NNR study sites.**

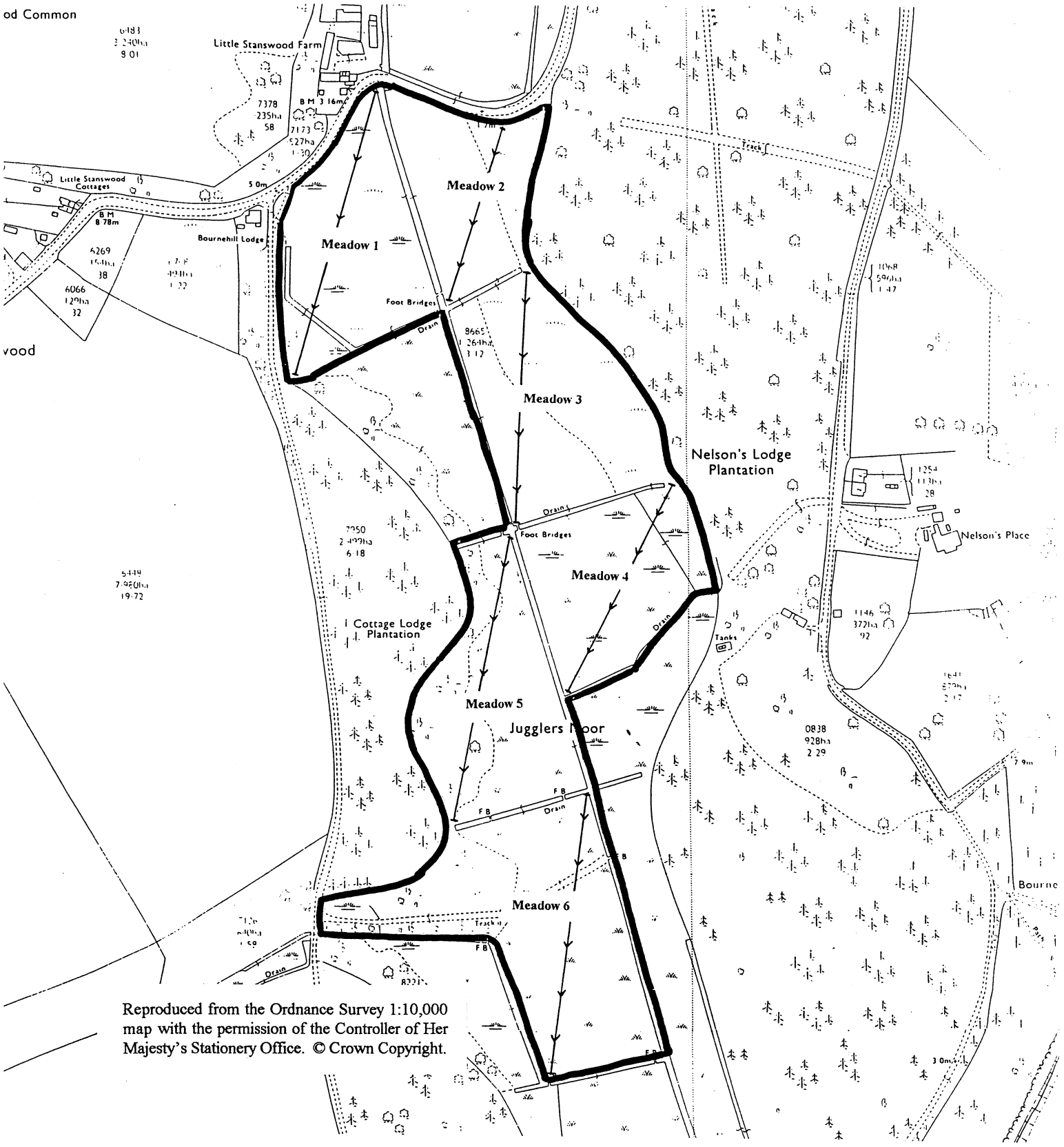
Map 2. Worgret Heath, Dorset. Habitats at Colony 1, SY895870 (see Map 3).



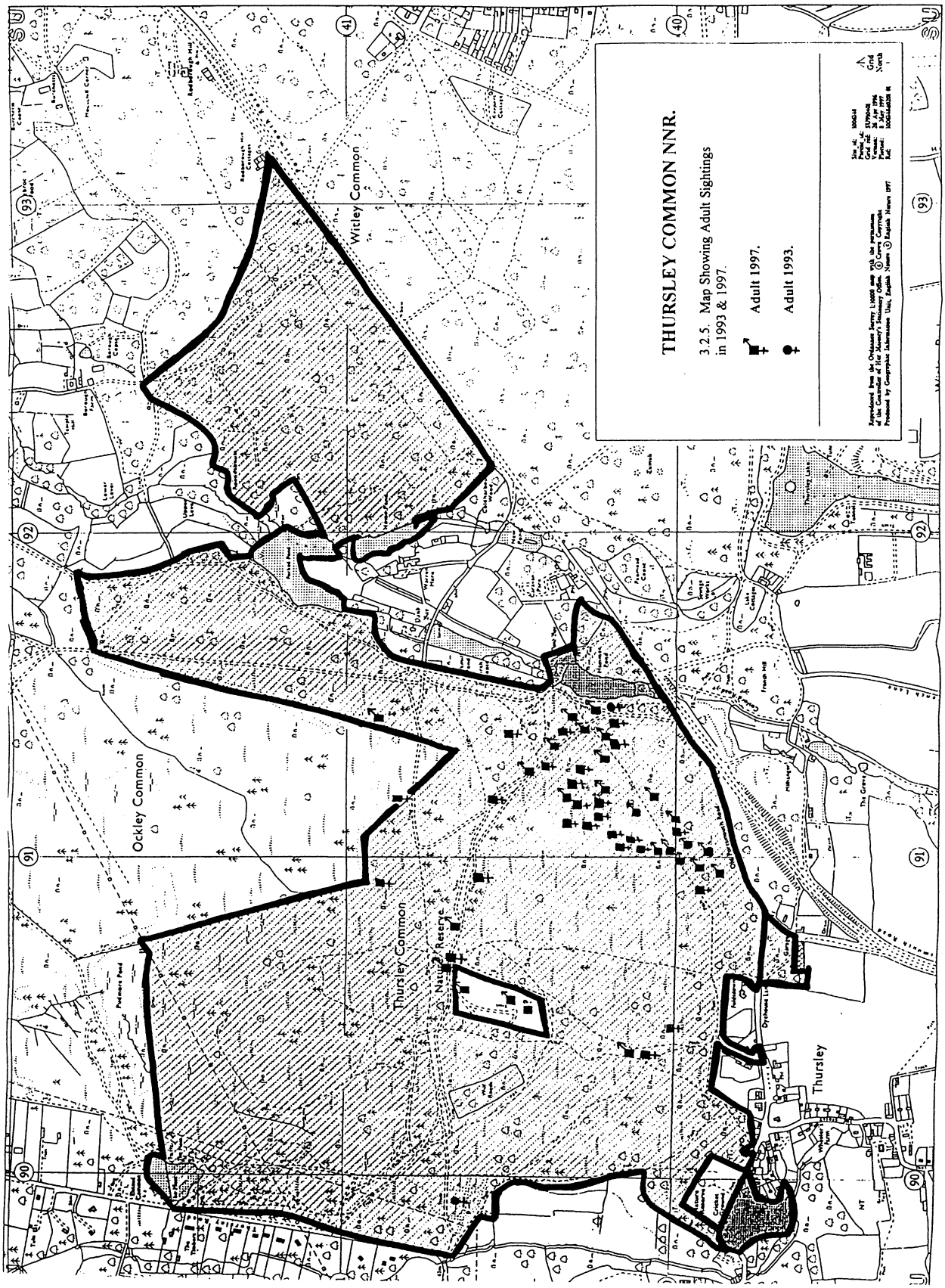
3.2.4. Plan Showing Habitat at Worgret Heath SSSI



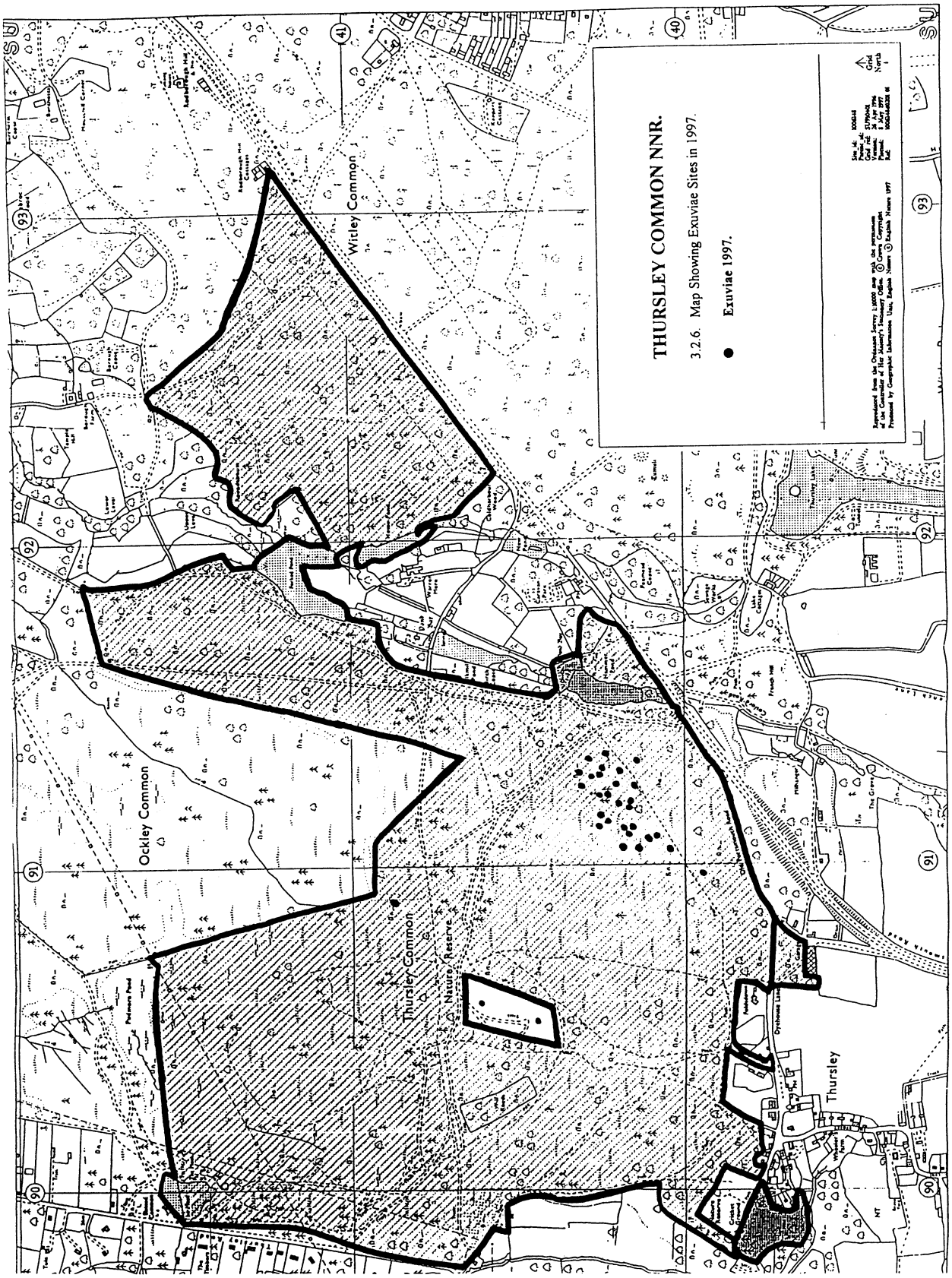
Map 3. Extent of colonies at Worgret Heath SSSI.



Map 4. Extent of colony at Jugglers Moor and transects where drop disc measurements were taken.



Map 5. Adult sightings at Thursley Common NNR.



Map 6. Exuviae sites at Thursley Common NNR.

Drop Disc Measurements Taken at Jugglers Moor (metres)

Meadow 1

1: .08	2: .06	3: .08	4: .25	5: .06	6: .06
7: .07	8: .03	9: .13	10: .14	11: .11	12: .10
13: .35	14: .20	15: .09	16: .08	17: .23	18: .13
19: .22	20: .10	21: .08	22: .05	23: .07	24: .06
25: .09	26: .12	average vegetation height .11m			

Meadow 2

1: .04	2: .07	3: .06	4: .06	5: .08	6: .09
7: .07	8: .17	9: .16	10: .15	11: .06	12: .13
13: .18	14: .15	15: .06	16: .06	17: .07	18: .02
19: .08	20: .08	21: .08	22: .05	23: .08	24: .03
25: .05	average vegetation height .08m.				

Meadow 3

1: .02	2: .05	3: .06	4: .05	5: .17	6: .07
7: .07	8: .03	9: .06	10: .08	11: .10	12: .06
13: .07	14: .09	15: .08	16: .07	17: .05	18: .06
19: .05	20: .05	21: .07	22: .10	23: .08	24: .07
25: .07	26: .06	27: .09	28: .06	29: .03	30: .01
average vegetation height .06m.					

Meadow 4

1: .07	2: .06	3: .07	4: .07	5: .06	6: .10
7: .13	8: .09	9: .06	10: .07	11: .07	12: .14
13: .10	14: .06	15: .06	16: .10	17: .10	18: .16
19: .04	20: .07	21: .05	22: .08	average vegetation height .08m.	

Meadow 5

1: .07	2: .15	3: .09	4: .65*	5: .10	6: .16
7: .09	8: .07	9: .07	10: .12	11: .12	12: .07
13: .20	14: .10	15: .12	16: .14	17: .17	18: .16
19: .23	20: .14	21: .17	22: .15	23: .27	24: .09
25: .06	26: .13	27: .15	28: .22	29: .10	30: .06
31: .13	32: .06	average vegetation height .14m.		* = blackberry	

Meadow 6

1: .04	2: .02	3: .03	4: .06	5: .13	6: .05
7: .16	8: .10	9: .10	10: .07	11: .14	12: .07
13: .06	14: .08	15: .10	16: .12	17: .10	18: .10
19: .15	20: .14	21: .12	22: .10	23: .13	24: .08
25: .12	26: .09	27: .07	28: .10	23: .13	30: .06
31: .05	32: .10.	average vegetation height .09m.			

4. Methods

4.1 Dung classification

For the purpose of consistency between the three sites, a scoring system for the ageing of dung was implemented, and could be easily referred to when monitoring the preferences shown by adults resting, sunning or preparing to hunt, and females when selecting oviposition sites. The absence of large easily identifiable dung types at Worgret Heath SSSI and Thursley Common NNR made it difficult to accurately assess the type of dung used.

The scoring system was as follows:

5 = FRESH Deposited that day, 'pat' or 'pellet' still intact, entirely moist.

4 = MOIST Outer surface beginning to dry, maybe with moisture still held on the surface, still very moist internally, beetles should be present.

3 = DRYING Dry over the whole surface, internally still very moist, beetles present.

2= DRY External surface totally dry, moisture only present in extreme centre of 'pat' or 'pellet', beetles may no longer be present.

1= SOLID 'Pat' or 'pellet' hard, crusty and completely dry. No moisture present, 'pat' or 'pellet' can either be easily friable at this stage, or very tough and difficult to break apart.

4.2 Techniques for marking adults

At the Worgret Heath SSSI and Jugglers Moor colonies, adults were marked throughout the survey period, in attempts to gain a better knowledge and understanding of the sizes of territories that both sexes hold, and to gain some information regarding their distribution and overall use of the sites, and the distances that adults may fly to disperse from their colonies.

At Worgret Heath SSSI the adults were marked using typists' correction fluid, nail varnish and model-makers enamel paint. Adults were marked with either of these solutions, on the wings or thorax. Coloured nail-varnish was used to mark the wings or thorax of some individuals, but this was found to be useless, because it took a long time for the varnish to dry on the insect, and, despite being coloured, it was very difficult to see on the insects when they were at rest or had their wings closed. However, when coloured model-makers enamel paint or correction fluid was used the insects were easier to re-locate. The correction fluid and enamel paint were applied to the thorax of the insects, and allowed to dry prior to their release. Some of the individuals were marked with correction fluid on their wings. Of fourteen individuals marked at Worgret Heath SSSI only four were seen in the colony area after they had been marked.

At Jugglers Moor adults were marked using white typists' correction fluid. No other marking substances were used here. The insects were marked on the thorax, and each

individual was also marked using a fine black marker pen with a letter on the patch of correction fluid. In total twenty individuals were marked. Despite having bold white patches on the thorax, the insects were still no easier to spot when resting on cow pats even when using binoculars, although identification of marked individuals in hot weather was easier with the aid of binoculars. Of the twenty individuals that were marked, many of them were seen during the same day that they were marked, but not seen on subsequent visits, with the exception of one individual which was seen again five days after marking. Correction fluid seemed to be a good medium to use because it is easy to apply and dries very quickly in the sunshine, reducing the amount of time that the adults are handled and kept away from hunting or searching for mates. On 10 September a total of seven individuals were marked in meadow 3 in an area less than 30 m in radius. This small area also had 34 cow-pats in it varying in age between Nos. 2 and 4.

4.3 Visit dates for survey work and recording conditions

Worgret Heath SSSI

Monitoring of the colony at Worgret Heath SSSI took place on the following dates, time spent surveying and weather conditions for each of the visits is also given.

25 July. Rain over the previous night, but the ground was warm and dry, sunshine was evident earlier in the day but cloud had appeared during the afternoon. Visit period 15:40-

10 August. Blue sky with a slight haze, 100% sunshine. Air temperature 29°C ground temperature 35°C wind. Visit period 11:10-16:00.

12 August. Vegetation present damp with dew, hazy sunshine with 15% cloud. No wind. Visit period 10:00-15:15.

19 August. 100% cloud cover with occasional breaks of sunshine. Air temperature 22.5°C round temperature 25.5°C . Visit period 09:35-11:00.

28 August. A warm day with 85% cloud. Air temperature 23°C, ground temperature 30-35°C. Visit period 15:30-16:40.

29 August. A warm sunny day with windy SW gusts, 5% high cloud cover. Air temperature 22°C, ground temperature 26°C. Visit period 14:30-15:35.

14 Sept. A warm sunny day with 5% cloud cover and very little wind. Air temperature 20°C, ground temperature 26°C. Visit period 10:45-12:35.

North Solent National Nature Reserve

Monitoring of the colony at Jugglers Moor took place on the following dates, time spent surveying and weather conditions for each of the visits is given.

12 August. A warm sunny day with a slight breeze and 1/8 cloud cover and 100% sunshine. Air temperature 28°C, ground temperature 34°C. Visit period 12:00-16:00.

21 August. A warm sunny day with only a slight breeze cloud cover 2/8 rising to 6/8 by the end of the visit and 80% sunshine. Air temperature was 24°C falling to 19°C, ground temperature was 26°C falling to 24°C. Visit period 12:00-16:00.

28 August. A bright day which gradually became overcast, cloud cover was 7/8, and sunshine only 50%. Air temperature was 18oc, ground temperature was 16°C. The ground was saturated, and rain fell for five minutes at 13:00. Visit period 12:00-14:00.

5 Sept. A bright warm sunny day, wind speed 2-3, cloud cover 2/8, sunshine 80%. Air temperature 20°C, ground temperature 20°C. Visit period 11:30-16:30.

10 Sept. A very warm sunny day with 90% sunshine, 0/8 cloud cover and no wind. Air temperature was 24°C, ground temperature was 22°C. Visit period 09:50-16:30.

Thursley Common National Nature Reserve

Monitoring of the colony on Thursley Common NNR took place on the following dates, time spent surveying and weather conditions for each of the visits is given.

19 July. A sunny warm day with a brisk NW wind. Temperature 23°C. Visit period 11:15-11:45.

25 July. A hot and sunny day with a brisk breeze. Temperature 22°C. Visit period 12:00-14:30.

1 August. A dry mild, but overcast day with a slight breeze. Temperature 24°C. Visit period 12:00-14:00.

5 August. A dull overcast and breezy day, rain had dampened the ground. Temperature 19°C.

9 August. A hot sunny day with no wind. Temperature 26-27°C. Visit period 15:30-17:00.

17 August. A hot sunny day with no wind. Temperature 27°C. Visit period 12:45-14:30.

28 Sept. A mild overcast day. Temperature 19°C.

13 Oct. A warm sunny day. Temperature 15°C.

5. Results

5.1. Size of male territories

On release after catching and marking, males behaved in two distinctly different ways. Some males would immediately fly away from the release site (which was exactly where they had been caught) and more often than not would fly out of sight. Other males, however, would fly only centimetres away, or would sit contentedly on the cow-pat where they were placed as if nothing had happened.

Of the males that flew away, only a very small number of them were seen again, but of those males which remained where they had been caught and replaced, a large majority of them would be seen again.

At Jugglers Moor, most marked males which were found again after marking seemed to 'hold' a territory of about 25m radius, and could often be found within that discrete area. Some males, however, were observed to have moved greater distances, and on 5 September, a male was marked in meadow 2, and released on the cow-pat where it had been caught. It remained on this cow-pat for some time, before apparently patrolling an area of approximately 20m radius. Three hours after he was caught and released, he was relocated approximately 400m away in meadow 3, presumably after having flown either over a tall willow hedge or, more likely, through the gap measuring about 6m between the two fields. On 10 September, this same male was observed still present in meadow 2, on the same cow-pat where it had been caught and released. This male spent the whole of the visit period (10:30-16:00) 'pat-hopping' around the whole of meadow 2. This behaviour is strongly suggestive that territories are held by males.

At Thursley Common NNR, both sexes were observed to occupy discrete ranges usually centred on a dung source. Highest adult densities were among rabbit warrens in areas of open heathland with a mosaic of bryophytes, short heather and patches of heather and gorse taller than 40 cm.

Adults at Thursley Common were able to find very isolated dung sources for example, horse droppings on bridleways crossing areas of mature heath. This must have involved them crossing dense habitats not usually used for foraging.

5.2 Size of female territories

Fewer female specimens were marked at both Worgret Heath SSSI and Jugglers Moor than males, so information regarding territory size is obviously less complete.

Females at all three sites were observed to occupy seemingly smaller, more discrete territories than those of the males described in paragraph 1.8. At Worgret Heath SSSI, of the females which were marked with nail varnish, correction fluid or enamel paint, many were not relocated after release. Of those insects which were observed again, most seemed to occupy small territories with a size less than 10m radius.

On Jugglers Moor, two females were caught in meadow 2, on 10 September, and both remained within an area of approximately 25m, for most of the visit period (10:30-16:00).

Both females were observed during the period apparently ovipositing in No.3, and a No.2, cow-pat. One female was observed to oviposit within 2m of where she had been caught and released, while the second female had moved approximately 40m into meadow 1.

Observations in Wales also suggest that females disperse away from core sites in late summer, leaving males present in increasingly large proportion.

No other observations suggest that females defended or held territories.

5.3 Courtship behaviour

Courtship behaviour in *Asilus* did not appear to be as obvious as it is in some other invertebrate groups. There seemed to be no display by the male and no attempt by the female to actively search for a mate. The males which were resting on areas of raised ground, such as droppings, or pieces of stick, would dart up into the air at the slightest movement of a passing insect, and if the passing insect was a female *Asilus,* she would immediately be grabbed and wrestled to the ground or a nearby stand of tall vegetation, and copulation would begin. This behaviour was noted at all three survey sites. Both sexes were considerably more active in very hot weather and at Worgret Heath SSSI males were observed during particularly hot weather continuously darting up and usually grabbing every passing female.

Adults activity appears to depend on quite high ambient temperatures. Above 20°C adults are active and wary, but below 18°C they vanished into the undergrowth. They were first recorded in late June in 1996. Adults were active in early July in 1997 (Don Tagg pers. comm.). During the first few weeks (about three) only males were recorded.

Observations compiled in Wales indicate that activity by adult *Asilus* is governed, at least to some extent, by air temperature. Adults ceased activity and went to roost when air temperature fell below 16°C, and maximum activity was typically noted at temperatures of about 19°C+ (Clements and Skidmore, 1998). Mating behaviour observed in Wales was broadly similar, with no perceptible courtship. There is also evidence that mating interceptions can result in one or other of the pair becoming a prey item, rather than in copulation.

5.4 Copulation behaviour

Following the successful 'capture' of a female by a male, the pair would settle either on the ground or on vegetation. At Jugglers Moor copulation was observed on the ground amongst grasses and in bracken up to a height of two metres. At Worgret Heath SSSI copulation was observed on the ground, in bracken, on gorse, birch , wood sage, and in hawthorn *Cratageus monogya* up to a height of three metres.

On Thursley Common NNR, copulation was observed on horse dung and around rabbit latrines.

When copulating, the male would typically cover the female by holding onto the sides of her thorax and gripping the tip of her abdomen with his. Both would remain almost motionless, except for slight movement by the tip of the males' abdomen. If the copulating pair were disturbed the female would take flight, leaving the male to cling on

with just the tip of his abdomen. The male could be observed dangling beneath and behind the female, with the female always leading the way. On landing again the male would immediately correct himself and continue to sit atop the female. At Thursley Common NNR pairs were observed in flight flying in tandem with the male (presumably) on top of the female. At Jugglers Moor, copulation was observed on two occasions. On the first occasion , the pair were on the ground. The female then flew to bracken stems five metres away and the copulation continued. The pair then flew again into taller bracken to a height of two metres, where copulation continued. A foraging juvenile wren *Troglodytes troglodytes* disturbed them here, and the pair then took off to a great height and over a three metre high hedge dividing meadow 1 from meadow 2 and out of sight. This period of copulation lasted for ten minutes until the point at which they flew out of sight.

The second observation at Jugglers Moor involved a pair again copulating on the ground, after the male had made a successful dart out from a No.3 cow-pat. They remained almost motionless on the ground for 50 minutes. This period of copulation was only punctuated by an occasional move by the female, but the distances she moved each time were under 50cm. Following the copulation the male disengaged himself and both individuals flew off in opposite directions, and out of sight.

On Worgret Heath SSSI, a pair was observed copulating for 54 minutes, beginning first on the ground and then moving onto dead bracken stems, wood sage and leggy gorse before the pair finally disengaged. A second pair were observed copulating in the grass before moving into a hawthorn tree to a height of three metres, and finished their copulation in gorse some 4m away from the hawthorn tree. A third pair were also seen to move between copulating in gorse, birch and hawthorn, and other pairs were observed copulating on bare ground.

A casual visit to Hartland Moor, Dorset (SY943855) by B.J.P. with S.R. Prowse on 17 August was rewarded with a sighting of a male and female copulating on bare ground, while a second male was gripping the thorax and abdomen of the copulating male (in the typical mating position). This group was observed for some minutes before the copulating pair flew away and out of sight, while the additional male was left behind. Photographs of this event are held by both observers.

Similar copulation events are reported from Wales.

5.5 Oviposition behaviour and selection of oviposition site

At all three sites females were observed ovipositing in dung, bare soil, vegetation litter and beneath or around rabbit pellets.

On Worgret Heath SSSI, females were observed ovipositing on 2 August and 10 August amongst a mixture of loose gorse litter and sandy soil, and under small twigs in the vicinity of a large number of rabbit droppings, some of these droppings being fresh No.4 or No.5 pellets, and others being older and drier (Nos. 2/3). Both instances of ovipositing lasted for approximately ten minutes.

On Jugglers Moor, females were observed ovipositing on a number of occasions. On 12 August a female was observed walking around the edges of a No.2 cow-pat in an open

exposed sunny position and seemingly inspecting or assessing its suitability before then spending approximately ten minutes probing the outside edges of the cow-pat with the tip of her abdomen, pausing often to 'pump' the tip of her abdomen into the friable dung around the extreme edges of the pat. When she had finished she flew away out of sight. A second female was observed during the same visit, only this time she did not inspect the cow-pat (which was a No.3 pat, again in an open sunny position) but began ovipositing immediately on landing, and again kept to the extreme edges of the pat where the most friable dung was to be found. Another female was observed ovipositing on 21 August, again around the extreme edges of a No.3 cow-pat which was heavily shaded by a tussock of *Juncus*. This observation lasted approximately ten minutes during which time her abdomen could clearly be seen to be pulsing rapidly, after which she rested on the pat for two minutes before flying away out of sight. A second female was observed ovipositing during this visit, and she was observed to oviposit in four different No.3 cow-pats, which were all within an area of 20m diameter and all in open exposed and sunny situations. Each time she was observed ovipositing she was using the most friable dung around the extreme outside edges of the cow-pats. On 10 September a female was observed in meadow 2 to oviposit over a period of fifteen minutes in three different places. In the first instance she oviposited around the edges of a No.2 cow-pat surrounded by bare soil. Immediately after finishing here, she moved one metre away and began to oviposit in an area of bare soil which had been dredged from the stream in the winter of 1996/97 and contain some cattle dung which has been well trodden in. Here she proceeded to oviposit in an area measuring approximately 1.5m by .5m, working the whole area and leaving almost no area of soil un-touched, deliberately stopping on two occasions to straddle two of the five rabbit droppings present and ovipositing beneath them. She then paused for a few moments and expelled two drops of white liquid from the tip of her abdomen before flying one metre away to oviposit around the edges of a No.3 cow-pat which was heavily shaded by grasses. She then flew away out of sight.

One female was also observed attempting to oviposit around the edges of a No.1 cow-pat but gave up after a few moments when she was unable to insert her abdomen into the substrate.

On Thursley Common NNR, females were observed on two occasions (as they have been in previous years) to oviposit underneath rabbit dung which was of grading No.1/No.2. In these locations the females have been clearly observed to insert the tips of their abdomens into the sand immediately beneath the pellets. The full implications of the large amounts of horse and limited amounts of dog dung in adult *Asilus* ecology at Thursley remains unresolved. No oviposition was observed in either type of dung. The disturbance of the tracks is such that it seems unlikely that larvae could develop in horse dung, and the presence of chemical worm drenches in the dung may also be deleterious.

However, the role of hrose and dog dung in adult feeding is clear. Along the main bridleways, the dung strongly attracts adults which catch a lot of prey around it, for instance *Onthophagus similis* regularly falls prey as it arrives at the dung. The bare sand on the tracks is also favoured for basking, especially new dung. However, adults are no more abundant on tracks without dung than on the surrounding open heath.

Observations in Wales confirm a general preference for the edges of dry dung-pats for oviposition, as well as oviposition on grass stems, very near soil level and standing near

the edge of cow-pats. Oviposition may also have been observed directly into soil away from dung, but this has not been confirmed.

5.6. Predatory behaviour by adults

On Jugglers Moor, No.3 cow pats were most frequently used by the adult flies as hunting posts, feeding and sunning sites, and oviposition sites by the females. Horse and dog dung were both used as hunting posts on Thursley Common NNR.

Asilus adults seem to spend long periods observing insect activity from a prominent perch such as a dung pat, mole-hills or raised pieces of dead woody vegetation. This was presumably to give them a raised vantage point from which to hunt. When the adults appeared to be in a hunting position, they would sit with their forelegs raised from the surface of the substrate where they were perched. If, however, they were not poised ready to hunt, they would sit with all legs resting on the substrate. The adults at each site were observed to be most aerially active in temperatures above 20°C. At both Jugglers Moor and Thursley, no adults were seen in temperatures of 18°C, but when this had risen to 19°C adults had appeared on cow-pats at Jugglers Moor and were easier to capture and mark. When the temperature had risen to 20°C, the adults were far more active, and considerably more difficult to capture. This was observed also at Worgret Heath SSSI. When sunning themselves the adults were observed to rest sideways to the sun in the manner of some butterflies, such as the grayling *Hipparchia semele*.

When observing *Asilus* eating prey it became apparent that after finishing the meal, the *Asilus* would often take-off vertically and discard the food item by deliberately throwing it away from where the feeding had taken place. One unmarked female was watched closely at Jugglers Moor on 28 August feeding in meadow 5 on a beetle, while resting on a No.3 cow-pat. When she had finished this beetle, she flew vertically and then dropped the husk 50cm away. After a few minutes, she made a short capture dart, and took another beetle and returned to the same cow-pat where she proceeded to eat it. After she had flown from sight, the beetle prey that she had fed on was recovered, and three other beetle husks were discovered on the surface of the cow-pat. From these observations, it would suggest that this had been a regular feeding spot for her, and that this cow-pat was maybe a central point in a territory. This female could not be caught for marking to see if this assumption was correct.

Observations in Wales confirm the use of dry cow-pats as 'hunting' platforms', used repeatedly by one individual as a site for basking, launching after prey/mates and for feeding. The finding of several previous prey items together on a single pat was a common occurrence. Other surfaces (an exposed limestone rock, a circular bare patch of soil) were also occasionally observed to be used in this manner. Capture flights up to one metre were observed.

It was apparent that when an *Asilus* was feeding on a large prey item, it was considerably more wary of movement (either human or insect) nearby, than when feeding on only a small prey item.

At Jugglers Moor on 21 August, a female *Asilus* was observed eating an *Aphodius* beetle while sitting on a No 3 cow-pat. During this observation, a rove beetle Staphylinidae spp, walked towards the feeding *Asilus* and started to grab at the *Aphodius* that she was eating.

The *Asilus* pulled her prey away and changed her position on the cow-pat. Again the *Staphylinid* attempted to grab the *Aphodius* and a 'tug-of-war' broke out, the *Asilus* eventually flew vertically up to a height of approximately 20 centimetres, and then re-alighted on the cow-pat. On landing the Staphylinid had gone and the *Asilus* proceeded to finish her meal.

The following lists show the range of prey items which we observed *Asilus* taking and eating during the survey period.

On Worgret Heath SSSI, the following prey items were observed being taken by D.R.Bird:

In 1996, an *Asilus* was observed taking and eating another *Asilus*. In the survey period in 1997, *Asilus* were recorded taking and eating mottled grasshopper *Myrmeleotettix maculatus*, and a *Chorthippus* spp. grasshopper. The dung beetles *Aphodius fimetarius* and *Aphodius erraticus*. A possible horntail *Uroceros gigas*, various *Scathophagid* and *Calliphorid* flies and other small Dipterans which could not be identified.

On Jugglers Moor, the following prey items were observed being taken by B.J.Pinchen:

Asilus were recorded taking and eating meadow grasshopper *Chorthippus parallelus*, field grasshopper *C. brunneus*, the dung beetles *Aphodius fimetarius*, *Aphodius fossor*, *Sphaeridium lunatum*, *Onthophagus similis*, and *Hister unicolor*. Various *Calliphorid* and *Scathophagid* flies were also recorded, and the hoverfly *Rhingia campestris*, as well as other smaller unidentified Dipterans.

On Thursley Common NNR the following prey items were observed being taken by Dr. J.S.Denton:

Asilus were recorded taking and eating mottled grasshopper *M. maculatus*, another *Asilus*, the dung beetle *Onthophagus similis*, *Sarcophaga* and *Calliphorid* flies and various unidentified Dipterans.

Observations in Wales indicate the taking of tipulid craneflies, *Sarcophaga* flies, various hoverflies and the damselfly *Lestes sponsa*, in addition to most of the species listed above (Clements and Skidmore, 1998). Other published reports include the taking of butterflies (Lycaeanidae) bees and wasps (Hymenoptera).

Asilus is occasionally eaten or disturbed by other animals. In 1994 J.S.D. saw a downy emerald dragonfly *Cordulia aenea* catch and eat an adult *Asilus* on Thursley Common NNR. When disturbed, *Asilus* usually returned to the same dung pile shortly afterwards.

Observations in Wales indicate that basking *Asilus* adults may be displaced from their pats by *Sympetrum* dragonflies and, on one occasion, by a chirping meadow grasshopper *Chorthippus parallelus*.

5.7 Larvae

At Worgret Heath SSSI a search for *Asilus* larvae was made in early November, by digging the soil in ten different areas with a trowel at depths of up to 15cm. A number of searches were made in areas where both adult flies and puparia had been found during the survey period, and where rabbit droppings were most abundant. No *Asilus* larvae were found during the search and no larvae of Coleoptera or other Diptera were found either.

Burrows of what are assumed to be minotaur beetles *Typhaeus typhoeus* were present at Worgret Heath SSSI, and some of these will be checked by D.R.B. during spring 1998 for the presence of any *Asilus* larvae.

At Jugglers Moor a cow-pat in meadow 2, where a female *Asilus* had been observed apparently ovipositing on 10 September, was dug up on 28 November with the surrounding spit of soil, to a depth of 20cm. The whole cow-pat and spit of soil were removed from the site and carefully excavated, and a search for *Asilus* larvae made.

During the process of the search, larvae of Coleoptera (Geoptrupidae and Scarabaeidae) and Diptera were found, along with the slug *Arion ater* agg., numerous Nematoda spp., Chilopoda spp, nymphal earwigs *Forficularia auricularia*, two Clubionid spiders and an adult rove beetle Staphylinidae spp. No *Asilus* larvae were found. The soil that was removed has been placed in the garden of the English Nature Office at Lyndhurst and will be monitored next year in case any *Asilus* larvae were present and were overlooked during the search. The Coleoptera larvae are being kept and will hopefully be reared out to adults.

No free-living larvae have been found by the Welsh survey in 1997, but a captive larvae reared from an egg hatched in August has been successfully kept in a small container of dung until at least early December. The larva has hardly grown during this period (2.5mm long at hatching; 3mm long by December), despite being kept indoors at room temperature, suggesting a slow rate of growth. Feeding by first instar *Asilus* larvae on nematodes present in the dung is postulated (Clements and Skidmore, 1998).

5.8 Exuviae

Exuviae of *Asilus* were found in quantity at both Thursley Common NNR and Worgret Heath SSSI. None were found at Jugglers Moor. The abundance of exuviae findings at both Worgret Heath SSSI and Thursley Common NNR and the absence of finding any at Jugglers Moor may be attributable to those sites having very little ground vegetation cover making exuviae easier to find, whereas Jugglers Moor has a reasonable cover of vegetation. Table 1 shows the drop disc measurements and the vegetation cover/density for this site..

Exuviae were either found lying on the soil surface, where they can easily be blown away by light winds, or they were found protruding from the soil head-first.

At Worgret Heath SSSI, D.R.B. collected and measured twelve exuviae, and the sizes of these were compared to those collected and measured by Melin (1923) and Xambeu (1901). At Worgret Heath SSSI, D.R.B. recorded an average exuviae size of 23x6.5mm.

Melin, with access to only one exuviae, recorded the size as being 20x5mm, while Xambeu gave the size as 25x5mm.

At Thursley Common NNR, adults emerged from at least 40% of rabbit latrines, as shown by the distribution of exuviae (Map 6). Minotaur beetles and *Asilus* use the same areas of ground. Of the sites where an *Asilus* exuviae had been found, 12 were selected at random and marked on 17 August for future monitoring. At this time, *Typhaeus* was inactive, being between generations. Six weeks later (28 September), large numbers of beetles had already constructed burrows and gathered many pellets from around the rabbit latrines and horse dung from the paths. There were from 3 to 12 *Typhaeus* burrows within 40 cm of each *Asilus* exuviae (median of 5-6 burrows).

The abundance of *Typhaeus* burrows around the barer sandy patches created by the rabbits around their latrines was remarkable. Indeed few rabbit pellets remained on the surface, where they had been abundant before the minotaurs emerged. All the *Asilus* exuviae found during the autumn activity period of *Typhaeus* were less than 10 cm from a *Typhaeus* burrow. These burrows were present, albeit at much lower density, over much of the open heath but the clumped distribution of *Typhaeus* burrows around bare sand patches correlated strongly with the presence of *Asilus* exuviae and adults.

Typhaeus also gathered horse dung from the paths. Burrows were situated at the stable edges of the bridleways but the dung was already trampled and dispersed. *Geotrupes* burrows were also found along the bridleways but with one exception were in shady areas where *Asilus* had not been recorded.

One *Asilus* exuviae was found during the Welsh study in 1997. This was found lying on the surface of a cow-pat, but had fairly evidently either been dropped or blown into this position. Observations of other Asilid species have indicated that newly emerged adults sometimes fly with the exuvium temporarily attached to the legs, presumably having failed to disengage properly (Skidmore, pers comm).

6. Conclusions

Some important findings of this study are:

- *Asilus* adults make use of dung as an oviposition site, as perches for hunting and basking, and indirectly as an attractant for coprophilous prey. All types of dung are used as perches.

- The dung used for oviposition so far appears to be only that of cattle and rabbit but not of horse or dog. Females lay eggs only in or under the edges of older, drier cattle dung and under dry rabbit pellets. Occasionally, females will oviposit in dung-contaminated soil.

- The food of larvae remains unknown but the co-occurrence with minotaur beetles is strong, even though no direct association has been shown.

- Adults of both sexes move around within discrete home ranges about 25 m in radius. The range is usually centred on a dung source. They can move and return over longer distance, up to 400 m being measured. Individual flies often use the same hunting perch for long periods.

- On the two heathland sites, large rabbit populations appear to be very important for *Asilus*, providing a permanent dung source which is fairly static over time. The latrines are semi-permanent features which the rabbits keep open and almost bare of vegetation.

Management implications

On cattle-grazed pastures, the timing of grazing must coincide with the emergence and oviposition period of *Asilus*, that is from early July (males) to late September. Continuity from year to year is also essential within a complex of meadows not further than perhaps 500 m apart (although whether adults will cross inhospitable terrain is not known).

On heathlands, rabbit populations must be maintained if there are no cattle. Until it can be shown that *Asilus* does not use horse or sheep dung, this advice cannot be extended to encompass all livestock. Fires appear to benefit *Asilus* indirectly by creating open areas that rabbits invade. The amount of available *Asilus* habitat has increased at Thursley Common recently as a result of several large fires. Management prescriptions for woodlark *Lullula arborea* is also suitable for *Asilus* except that the value of sheep in place of rabbits needs to be evaluated (English Nature, 1997).

7. Recommendations for further work

It is clear from the survey work that has taken place this year that more work still needs to be done to ensure that the full autecology of the species is understood, and in order that better protection and management of the current sites where *Asilus* occurs can be carried out. This would also enable prospective dispersal sites to be managed in a way that will be favourable to both *Asilus* and other invertebrate species.

Monitoring of the colonies studied for this report should be continued to assess population changes and site use by the species, to determine how any future changes on the sites affects the populations of *Asilus*, and whether the adults appear in cycles which vary from year to year.

The minimum site area needed to support a viable population, and dispersal ability are unknown. These can be investigated by marking, where possible, all adults in a colony, and exploring suitable habitat nearby to search for these marked specimens. Certainly at Jugglers Moor there is suitable habitat within half a mile which could quite possibly be colonized.

More work needs to be carried out to assess accurately the range of habitat types that can be successfully used by the species.

Despite the observations from this report and the parallel Welsh study, it is still not clear how the use of dung fits with the fly's life cycle. The purported predation on dung beetle

larvae has not been confirmed. Why do some females oviposit in the edges of dung (Jugglers Moor), while others oviposit beneath it into sand (Thursley Common NNR), or in a mixture of loose soil/dead plant litter (Worgret Heath SSSI and Jugglers Moor)? Is the dung used only as an incubation site for the eggs through the heat generated, or is it used simply because it is a friable substrate into which the female can easily penetrate with her ovipositor? This might explain why cattle dung of the drier No.3 types are used, and even then only the extreme outside edges. What is the total range of dung types used for oviposition? Are only omnivorous species used or preferred or is the dung of carnivores used?

The use of the dung of horses and sheep needs to be investigated on sites where rabbits and cattle are absent.

Structural features that lead to high densities of *Asilus* need investigating. These include vegetation structure and hydrology of damp sites.

8. Acknowledgements

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Appendix. Additional records and sites

A number of other sites where *Asilus* were observed during the summer 1997 and in previous years were reported, and the locations and observers are listed below:

Toms Down, North Solent NNR, Hampshire. B.J. Pinchen.

A single female observed on dry heathland, adjacent to short turf grazed pony paddock. Seen on one occasion only. GR. SU454016. 20 August 1997.

Stanswood Valley, North Solent NNR, Hampshire. B.J. Pinchen.

A male and a female observed sitting on No 3. Cow pats approximately 600 yards apart. This area is an enclosed valley mire with Molinia/Heather dominant ground vegetation, and remains wet throughout the year. GR. SU462013. 11 September 1997.

Holmsley Bog , New Forest, Hampshire. S. Cottell.

A single specimen seen and photographed by the observer. Sexing the specimen was impossible from the poor quality of the photograph.

Another wet valley mire Molina/Heather site which remains wet throughout the year. GR. SU220013. 12 August 1997.

Martin Down NNR Hampshire. S.R. Prowse.

Three individuals seen, all resting on mole hills amongst the short grass sward. GR. SU056185. 9 September 1997.

Cholderton, Near Salisbury Wiltshire. Dr D. Sheppard.

Reported as being common and present for a number of years, by the farm owner, Mr Henry Edmunds, mostly seen in short turf amongst livestock. GR. SU2342. August/September 1997.

Bridport Area, Dorset. J.R. Cox.

"A few seen in a pony grazed paddock on the western edge of Bridport". approx. GR. SU4593. 19 September 1997.

Winfrith Heath, Dorset. M. Parker, via D.R. Bird.

A heathland site with no cattle grazing. *Asilus* reported on 6 August 1989, and several seen on 5 September 1994. GR. SY8087.

Knowle Hill, Wool, Dorset. B. Taylor via D.R. Bird.

Reported as "a solitary specimen a male, was taken by B.Taylor in a neighbours garden in Wool and was obviously a stray". 30 July 1985. GR. SY8486.

Keysworth Farm, North of the River Frome, Dorset. M. Parker, via D.R. Bird.

A large colony on a dry acid grassland site with cattle grazing, although no cattle were present when *Asilus* was recorded. This colony is at risk if a proposed bypass (Sandford and Northport) goes ahead. 6 August 1994. GR. SY9389.

Weatherby Castle, Dorset. M. Parker, via D.R. Bird.

A strong colony on cattle grazed chalk grassland. GR. SY8096. 26 August 1996.

Hog Hill, Dorset. M. Parker, via D.R. Bird.

A colony on a cattle grazed chalk slope. GR. SY6688, recorded on 15 September 1985 and 31 August 1996.

M. Parker records the species as being noted at the following Dorset sites also: Sutton Poyntz GR. SY7084, Bere Regis bypass embankment GR. SY8495 and Kingcombe Meadows GR. SY5599, no indication of colony sizes or dates are given.

Meon Valley Area, Hampshire. M. Finnemore, B. Proctor.

Reported from Old Winchester Hill NNR, GR. SU6420. and Beacon Hill NNR GR. SU6022. Soberton Down GR. SU6116.and from "grazed fields along the River Meon at Soberton, Droxford and Meonstoke"

Yew Hill, Near Winchester, Hampshire. J.H. Taverner.

A Butterfly Conservation chalk grassland reserve. Approx. 20 *Asilus* recorded on 21 August 1997. GR. SU4526.

Hartland Moor, Dorset. D.R. Bird.

A female observed presumably ovipositing in sandy soil near to cattle dung. GR. SY946857. 12 August 1997.

Single female seen on sandy track. GR. SY941810. 4 September 1997.

Arne, Dorset. D.R. Bird.

Small colony present to the West of the RSPB nature reserve car park. GR. SY972878. 28 August 1997.

Stoborough, Dorset. D.R. Bird.

Singles seen on trackway embankment and cattle dung. GR. SY937855. 15 August 1997.

Soldiers Road, near Stoborough, Dorset. D.R. Bird.

A pair observed copulating in short turf. A cattle and pony grazed heathland site. GR. SY940980. 16 September 1997.

Witley Common, Surrey. Dr J.S. Denton.

Two adults seen near cemetery, both near dog dung. One male also seen on parade ground. GR. SU9340. 9 July 1997.

Marwell Farmhouse, Hamsphire. Near Owlsbury. Dr J.S. Denton.

Single specimen reported from meadows. GR. SU513216. 10 August 1997.