THE USE OF THE BUTTERFLY TRANSECT METHOD FOR THE STUDY OF THE NOCTURNAL MOTH *Luperina nickerlii leechi* GOATER (LEPIDOPTERA: NOCTUIDAE) AND ITS POSSIBLE APPLICATION TO OTHER SPECIES

Published in Biological Conservation 80 (1997) 147-152

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Abstract

Results are presented from a survey of the nocturnal moth Luperina nickerlii leechi *Goater using the well-established butterfly transect method adapted for use at night. This subspecies is in the British Red Data Book* 1 (*Endangered) and is included in the UK list of globally threatened/declining species. It is found only at one site (in Cornwall) where it forms a small closed population, apparently restricted to where its larval foodplant* Elytrigia juncea (*L.) Nevski grows. Recording at night was achieved by counting resting moths on the first transect pass and flying moths on the return transect. Transect moth counts varied from year to year and were used to provide an annual Index of Abundance. The distribution area where* Elytrigia juncea *dominated the vegetation within the transect and over the whole site was measured and used by comparison with transect counts to provide an annual Population Index, taken at the peak flight period. Capture/mark/recapture surveys were used to give an estimated total site population on one night. Transect counts were generally too low to provide significant indices of abundance. whereas the annual Population Index provided a more meaningful reflection of annual changes in abundance. The usefulness of this method for assessing populations of other nocturnal moths is considered, both for single species and multiple species recording.*

Keywords: *Luperina nickerlii leechi,* moths, nocturnal transect, population index and abundance index.

INTRODUCTION

Luperina nickerlii is a rare moth in the British Isles, being found here as four distinct subspecies each separated by at least 320 km (Heath & Emmet, 1983; Goater & Skinner, 1995). The subspecies *leechi* is classed as Red Data Book I Endangered (Shirt, 1987) and has only been found at one site in Cornwall. It is listed as a key species in the UK Biodiversity Steering Group Report (1995). *L. n. gueneei* (RDB2) occurs in large populations on sand dunes in Wales and Lancashire; *L. n. demuthi* occurs in extensive colonies on the salt marshes of Suffolk, Essex and Kent; *L. n. knilli* occurs on the coast in Ireland. On the Continent, *L. nickerlii* occurs mainly inland (Goater & Skinner, 1995).

Previous research on the population of the sandhill rustic moth *Luperina nickerlii leechi* in Britain has concentrated on its ecology and behaviour (see Goater, 1976; Spalding, 1991*a)* and some population estimates (Spalding, 1991*b).* It occurs on a sand and shingle beach measuring about 500x240 m (Spalding, *1994a),* where it forms a closed population. The restriction of the moth to this habitat makes it a good subject for long-term study. The eggs are laid within sheaths of sand couch *Elytrigia juncea* (L.) Nevski; the larvae live at first inside the grass stems and then underground, where they feed on the roots before pupating. The adult moth rarely flies (Goater, 1976) and is most often seen resting, usually on the stems of its foodplant; out of 371 resting adults recorded between 1987 and 1989, 320 (86%) were seen at rest on *E. juncea* (Spalding, 1991*a).* This grass is widespread on the beach where it occurs in clumps (Spalding, 1994*b)* connected by underground rhizomes. However, previous work by the author has indicated that surveys can be limited to areas of loose sand/shingle where *E. juncea* grows largely as a monoculture (Spalding, unpubl. data), so that colony boundaries are clearly defined. Some mark/recapture studies have been carried out in previous years with limited success (Spalding, 1991*b)*. Typically, moth populations can be very low, sometimes 100-500 individuals (e.g. Kozlov, 1995), and variable (e.g. Sheppard, 1951), so that the small numbers found here are not surprising. However, the population of *Luperina nickerlii leechi* at this site is likely to be low compared to typical populations of those moths associated with more abundant biotopes such as semi-improved grasslands.

L. n. leechi comes readily to light-traps (especially actinic lights (Spalding, 199I*a)),* but only in windless conditions which are unusual at this site; the other British subspecies appear to be more robust, fly more often and come more readily to light. However, effective light traps are generally unsuitable for studying the ecological requirements of moths since they rely for their success on the disturbance of normal behaviour. It was, therefore, decided to use the butterfly transect method to monitor *L. n. leechi,* modified for use at night.

The Butterfly Monitoring Scheme has been one of the most successful methods of measuring changes in the status of British butterflies (Pollard *et al.*, 1986). It involves the establishment of a transect 5 m wide which runs through the chosen site (e.g. a nature reserve) and crosses the major habitat types present, so that the whole area is sampled. All butterflies seen within the transect or 5 m ahead are noted (Hall, 1981). Weekly transect counts are taken for each species and the Index of Abundance calculated from the sum of the weekly means (Pollard *et al.,* 1986). The transect system can also be used for making total population estimates of a single species on site, both for the adult stages (Thomas, *1983a;* Warren, 1987) and larval populations (Thomas & Simcox, 1982). Several studies have shown that there is a good correlation between transect counts and population estimates for the same site using capture/ mark/recapture techniques (e.g. Pollard, 1977; Thomas, 1983*a).* Population estimates of day-flying Zygaenidae have also been made by using a variant of the transect method (W. G. Tremewan, pers. comm.). It is important to ensure that the transect representatively samples the whole site and that the total flight area is recorded. More than one pass along the transect may be necessary, e.g. for Zygaenidae (N.O.M. Ravenscroft, pers. comm.). Variations on the transect methodology have been used for nocturnal moths, e.g. for species richness and diversity in relation to altitude (Herbert, 1980). The present survey uses an adaptation of the butterfly transect system, probably for the first time, by working at night without light-traps for adult moths. It is hoped that the monitoring system can be extended to other sites where *Luperina nickerlii* occurs so that national trends can be established.

METHODS

The survey consisted of five parts: (1) the establishment of a transect count to give an Annual Index of Abundance); (2) the measurement of the area of the foodplant *E. juncea* within the transect and over the whole site; (3) moth counts for the whole site (a combination of (2) and (3) provide an annual Population Index); (4) a capture-mark-recapture survey to give an estimated total site population on one night so that the annual Population Index might be related to absolute numbers; (5) the recording of other moths along the transect to see if this method was suitable for night-flying species.

Transect counts and measurements

The site where *L. n. leechi* occurs is divided into two sections (north and south), either side of a dry unvegetated area where in 1984 flood water scoured out a channel. A transect running SSE to NNW and 464 m long by 10 m wide was established in 1994 and crosses both sections to include the main colonies of *E. juncea,* making use of permanent site features to ensure consistency of orientation from year to year. Searching for moths resting on the low-growing vegetation was by powerful battery-operated searchlight. The same transect was used in 1995, when the transect was also monitored on a return journey, this time for flying moths using the searchlight to search the air up to 3 m high. Moths recorded were caught using a net (some settled on the ground).

Monitoring began on 19 August in 1994 and 14 August in 1995 (1995 was generally an early season for Lepidoptera) and continued until no more moths were recorded along the transect (12 September 1994 and 31 September 1995). The transect was started at 23.00 h, previous work having indicated that this was the time of peak numbers (Spalding, 1991*a).* The transect was monitored every third night regardless of the weather, except for 3 nights in August 1995 when the sampling was done a day early (17, 21 and 24 August). The 3 night interval was chosen because previous work (Spalding, 1991*b)* had shown that some *L. n. leechi* live for at least three nights in the wild. Readings were taken of temperature, wind speed and direction, cloud cover and whether it was raining, all of which can affect moth activity (no readings were taken on 17, 21 and 24 August 1995). The sex of each moth seen along the transect and throughout the area was determined by inspection of the abdomen (and in difficult cases by inspection of the antennae).

The whole area was searched for moths at the height of the flight period, which is generally *c.31* August (Spalding, 199I*b),* and the total compared to the transect count. The main areas where *E. juncea* was a monoculture were measured on 29 September 1994 and 7 October 1995 by pacing (1 pace = I m); the positions of these areas on the site were sketched and the area within the transect was calculated as a proportion of the total.

Population estimates using capture/mark/recapture

In 1995, capture-mark-recapture experiments were conducted in order to estimate life span in the wild and to estimate total population numbers at the height of the flight period (to provide back-up figures for the transect results). The population was estimated from a C-M-R survey (the Petersen method, described in Krebs, 1989) by catching and marking specimens in the first part of the night and recapturing later the same night; surveying during a single night was designed to increase recapture rates. Other methods (e.g. Craig (1953) modified by Eberhardt (1969) were rejected because of previous low recapture rates here (12 out of 372 during 1987-1989) and the low mobility of the moths. Although single census mark-recapture methods can generate large biases (Gall, 1984), they do avoid repeated disturbance which can reduce recapture frequency (Morton, 1982). The capture of insects for marking can result in changes of behaviour (Singer & Wedlake, 1981), but most of the moths were marked without disturbance by applying ink while they were resting. Following a suggestion that bird predation may have been a factor in reducing recapture rates in previous years, marking procedures were modified in 1995 by painting the underside of the abdomen where marks cannot be seen by birds. A different colour was used for moths caught in the northern and southern areas, and different colours for different nights. All moths seen were marked (at least 50% of the individuals in a population should be marked (Roff, 1973)). On 31 August 1995, the site was monitored twice, using different marker colours, to provide an estimate for the total population on that night. C-M-R surveys were also carried out on 29, 30 and 31 August, with subsequent recaptures on 1 September to provide estimates of residence time in the wild.

Data analysis

The mean transect count was calculated for each 3-day period and the Index of Abundance calculated from the sum of these means. When a count was missed, the total was estimated by taking the mean of the two adjacent counts. Counts for 1995 included numbers from the return transect during which counts of moths in flight were taken.

The Population Index was provided by a modification of the method used by Thomas *(1983a):* Population Index $p = 100NA/T$, where N = moth count on each transect expressed as numbers per 100 m^2, A = distribution area of *Elytrigia* on the site and T = distribution area of *Elytrigia* in the transect. The Population Index was calculated for the night each year when the transect count was highest.

RESULTS

The Index of Abundance calculated was 30 for 1994 and 78.5 for 1995, based on the results of the mean transect counts (Fig. 1). The counts for 1995 include results from the return transect; only eight *L. n. leechi* were seen in flight (seven of these when wind speed was below 5 m/s). The total distribution area of *Elytrigia* increased between 1994 and 1995 from 5167 to 10,120 m^2, an increase of 96%; that within the transect decreased from 1315 to 1021 m^2 (a decrease of 22%). The observed numbers of *L. n. leechi* within the transect and over the whole site at peak flight period were 11 and 33 respectively in 1994 and 12 and 32 in 1995. The Population Index for 1994 was 100x0.84x5167/1315 = 330, and that for 1995 was 100x1.18x10 120/1021 = 1170.

The C-M-R survey on 31 August 1995 resulted in nine (10%) recaptures out of 88 moths seen, a higher recapture rate than previously achieved. Using a variation on the Petersen method (Seber, 1982), this gives a total population estimate of 244, with 95% (binomial) confidence limits of 150-600 (Krebs, 1989). Total recaptures between 30 August and 1 September were 16 (3 males and 13 females); one female was recaptured twice (marked 29 August, recaptured twice on 31 August). Two females marked on 30 August survived until 1 September. No recaptures were made 3 or more nights after initial marking.

Total counts of *L. n. leechi* for 1994 (one count) and 1995 (5 counts) are given in Table 1. The largest count was made on 1 September 1995. The ratio of total count to transect count for the same night can be used to provide a quick 'rule of thumb' method for calculating total counts for other nights when only the transect is counted.

Other species (31 individuals) were recorded on the return transect, with a peak of 11 moths on 30 August 1995.

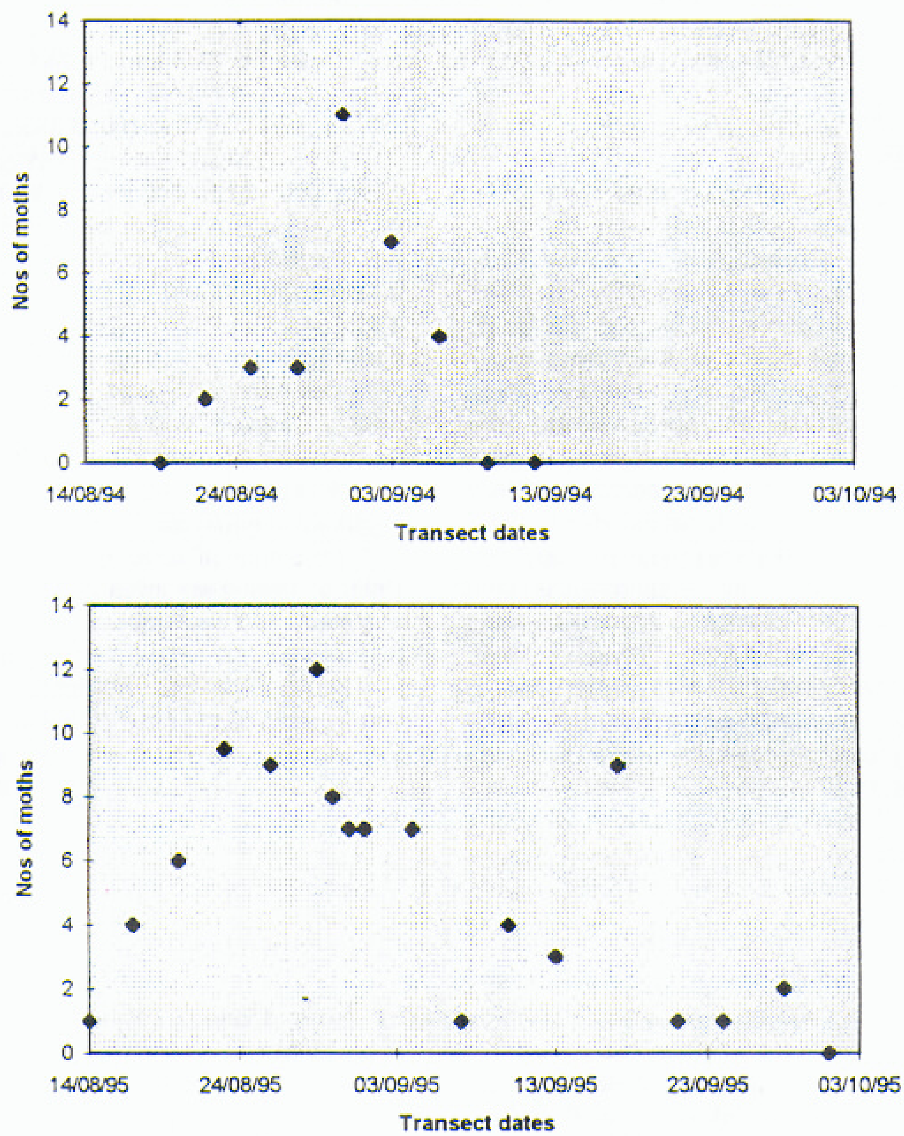

Fig. 1. Transect counts of *Luperina nickerlii leechi*: (a) in 1994; (b) in 1995.

DISCUSSION

Estimates of abundance and population size for *L. n. leechi*

The annual Indices of Abundance - 30 for 1994 and 78.5 for 1995 - represent an increase by a factor of 2.62. However, low transect counts (e.g. 11 in 1994, 12 in 1995) make it difficult to attribute real significance to the results. Transect counts below 40 are considered by Thomas (1983*a*) to be inaccurate; in 1995 only three total site counts were above this figure - 48 and 60 (Table 1) and 49 during the second part of the C-M-R survey on 31 August.

Using numbers recorded in the transect compared with total site counts to estimate total populations (see Warren *et al.*, 1984) has not proved a satisfactory method for *L. n. leechi* as the site/transect count ratio was too variable (Fig. 2) to be reliable; this might be due to low numbers on the transect or because of variable weather patterns. C-M-R results in 1995 were more successful than previously, with a 10% recapture rate. Four moths survived 3 nights, confirming previous life span estimates (Spalding, 1991*b)*, although moths in captivity have been shown to survive for up to 17 days for females and 5 days for males (Spalding, 1994*a)*. It is unlikely that any moth was counted more than once during the regular transect surveys set 3 days apart. Low numbers of recaptures may be due to high predation, high rates of emergence during the marking period or failure to find individuals. Previous observation indicates that most emergence is early at night, and tests of marked captive moths have shown that they do not lose their marks. Increased recapture success following marking under the abdomen indicates that bird predation might be a problem. Whatever the reason, low recapture rates mean that C-M-R surveys are unlikely to provide accurate estimates of population changes. Thus transect recording may be a more accurate method of estimating population size for this species, as suggested by Thomas (1983a) and Morton (1984) for species that fly infrequently.

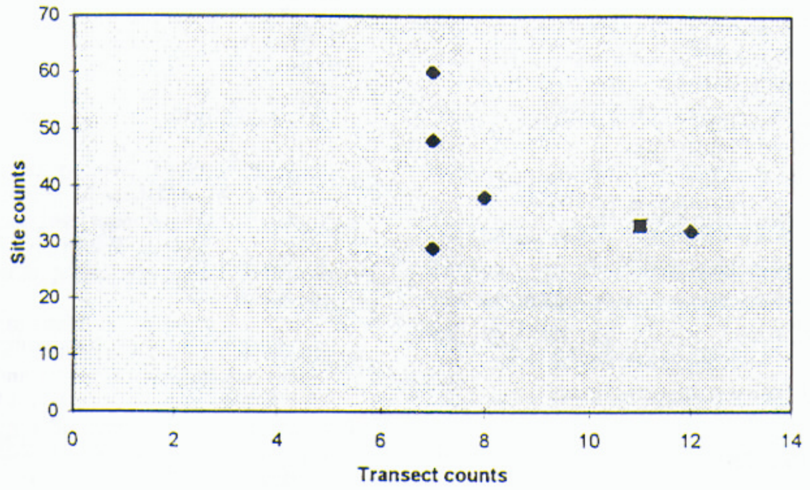

Fig. 2. Total site counts for *Luperina nickerlii leechi* compared with transect counts on the same nights; ■ in 1994; ◆ in 1995.

Table 1. Total site counts of *Luperina nicker/ii /eechi* (males and females) compared with transect counts on the same nights in 1994/95, to give estimated site/transect ratios

Date	Transects			Total site			Site/transect ratio
	Females	Males	Totals	Females	Males	Totals	
31.8.94	5	6	11	26	7	33	3.00
29.8.95	11	1	12	30	2	32	2.67
30.8.95	7	1	8	34	4	38	4.75
31.8.95	4	3	7	34	14	48	6.86
1.9.95	7	0	7	52	8	60	8.57
4.9.95	6	1	7	23	6	29	4.14

Transect results are particularly useful when incorporated into the Population Index. The calculation of the Population Index for each year is more complicated than calculating the Index of Abundance, but is likely to provide a more meaningful reflection of changes in abundance from year to year because of the large changes in abundance of the food plant. Preliminary survey results indicate that the moth numbers increased as *Elytrigia* recolonized large areas of bare ground (Spalding, 1991b). For several insects, links have been shown between numbers of adults and the total food resource, e.g. Dempster (1971), Dempster and Pollard (1981) and Ehrlich (1984) (but see Thomas, 1983b for an alternative view). Total site counts at estimated peak flight period show similar results for the two years (33 in 1994, 32 in 1995), even though the distribution area of *Elytrigia* had increased by 96%. This might be expected as colonization of new habitat will take place in the first year as larvae, followed by an increase in adult moths in the second year. In 1995 peak numbers almost certainly occurred later than in 1994 due to the extended flight period and consequently the 1995 count is probably a considerable underestimate. However, transect counts (summed to provide an annual Index of Abundance) are an easier field method, especially for other species where whole site counts and estimates of habitat areas are difficult to achieve.

The use of night transects for single species surveys

Single species surveys require a basic understanding of the ecology of the studied moth, so that transect parameters can be set according to the factors affecting the activity of that species. For example, during the flight period adults of *L. n. leechi* can always be seen on site, so that it is possible to gather transect data for these sedentary moths without reference to weather conditions. Only eight *L. n. leechi* were observed flying throughout the 1995 season, when wind speeds were below 7 m/s. On calm nights, the inclusion of records of *L. n. leechi* in flight complements the transect data. Identification during single species surveys (whether of resting, nectaring or flying moths) is generally easy because the behavioural characteristics of the studied species become very familiar and it can be easily distinguished from most other moths (e.g. the common *Agriphila tristella* is much smaller than *L. nickerlii* and flies differently). However, *L. n. leechi* and *Luperina testacea* have to be caught to be distinguished from each other. No trouble was experienced in catching flying moths within the transect. This technique is suitable for the study of *L. n. gueneei,* which has similar behaviour in its sand dune habitat. The ecology of *L. n. demuthi* is different as it occurs in saltmarshes where it feeds on common saltmarsh-grass *Puccinellia maritima* (Hudson) Parl.

The use of night transects for multi-species surveys

Standard parameters for multiple species should be set up, along the lines of the national butterfly transect scheme (e.g. Hall, 1981). A large number of different factors affect moth activity, including wind speed, cloud cover, moonlight, atmospheric pressure, temperature and humidity (e.g. Bowden, 1982), in addition to seasonality and flight activity during the night. These factors should be taken into account to ensure that moth activity is sufficient to provide meaningful results. Unlike butterflies, some moth species are active at all times of the year, so the seasonal parameters (1 April - 30 September) set for butterflies are unsuitable for all year-round surveys. Temperature threshholds set low enough to allow winter recording would be too low for summer use; they could be set as a sliding scale based on mean monthly temperatures. Surveys should be made during different parts of the night so that all species are recorded, e.g. dusk flyers, generalist species and late flyers. Standardization between recorders on the same site is essential. When setting up a multiple species transect, initial habitat surveys should be completed using moth traps and other methods to record the species present and to provide enough information to allow suitable transect pathways and recording methods to be established for the site.

The advantages of this method over light trapping are: (I) recording has less effect on the behaviour of the studied moths than the use of light-traps; (2) an Annual Index of Abundance can be established so that comparisons can be made from year to year; (3) if the area of suitable habitat for each species is known, an annual Population Index can be established; (4) the system is cheap and easy, requiring only a long-handled net and strong torch; (5) samples include moths that are not attracted by other methods such as light-trapping or sugaring. The disadvantages of this method include: (1) flying and nectaring moths are sampled while egg-laying females and sedentary species may be overlooked; (2) high-flying moths will not be recorded; (3) moths may be too numerous to identify easily on nights of high moth activity; (4) no weather parameters have been established for a national recording scheme.

ACKNOWLEDGEMENTS

It is a pleasure to acknowledge scientific advice from Mr W.G. Tremewan and Dr M.S. Warren, who both critically read this manuscript. Additional advice came from Dr R.L.H. Dennis and Dr N.O.M. Ravenscroft. I am grateful to two anonymous referees whose comments enabled me to improve this paper. I am especially grateful to Mr R. Howard and Miss C. Neil who provided invaluable assistance and pleasant company during the nighttime surveys.

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