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Second (Progress) Report
Field study of *Ctenotus lancelini*

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Summary

Survey of Lancelin Island reptile fauna have been undertaken in the Islands three main habitat types using eleven grids of nine traps (5 in rocky habitats, 4 on the large central dune, and 2 on the eastern foredune). Fifty-three *C.lancelini* have been trapped during seven trapping periods of 2-4 days duration conducted between mid-December 1993, and early March, 1994. A total of 59 *C.lancelini* have been marked, and 61 captures recorded (one animal dropped before marking, one recaptured once). Preliminary results suggest that all species of reptiles use all major habitat types, but there is considerable between-grid variation in capture rates. Adult *C.lancelini* have been caught on nine grids, and recent hatchlings on five grids.

Ctenotus species (*C.lancelini*, *C.fallens*) have been caught most frequently (85% of captures). Relative *Ctenotus* capture rates show a trend for some grids to have higher capture rates for both *Ctenotus* species. One grid on the eastern foredune stands out as having the highest capture rates for both *Ctenotus* and invertebrates. It is further characterised by having the largest amount of vegetation and, in common with other grids with relatively high *C.lancelini* capture rates, a protected north-eastern aspect. Capture rates for traps in rocky areas were generally quite low, except for one grid on the north-eastern slope of the large south-western patch of limestone. One trap in this grid had the highest capture rate of all traps, having caught 9 individuals. The only two grids with no *C.lancelini* captures were in rocky areas (one on the northern limestone patch, and one on the large southern patch).

Temporal variation in capture rates of *C.lancelini* was substantial, with adult capture rates declining since early January. Invertebrate capture rates also declined over this period. Recent hatchling *C.lancelini* have been caught since 20.1.94. Similar but less dramatic patterns are apparent for *C.fallens*. There appears to be some sexual dimorphism in *C.lancelini*, with larger females tending to have greater snout-vent length (SVL) than larger males. No *C.lancelini* captured have had SVL between 40 mm and 65 mm, suggesting that young animals attain SVL of ca. 65-70 mm during their first year.

Preliminary results suggest the species is not in immediate danger of extinction. A more comprehensive understanding of *C.lancelini* population biology is required before attempting an assessment of the impact of the decline of in the rocky areas on the viability of the Island population.

Introduction

This is the second report on the progress of field studies of *Ctenotus lancelini* on Lancelin Island. The studies commenced in late November 1993, and are expected to continue for at least another 12 months (although the current contractual arrangements bwetween CALM and BJ are only relevant for the period November 1993 to June 1994).

This report gives details of the trapping programme and evaluation of its performance based on the first few months of captures. Descriptions of grid and trap array are provided for the benefit of any subsequent island workers. Comments are made on field observations of *C. lancelini* , and on the preliminary view of the species breeding biology, status, distribution and habitat on the Island. Some results relating to *C.lancelini* biology are contrasted with data for *C.fallens* . Details relating to *C.lancelini* captures from the commencement of the study up to March 11, 1994 are given in Appendix, as are some field notes on Silver Gull activity.

The earlier hypotheses relating to the apparent decline of *C.lancelini* are evaluated with regard to preliminary results, and comment is provided regarding the potential for *C.lancelini* abundance to be altered as a consequence of habitat treatments outlined in the current Interim Management Guidelines (Burbidge 1993). Since the primary function of this report is to inform people of the progress of the study no statistical treatments of data have been undertaken.

Those who may wish to use the information presented herein should bear in mind that this report was prepared when the field study was at a very early stage. While the information about trap and grid locations will be of relevance throughout the study, other information or conclusions should be considered as tentative, and their validity checked by reference to subsequent reports (or to the author) before being quoted or otherwise used.

The trapping programme

Description of the traps used is given in a previous report (Jones 1994).

Trapping schedule

This report is based on seven trapping periods, which are referred to throughout this report as Trip 1, Trip 2, etc. The dates of the trips are as follows: **Trip 1**: 22-23 Dec., 93; **Trip 2**: 17-20 Jan., 94; **Trip 3**: 29-31 Jan.; **Trip 4**: 4-6 Feb., **Trip 5**: 14-16 Feb.; **Trip 6**: 25-27 Feb.; **Trip 7**: 9-11 March.

During trapping periods, traps were cleared throughout the day. Grids with higher capture rates were cleared more frequently (usually twice daily). Lizards in such small pits together cannot avoid each other, and there may be predation by larger individuals, so a major aim of the clearing schedule has been to minimise the duration of an individuals stay in 'popular' pits. Grids with lower capture rates have usually been cleared only once each day.

Invertebrate numbers were recorded after all pits have been opened for a period of 24 hours on each trip. Not all grids could be cleared at the same time, so this period was somewhat variable (22-28 hrs). Invertebrate numbers have been quantified according to the following rules: only animals with body length > 3mm are dealt with; classification is usually at the level of Order, but for groups with obvious species diversity the animals are further classified as big, small or tiny. Counts of the number of individuals of each group in the pit were of individuals if there were less than ten individuals, but if more than ten, numbers have been estimated in units of five (only 15 and 20 used to date). Some small rare taxa have not been counted during later trips (e.g. Pseudoscorpions). These counts are most easily done if there is very little soil/litter in pits. The aim of this data is to generate an index of relative invertebrate activity for comparisons between seasons or between sites.

Trap array

Initially ten grids of traps were used to sample reptile populations in different areas representing the three major habitat types, which together account for more than 90% of the Island's area. Preliminary results for these grids were used to evaluate the requirements of trapping in other areas. Subsequently three further grids were added during January and February, 1994. The position of the 13 grids is shown in Figure 1.

Preliminary results indicated that *C.lancelini* occurred in areas with either rocky or sandy substrates, and with a range of vegetation types. The proposal to place single traps or lines of three traps within minor habitat units (e.g. the rocky slopes) was abandoned in favor of employing further grids, since the grids were judged to be more likely to make useful contributions to the population studies.

The standard grid consists of nine traps, each about ten meters apart. Grids are numbered as Grid 0, Grid 10, Grid 20, etc., and traps numbered from 1-9 (e.g. trap # 1-9 are on Grid 0, 11-19 on the Grid 10, 21-29 on Grid 20, etc). Trap numbers start at the most southwestern corner of the grid (see Figure 1).

Additional traps are currently being added within some grids with higher capture rates for *C.lancelini* in an effort to more quickly increase the proportion of marked animals within such grids. Such traps have been placed on the basis of "this looks like a relatively good spot" and they are numbered with trap numbers appropriate for the grid number, but are identified by the prefix 'A' for additional. (e.g. A1-A5 are additional traps placed within Grid 0). (The position of additional traps should be checked by reference to subsequent reports, since more may be added in the future).

Over the summer period some traps were taken or pulled up (by recreational Island visitors), so not all traps could be used on each trapping period. Trap disturbance has been very low since late February, and hopefully the end of the summer holidays will be associated with a further decline in the abundance of children on the Island.

Evaluation of trapping techniques

A total of 60 *C.lancelini* have been captured and marked (57 were pit captures). Fourteen recently hatched *C.lancelini* have been trapped. For most of this period about eighty traps were in use. This result suggests the trapping design is functional for the study of the *C.lancelini* population as described in the first report.

Except for the problems of children being delighted to find little plastic buckets on their trips to the Island/beach, the traps have proved to be relatively easy to open, close and maintain. In some very exposed areas covers have needed a rock on top to ensure they don't blow off in strong winds, particularly when the traps are unattended for a week or so. The small size of the pits means that if the cover blows off while reptiles are in the pit it can get very hot very quickly, so covers must be windproof while traps are open.

The small pit size also means if there is more than one lizard in the pit they will be unable to avoid each other. I've observed one case of a *Morethia* with damage to a forelimb consistent with having been bitten by a much larger *C.fallens* in the same pit. There has been no evidence of larger lizards eating smaller ones in the pits, and no records of dead lizards in pits. There have been no birds found in pits.

Initially there was some doubt about the efficiency of the small pits to retain larger lizards. Observations of large *C.fallens* (the largest and most athletic species) suggest that the pits contain them well. Such animals can leap out of the uncovered pits when one puts one's hand in, but they seem only to do this successfully when covers are off and they're threatened. The pits work well for *C.lancelini* which, even when threatened, are not able get out of them. There have been no captures of the Island's gecko, which could probably escape the small pits, since there is a slight taper towards the pit's base.

The issue of the scale of the grids can not yet be evaluated with respect to it's appropriateness for population studies of *C.lancelini* due to the low recapture rates of adult *C.lancelini* . Initially this was probably due to the low rate of marked individuals in the population, but since mid-January capture rates for adults of all species have been lower than in late December-early January (see later for further details on activity). The placement of the additional pits within some grids will help evaluate the issue of the scale of grids.

Trapping results

Table 1 shows the captures recorded for each species on each grid. Only *C.fallens* was caught more frequently than *C.lancelini* . Of the total of 307 captures recorded: 65% were of *C.fallens* , 18% of *C.lancelini* , 13% of *Morethia* , and 4% of *E.bos* . Recapture rates were low for all groups except for *C.fallens* on some grids during later trips. Of the 201 *C.fallens* captures recorded there have been 151 first captures. One *C.lancelini* (an adult) has been captured twice. Hence, results presented here are based on capture rates. Capture rates refered to in the subsequent discussion are expressed as the number of captures (of the subject group) per trapday (one trapday (TD) corresponds with one trap being open for one day), and were derived for the relevant unit (trip/ grid or trap) by summing captures and dividing these by the appropriate number of trapdays.

The general distributional patterns apparent in the capture records suggests that the four reptile species each occur in all major habitat types (if not on all grids). Captures of *Cyclodomorphus branchialis* and *Egernia bos* were too few to provide useful clues as to relative abundance of these species in different areas. Only two *C.branchialis* have been caught in pits. The identity of the *Morethia* caught must be considered tentative: it seems likely that only *M.lineoocellata* has been caught, but some of my earlier identifications may have been questionable.

Several assumptions have been used in the discussion of trapping results which may prove to be unwise when more data is available to evaluate the assumptions. The primary assumption is that seasonal activity patterns are equivalent for all parts of the Island. It is possible that the between-grid variation, which is herein interpreted as geographic variation in habitat quality, may be contaminated by variation in seasonal activity patterns between different grids. For the purposes of this report, the assumption that capture rates are proportional to population density has been judiciously employed. It seems likely that capture rates reflect two aspects of variation: that associated with an area's population density, and that which is associated with the relative usage rate of the small area immediately adjacent to the pit. Generation of adequate recapture results should facilitate partitioning of these factors.

Ctenotus distribution and relative capture rates

There is substantial variation in the overall reptile capture rate (reptiles caught per TD) for different grids, and considerable variation in the relative capture rates for species on different grids (Figure 2). On all grids *C.fallens* capture rates exceed those for *C.lancelini* . There is a general trend of positive covariation in the relative capture rates of the two species. The relative capture rates of the two *Ctenotus* on Grid 110 differs from other grids by the combination of no *C.lancelini* captures and a relatively high *C.fallens* capture rate.

Ctenotus lancelini has been captured on nine grids representing all major habitat types. Two limestone grids (G60 & G110) had no *C.lancelini* capture records. The number of *C.lancelini* marked per grid ranged from 1 to 21, suggesting substantial variation in population density or relative usage rates between grids. Two grids had relatively high *C.lancelini* capture rates (G0, on the northern part of the white sand foredune, and G70, on the NE slope of the large southern limestone area).

On the four grids with relatively high *C.lancelini* capture rates (G0, G10, G20, G70) captures were not evenly distributed between pits (Figure 3). *C.lancelini* capture rates for T75 were the highest recorded for any trap. On Grid 0 there was an apparent trend for more northern pits to be associated with higher capture rates. A similar trend may be reflected in capture rates for Grids 0 and 10, since Grid 0 is north of Grid 10 (see Figure 1).

Temporal variation in *Ctenotus* capture rates

The capture rates for individuals per Trip are shown in Figure 4, and show a general decline in capture rates of *C.lancelini* and *Morethia* over subsequent trips. Inspection of capture rates for recent hatchlings and adults shows more clearly the temporal patterns in activity over January to March (Figure 4b & c). For the purposes of this report any animal hatched prior to the summer of 1993-4 is considered adult.

Capture rates for adult *C.lancelini* and *C.fallens* were relatvely low after Trip 4, while *Morethia* capture rates were relatively constant. Capture rates for hatchling *C.fallens* increased steadily since Trip 4, and for hatchling *Morethia* , less dramatically after Trip 1. The first *C.lancelini* hatchling encountered was trapped on 20.1.94 (during Trip 2), and capture rates for these fluctuated between trips. The relative capture rates of adult *Ctenotus* suggest that both species tended to show similar seasonal patterns of variation in activity during mid to late summer.

The general seasonal trend described above for adult *C.lancelini* appears to override the importance of daytime temperature in determining activity, although on average, later trips were during warmer weather. There was a tendency for *C.lancelini* captures to be more frequent during the morning, but data is currently scarce. Only one adult *C.lancelini* was caught during the last two trips (6 & 7), and this was on a day which was overcast, humid, and cooler than all other days on these two trips (due to a degenerated cyclonic low). Capture records suggest, that in terms of temperature, 20-30 ° C provided suitable conditions for activity, though some activity was recorded above 30 ° C. Wind conditions also seemed to influence activity, and wind strength sometimes differed substantially between areas. Temperatures recorded at similar times on different grids indicated that the temperature may differ substantially between grids (most extreme example recorded was 34° on one grid and 40° on another). Other environmental parameters may be influential in determining *C.lancelini* activity patterns. Casual observations suggest that, given temperatures are suitable, humidity and wind strength and direction may be important factors affecting activity.

Invertebrate activity (Figure 5) showed a pattern of temporal variation similar to that for captures of adult *Ctenotus* (Figure 4), with fewer pits containing invertebrates during later trips. There was a general trend for grids with higher capture rates for one or other *Ctenotus* species to have higher levels of invertebrate activity. Grid 0 was characterised by the highest capture rates for both *Ctenotus* species and for invertebrates.

Figure 5c shows the capture rates for individual pits on the four grids with higher *C.lancelini* capture rates. Grid 0 had the highest invertebrate activity. While there appeared to be a general trend for higher capture rates of *C.lancelini* and invertebrates to be positively associated, notable exceptions were Traps 8, 17 & 75. The position of Traps 17 & 75 are both such that they may have higher than average suitability as basking sites (good exposure to early morning sun). Trap 8 does not appear to have similar exposure, but is placed in the lowest part of a small hollow, and the area may be used as a 'track' or 'runway'.

Ctenotus lancelini

Population status of *C.lancelini*

No meaningful quantification of *C.lancelini* population numbers or density can be derived on the basis of the data in hand. The species' status is best evaluated with reference to several summary statements:

59 *C.lancelini* have been individually marked
one marked adult has been caught twice
the species has been caught on nine of the eleven grids being used throughout January and February
14 recent hatchlings have been caught on five different grids.

There is no robust numerical data which could be used to quantify the extent of decline of *C.lancelini* within the rocky areas.

Observations of *C.lancelini*

Only one *C.lancelini* was seen active during the course of the fieldwork. At least five of the trapped *C.lancelini* were seen to disappear into seabird burrows on release. One released individual disappeared into loose sand, the movement of which indicated the individual moved under about 5-7 mm of sand for about 20 cm before emerging into a patch of litter. An earlier report (Jones, Jan. 1994) highlighted the morphology of *C.lancelini* and hypothesised that the species' relatively short limbs may have been indicative of a lifestyle associated with foraging under 'things'. The above observations, and those of earlier workers who frequently found *C.lancelini* below rocks are consistent with the above hypothesis.

Some difficulty was encountered with the process of determining the gender of both *Ctenotus* species, especially during early trips. The recognition of gravid individuals was confident only for heavily gravid females. Problems associated with these issues have been exacerbated by the low recapture rates for *C.lancelini*, and the low capture rates on later trips. Further details about breeding in *C.lancelini* will need to await more trapping, and will only become clear after trapping throughout a whole spring-summer season.

Despite the paucity of data it is useful to inspect the plots of weight vs SVL for *C.lancelini* (Figure 6). The absence of any captures of animals with SVL between 40-60 mm suggests juveniles reach 60-70 mm SVL in their first year. The separation of males and females suggests that there is some sexual dimorphism in overall body size. The separation of males and females along the weight axis may be an artefact associated with higher body weights for females carrying eggs (caught during December and January). The curvilinear nature of the relationship between weight and SVL for females shows a tendency for an asymptotic SVL of 83-86 mm, but heavy females (>10g) were probably in later stages of egg production. All females with SVL of less than 80 mm had weights equivalent to males, and this might indicate that females do not breed at SVL < 80mm. It is thus a possibility that females do not breed until their second summer.

Habitat quality for *C.lancelini*

It may be premature to consider the trapping results in terms of habitat quality. Some general trends are apparent, though at this preliminary stage the suggestions made herein should be considered only as tentative hypotheses. Most of the observations of habitat mentioned below are based only on qualitative observations.

The four grids with most *C.lancelini* captures (Grids 0, 10, 20, 70) differ from all other grids in that they had an eastern to north-eastern aspect. Grids 0, 10 and 70 had a substantial rise behind the grid to the south-west. The southwestern traps on Grid 20 (T21-23) followed the line of small crest, and only pits on the north-eastern slope caught *C.lancelini* (Figure 5c). These grids were thus relatively well protected from southerly and westerly winds, and exposed to the early-morning sun. While Grids 0 & 10 were on the white sand foredune, grid 70 was on the north-eastern slope of the large southern patch of limestone. Grids 0 & 10 had contrasting vegetation, the most apparent aspect of difference was the abundance of vegetative matter. Grid 0 had the tallest shrubs on the Island (to 2m), and these grew in a small hollow between the beach and the large central dune. Several other grids had similar vegetative cover in terms of percentage cover, but Grid 0 was characterised by having more vegetation, and hence what appeared to be a larger amount of litter per unit area. Vegetation on Grid 0 was however, quite patchy, with small areas of open sand between patches of shrubs. Grid 0 had the highest invertebrate capture rate, and also the highest *C. fallens* capture rate.

The vegetation on Grid 70 was distinct from that on other limestone grids (30, 60, 90 & 110), and characterised by extensive thickets of low dense shrubs (to 40-50 cm) separated by narrow strips occupied by dead winter weeds and occasional small outcrops of limestone. Below the foliage of the thickets there was a substantial accumulation of litter. Surface rocks appeared to be rarer than on other limestone grids, but some were concealed within the thickets.

The distributional data for *C.lancelini* , taken together with the habitat observations suggests that *C.lancelini* can persist in most Island habitats, but that small areas exist which have the potential to support higher than average densities. Such small areas occurred within two of the three major habitat types. Quantitative analysis of trap results and indicators of *C.lancelini* abundance should help to unravel the relative importance of the above mentioned variables (topography, and the relative abundance of live vegetation, surface litter or cover, invertebrates, and *C.fallens*).

Discussion

The hypotheses for decline of *C.lancelini*

Prior to the commencement of this work *C.lancelini* was believed to be restricted to rocky Island habitats (Wilson and Knowles 1988). Anecdotal evidence indicated recent and significant decline of the species within this habitat type (Browne-Cooper and Maryan 1992). Subsequent workers could not successfully disprove either of these assertions (Rolfe 1993). On the basis of the above evidence it seemed possible that the risk of extinction of *C.lancelini* may have increased substantially in recent years, and further, that the possibility of extinction might have been unacceptably high. Consideration of possible reasons for decline led to the following hypotheses:

that increasing numbers of Silver Gulls were contributing to a decline in *C.lancelini* habitat quality by direct predation or indirect habitat disturbance;

that increasing winter weeds were responsible for lowering habitat quality for *C.lancelini*, especially in rocky areas;

that recent habitat changes in the rocky areas increasingly favoured *C.fallens*, tipping a competitive equilibrium to the disadvantage of *C.lancelini*.

These hypotheses are discussed below with reference to preliminary field observations.

Silver Gulls

Silver Gulls may impact on *C.lancelini* abundance by several means. Direct predation of lizards and disturbance to their habitat associated with intense use of nesting areas have been suggested as factors with the potential to limit *C.lancelini* abundance in rocky areas (implied by Burbidge 1993). Direct data for evaluating the importance of these factors would be difficult to obtain. However, if such factors are important in defining an area's habitat quality for *C.lancelini*, then presumably both are likely to be proportional to the relative rates of Silver Gull activity on different grids. The proposed habitat analyses require a meaningful numeric indicator of the relative usage rates of different areas for incorporation in analysis with other habitat variables. Field observations of relative levels of Gull activity and abundance are prerequisite for defining a numerically useful variable (Appendix 2).

Temporal variation in Silver Gull abundance may be associated with localised and intensive use of parts of the Island by nesting birds, or with the less intensive activities such as foraging or resting. Temporal patterns of variation associated with these two aspects contrast, foraging or resting patterns vary during the course of the day, while nesting activities result in intensive use for part of the year.

Observations of the small numbers of gulls seen feeding on the Island suggests that the Gulls 'natural' dietary component is composed of two main units: forage from the waterline and the mats of beached seagrass, and food associated with the Islands birds. Gulls were frequently observed in attendance near dense patches of nests or young birds (primarily Crested Terns and Fairy Terns). Fairy terns nested on the beach and sitting birds varied between 3-8 over nearly three weeks. No chicks were observed, and on one day I watched three successful attempts by the Gulls to take the eggs. Gulls also frequently stole food from adult Crested Terns attempting to feed their young. The information about the rarity of encountering *C.lancelini* active on the surface and observations of Gull activity during January and February predation of *C.lancelini* by Silver Gulls is likely to be relatively low during late summer.

During Trip 7 there were fewer Crested Terns on the eastern beach, and this facilitated observations of the Silver Gulls use of this area as a resting place during the late morning or afternoons. These observations are consistent with the suggestion that in late summer the impact of Silver gull's usage of the island on the *C.lancelini* population is likely to be low, especially when compared with the more intensive usage associated with nesting.

Sightings of isolated pairs of Gulls on the central dune during January and early February indicated that some nesting was occurring, but only in that habitat type. In late February and early March there were very few Sliver Gull sightings in that area, but birds with sub-adult plumage accounted for about 10-40% of Silver Gulls seen on the eastern beach. Only one gull nest was recorded on any of the grids (since trapping commenced), but the eggs and adult disappeared about three weeks after the first sighting. Some grids have up to three identifiable old Silver Gull nests, suggesting usage of these areas may be intensive for several months of the year. The evaluation of the potential for Silver Gull activity to limit *C.lancelini* abundance is likely to be dependant on its coincidence with *C.lancelini* seasonal activity patterns. Quantification of the relative levels of Silver Gull activity based on nest characteristics (nest abundance, chick abundance) present the best opportunity to quantify the major aspect of Silver Gull activity which is likely to impact on *C.lancelini* populations.

A full season of data is required to be able to properly assess the impact of the activity or abundance of Silver Gulls on *C.lancelini* populations.

Weeds

The most extensive weeds are winter grasses which germinate in soil bearing most of the seabird droppings from the previous summer. These grasses occur in all of the Islands habitats, but are most abundant and extensive in the rocky areas. Within the areas with deep sand, weed growth is very patchy and usually associated with areas without woody shrub cover. In the areas with deeper sand the digging undertaken by burrowing seabirds may tend to limit weed abundance by burying patches of weeds.

The effects of the heavy weed infestation of the rocky areas appear to be complex. While there may a be direct response by *C.lancelini* to the reduction of basking sites associated with the period of maximum weed mass, there appears the potential for change in a suite of habitat characteristics.

Wind is a major feature of the Island's weather, and the limestone headlands front to the south-western winds. The winter weeds persist after their death and the fibrous root system firmly binds the soil throughout summer. The above ground stems and leaves provide an functional sand trap for particles blown in on the easterlies and north-easterlies of summer. The functional structure of the soil bound by the grass root mass is dramatically different to the loose surface sand common in the absence of such weeds. It is possible that this is a habitat characteristic of importance to *C.lancelini*, and to *E.bos* which, on Lancelin Island, digs its own burrows as well as using the seabird burrows.

In addition to soil changes, there seems to be the potential for the dense weed growth in rocky areas to dramatically change the vegetation, since small seedlings of the native plants may not survive if they germinate with dense patches weed seeds. The rapid growth rates of the annual weeds may well have changed seasonal patterns of soil nutrient availability which could be expected to influence patterns of flowering and fruiting of the original flora of these areas. If the rate of regeneration of the shrubby native species is substantially reduced the winter grasses may become the dominant feature of the Island's vegetation.

Evidence of the relative extent of weed cover in different areas is available throughout the year, since dead weeds persist throughout summer and autumn. There is substantial variation in weed height throughout the season, though this has been relatively constant to date. The extent (height and density) of weed cover will be recorded at two times: at its maximum, and when the *C.lancelini* activity is at a seasonal peak.

Ctenotus interactions

There was a trend in the pattern of *Ctenotus* captures on different grids suggesting that the two species tended to do well in the same areas and hence may have overlapping habitat requirements. Primary resources (food, shelter/exposure) which have the potential to limit *Ctenotus* abundance may be shared, hence the relative abundance of each species may be influenced by competitive effects. This suggests that further investigation of how the species might share or split resources may be crucial to determining the potential for improving habitat quality for *C.lancelini* .

Habitat manipulations

Earlier proposals referred to three habitat treatments aimed at improving habitat quality for *C.lancelini* : poisoning weeds in rocky areas (Rolfe 1993), poisoning Silver Gulls (Burbidge, 1993), and adding artificial cover in rocky areas (Jones 1994). All these proposals were considered at a time when the species was believed to be restricted to the rocky habitats.

Effective control of both weeds and Silver Gulls are logistically difficult and are likely to require ongoing funding for years. Further, killing of weeds in rocky areas may lead to a short-term decrease habitat quality for *C.lancelini* (due to the reduction of surface cover) which may not be overcome until native vegetation regenerates. The impact of spraying on lizards is apparently unknown (Peter Nilson, 'Crop Care Australasia', personal communication), as are possible effects on the invertebrate fauna. While it seems most likely that it is only coincidence, it must be noted that the only two grids with no *C.lancelini* captures were the only two grids which covered areas sprayed with dilute 'Fusilade' in 1993 (Rolfe, 1993). Poisoning of Gulls on the Island may lead to mortality for the Banded Rail, which seems on the Island, to eat a wide range of food including plant and invertebrate material (my observations of foraging activity and of characteristic egested pellets).

To date, there is no information to suggest that any of the proposed treatments would be likely to lead to the type of increase in *C.lancelini* population size which would significantly decrease the probability of the species extinction.

Further study

The extreme temporal variation apparent in the trapping results supports the necessity for a full year of trapping results. An understanding of annual patterns of activity and breeding is a prerequisite to reliable interpretation of estimates of population numbers. The extent of the temporal variation in activity, and observations of substantial geographic variation in microclimate prompts recognition of the possibility that *C.lancelini* activity patterns may not be synchronous on all grids. If this proves to be the case, then some between site variation referred to earlier may actually be due to climatic differences between grids. A full year of data will help clarify these issues by permitting identification of peak activity for each grid or habitat type. Information about breeding in females is fragmentary (since trapping seems to have started when there were a few heavily gravid females) and would be dramatically improved by trapping results for spring and early summer.

The general patterns starting to become apparent regarding important habitat parameters for *C.lancelini* suggests that further development of an understanding of factors associated with higher densities is likely to be productive. Given the contrasts between capture results for this study and previous attempts to locate *C.lancelini* individuals, it may well be that this animal may be more widespread than previously thought. The information available to date on habitats, seasonal activity patterns and trap design may well facilitate the success of surveys in other areas. The study of habitat factors associated with areas with higher densities may also lead to an understanding of the significance of the different aspects of habitat change associated with weed invasion.

Study of the diet of *C.lancelini* proposed in the original proposal has been amended. No *C.lancelini* faecal pellets have been found in traps, and only one *C.fallens* pellet has been found. Holding animals to collect pellets during the hottest months was considered unwise. Taking stomach contents from gravid females may influence the resources available for egg-production. Hatchling *C.lancelini* are too small for gut-flushing. The best option for the collection of a useful sample for dietary information is systematic retention of animals caught following a period of low seasonal activity, and during the cooler months. Such conditions are expected during spring or early summer. Selected individuals will be placed in calico bags and returned to the pit for up to 24 hours before being weighed and released. Collected pellets will be inspected over summer 1994-5.

Further consideration has been given to the proposal to undertake systematic rock-turning in rocky areas. The results of such an exercise are limited by a number of factors. Primarily, the paucity of surface rocks limits the likelihood of generating numerically robust data. A major source of variation in rock situation is associated with vegetation and rocks occur in three main vegetation types: among weeds, among low dense thickets of shrubby vegetation, and among low open shrubs. While trapping results are scant, I have come to suspect that the shrubby thickets may prove to be an important habitat feature for *C.lancelini*. Rock turning within these thickets would lead to a potentially damaging level of trampling and disturbance of vegetation, and dense adjacent cover is likely to impede confident identification or capture of reptiles sighted. For these reasons rock-turning results are unlikely to be of significant value to the population studies on Lancelin Island. The value of rock-turning as a quantitative survey technique is compromised by the same set of problems.

Management recommendations

The results in hand suggest that there is a rather low probability of extinction of *C.lancelini* on Lancelin Island during the next few seasons. An extensive fire or the introduction of a feral animal appear to be the only factors with the potential to cause dramatic and rapid decline. The CALM's original project outline (Burbidge 1993) recommended three strategies: field study of the population, the development of captive breeding techniques, and habitat treatments aimed at lowering numbers of Silver Gulls and the abundance of weeds aimed at maintaining or increasing the Island's *C.lancelini* population. The field studies are well underway and preparations have been made to initiate captive breeding in *C.labillardieri* (presumed to be a sister group to *C.lancelini*)

Since *C.lancelini* seems not to be in immediate danger of extinction, and with consideration of the possible implications of poisoning on the Island, it seems most prudent to delay such treatments. By next autumn the field study should be nearing completion and results will permit a more informed assessment of the probable value of such treatments. Continuation of work on Lancelin Island, and on studies of *C.labillardieri* is vital to the overall aim of efficiently ensuring the secure persistence of *C.lancelini* .

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Acknowledgments

This work has been funded through a grant from the Endangered Species Programme (Australian Nature Conservation Agency) to the Western Australian Department of Conservation and Land Management which permitted the parttime employment of the author. Thanks go to David Pearson (CALM) for valuable discussions and logistic support, and to all those people who have shared their knowledge of Lancelin Island and *Ctenotus lancelini* . The efforts of the team of 'pit-diggers' are also gratefully acknowledged. Sincere thanks also to John Dell and Ric How (Western Australian Museum) who have kindly shared their substantial knowledge of reptile studies and of *Ctenotus fallens* in the Perth area.

Appendix 1 Capture records for *Ctenotus lancelini*

DATE	TRAP	NO	WT	SVL	TL	TD	HLL	HL	HW	GEN	TAIL	U	SC	REMARKS
25.2.94	A1	L										U		
15.12.93	H	L01		83			22	12.5		3	18/23			RPIII sh, IV no claw
16.12.93	H	L02		80			27	12.2		5	52			
16.12.93	3	L03		83			28	13.0		3	22/105			RFL no FA
22.12.93	27	L04	10.2	75			29	13.3		4	60/123			
22.12.93	39	L05	7.8	67	154		25	12.7		4				
22.12.93	29	L06	7.8	70	133		28	12.7		4				
23.12.93	8	L07		73	111		26	12.0		3				
23.12.93	26	L08	7.4	83			28	13.0		3	18/85			
23.12.93	36	L09	12.2	85			29	13.5		3	95/144			no RPII, LPI sh., RMIV dam.
20.1.94	6	L10	8.5	75	157		26	12	6.9	4				
23.12.93	6	L12	8.5	80	130		26	13.0		3				
23.12.93	8	L13	6.0	70	125		25	11.5		3				
17.1.94	4	L14	7.5	77			25	12.0	7.0	3	38/115			
3.1.94	27	L19	7.7	68			27	12.7		5	90/129			most tips missing LM
17.1.94	17	L20	9.2	74			25	12.0	7.3	2	104/133			
20.1.94	4	L21	5.8	76				12.3	6.7	4	18/88/91			RPIV sh., no V
18.1.94	75	L30	10.6	82			24	14.2	7.5	3	61/120			
23.12.93	11	L31	7.7	75			29	13.3		5	33/114			hd with dark spots
18.1.94	8	L32	6.8	73			28	13.2	7.2	4	35/102			tail regen kinky
18.1.94	75	L33	8.6	84			27	13.2	7.3	3	20/109			no RM
18.1.94	102	L37	8.8	72	152		26	12.5	7.0	4				
18.1.94	72	L39	6.6	68			26	12.3	7.4	4	31/91/105			
18.1.94	75	L40	11.7	81	161		25	13.4	7.5	3				
20.1.94	7	L41	9.4	83			26	13.5	7.6	3	59/120			
29.1.94	8	L42	0.6	34	60	2.7	15	7.3	3.8			U		
20.1.94	7	L43	0.9	34	61		15	7.0	4.2			U		
30.1.94	75	L44	13.2	86		8.0	28	13.8	8.0	3	32/111			
29.1.94	5	L47	0.8	33		3.0	14	7.0	4.0		93	U		
18.1.94	17	L48	8.4	77	128		29	12.6	7.0	3				
18.1.94	42	L49	12.6	85	164		28	13.5	7.3	1				
29.1.94	11	L50	8.7	78		7.3	27	13.0	7.5	3	103/106			RFA paralysed, t tip growing
14.2.94	7	L50	0.6	29	47	2.6	13	7.3	4.1					
20.1.94	8	L51	9.6	79	147		27	12.7	7.0	3				hd with dark spots
30.1.94	45	L52	6.7	68	136	6.4	25	11.8	6.2	3				
31.1.94	8	L53	0.9	33	59							U		
31.1.94	4	L54	0.8	35	66							U		
5.2.94	47	L57	9.7	72	156	7.5	27	13.0	7.5	4				
5.2.94	27	L58	7.5	67		6.4	27	12.0	6.8	3	74/139			
5.2.94	2	L59	8.2	73		7.2	25	12.3	7.2	3	75/133			
15.2.94	75	L60	0.7	32	56	2.7	14	6.8	3.9					
18.1.94	5	L61	9.6	85			28	13.5	7.4	4	42/109			LPIV sh., RPIII sh.
25.2.94	A2	L61	9.2	87		7.4	27	13.5	7.8		46/110			
4.2.94	17	L62	8.5	74		8.0	29	13.4	7.6	4	57/130			
4.2.94	8	L63	7.9	77		7.5	26	12.7	7.2	3	84/138			
4.2.94	75	L64	9.6	82		7.0	27	13.2	7.4	3	42/61/120			no LP
5.2.94	1	L67	7.1	74		6.3	25	12.0	6.5	1	78/133			
6.2.94	2	L68	9.9	80		7.6	28	13.0	7.7	3	25/87			
14.2.94	58	L69	0.5	34	65	2.5	15	7.2	4.0					
15.2.94	75	L70	0.5	30	56	2.6								45 mm tail in etoh
25.2.94	71	L70.80	0.6	32	59	2.4	13	7.1	4.2			U		
16.2.94	54	L71	10.1	73	109	8.3	28	13.4	7.7	4	19/109			
26.2.94	25	L75		34		2.8	16	7.4	4.2		13	U		
16.2.94	75	L80	0.6	33	60	3.2	15	7.0	4.2					
18.1.94	7	L81	9.7	82			26	12.5	7.0	3	17/44			LPIV sh.
9.11.94	126	L83	0.8	33	63	3.0	14	7.3	4.0			U		
27.2.94	75	L90	0.5	33	55	2.5	14	7.1	4.0					scar on RHS
20.1.94	94	L91	8.0	74				13.1	7.4	4	18/50/81			LPIII & IV sh.
20.1.94	72	L92	13.9	85	168			13.2	7.1	3				

Appendix 2: Field notes on Silver Gulls

The notes provided are rough field notes: they were collected to help the process of derivation of reliable quantitative indicators of relative rates of usage of different areas by Silver Gulls. See main text for description of the selected variables. During the first two months of work we (BJ & CALM) believed an Honours student would undertake a more detailed study of Silver Gulls in the Lancelin area, but the student pulled out in early February.

Early day-trips: 8.12.93 8 of 12 gulls on southern beach showed some subadult (sa) plumage (1100 hrs); 1 nesting adult on area nr G110 (eggs not found); 1 adult sighted on G60 (1100). 3.12.93 2 nests with eggs in area of G60-90; 20-40 constantly overhead while in area of G60-90: seem to be coming mostly from southern slopes, where they are evenly spaced (10-20m) between birds or pairs.

Trip 1 Activity on southern slopes and area G60-90 similar to 3.12.93. Counts on eastern beach not possible due to abundance and activity of Crested Terns. 23.12.93 2-4 gulls in constant surveillance of nesting Fairy Terns (10-20 birds). They apparently worked together, one attacking and another sneaking in to steal egg. 2 successful attempts witnessed.

Trip 2 Eastern beach and southern slopes same as last trip. 18-20.1.94 1 subadult on beach in little cove: saw an adult delivering food sporadically, most frequently during late afternoon. The adult spent most of one morning attending/defending/eating a large dead cuttlefish.

Trip 3 29.1.94 nesting adult with 2 eggs nr T119.

Trip 4 About 10-20 regularly seen feeding amongst northern patches of beached seagrass, along with 4-6 Banded Rails. 4.2.94 nest nr T119 same as last trip.

Trip 5 Seems to be generally fewer gulls about vegetated parts of island. Still using northern seagrass patch. 15.2.94 nest nr T119 abandoned; 100-150 gulls on eastern beach (1300) (only a few Crested Tern runners left).

Trip 6 The gulls previously seen regularly on the southern slopes seem to have gone. 25.2.94 1 adult sighted nr G0, 2 nr G110, 1 nr G60 none on other grids (800-1100); 6 of the 25 gulls on eastern beach have some sa plumage (1300)

Trip 7 Nesting activity seems to be at a minimum: no eggs, chicks or nesting behaviour. Air defence elicited by me presumed to be associated with birds pair bonding or establishing nest areas. No more than 3 individuals seen on southern slopes at any one time. 9.3.94 4 gulls doing 'air defence' (AD) on G130, 1 doing AD on G20, 7 adults (3 pr +1) on G30, and no gulls on others (900-1200); 2 groups on eastern beach, 40 + 50 = 90, about 10% have sa plumage (0930); from G130, 1 gull on ground nr G60-90 (0950); 18 adults (all red) on G30 (1615). 10.3.94 4 adults on G30 (1310); 2 pr AD on G50 (1600); none on G30 (1810).

Figure and Table Captions

Figure 1. Lancelin Island, showing the position of trapping grids and major habitat types (rocky areas, central dune and white sand foredune).

Table 1. The number of captures of the four commonly caught reptiles on different grids and trips. Captures of adults (A) and recent hatchlings (RH) are listed separately.

Figure 2. Reptile capture rates averaged for each grid (over Trips 1-7, and expressed as captures per open trap per day) for each of the four commonly caught reptiles.

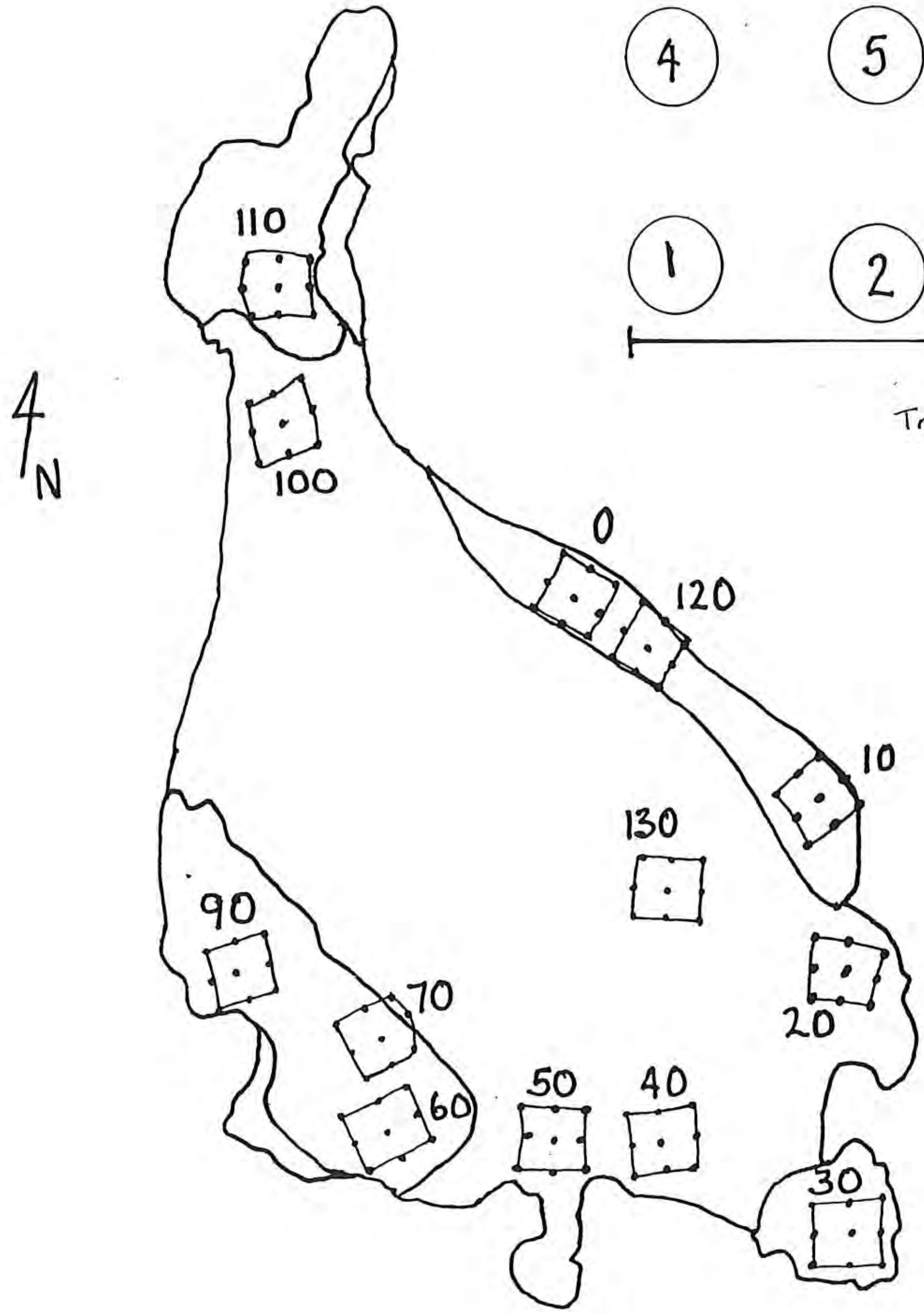
Figure 3. The number of *C.lancelini* caught in different traps on the four grids with higher *C.lancelini* capture rates (for Grids 0, 10, 20, 70 on Trips 1-7).

Figure 4. Reptile capture rates for Trips 1-7 (based on captures on Grids 0-100 for Trip 1, Grids 0-110 for Trips 2-6, and Grids 0-130 for Trip 7). (a) for all individuals, (b) for animals considered adult, and (c) for recent hatchlings. (Adults refers to animals hatched prior to the summer of 1993-4).

Figure 5. Invertebrate activity levels. (a) the percentage of traps with at least one invertebrate on subsequent trips, (b) the percentage of traps with invertebrates averaged over Trips 2-7 for each grid (based on Grids 0-110 for Trips 2-6, and Grids 0-130 for Trip 7). (c) The number of captures of invertebrates and of *C.lancelini* on the four grids with higher *C.lancelini* capture rates. (The number of invertebrates captured was divided by 10 to facilitate visual comparison of lizard and invertebrate captures per trap).

Figure 6. Weight vs snout-vent length (SVL) for female and male *C.lancelini* (excluding recent hatchlings, and animals with obviously small tails). Circled points indicate animals which had tails likely to be light due to regeneration or tail loss.

FIGURE 1.


N
110
100
0
120
10
130
90
70
20
60
50
40
30

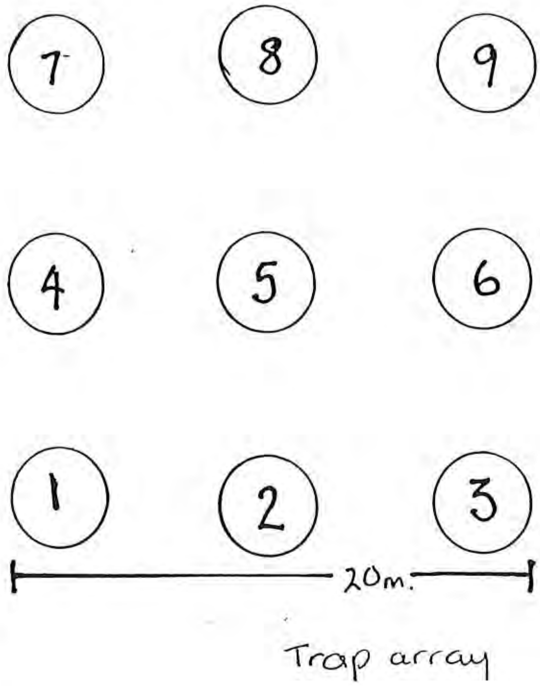

7
8
9
4
5
6
1
2
3
20m.
Trap array

Table 1

Ctenotus lancelini

Trip #	1		2		3		4		5		6		7	
Grid	A	RH	A	RH	A	RH	A	RH	A	RH	A	RH	A	RH
0	3		8	1		4	4			1				
10	1		2		1		1	1						
20	3						1					1		
30	1													
40			1		1		1							
50									1	1				
60														
70			5		1		1			3		2		
90			1											
100			1											
110	-	-												
120	-	-	-	-	-	-	-	-	-	-	-	-		1
130	-	-	-	-	-	-	-	-	-	-	-	-		

Morethia

Trip #	1		2		3		4		5		6		7	
Grid	A	RH	A	RH	A	RH	A	RH	A	RH	A	RH	A	RH
0			2	2					1	1				
10			1					1					1	
20			1								1			
30			1									1		
40							1							
50						1		1				1		2
60						1				1		1		1
70	1		1		1					3		1		2
90			2											
100														1
110	-	-	1						1			1		1
120	-	-	-	-	-	-	-	-	-	-	-	-		1
130	-	-	-	-	-	-	-	-	-	-	-	-		

Ctenotus fallens

Trip #	1		2		3		4		5		6		7	
Grid	A	RH	A	RH	A	RH	A	RH	A	RH	A	RH	A	RH
0	5		11		7		8	1	5	2	1	2	4	9
10	7		11		7		7		2	1		2	1	3
20	2		3		1		1							2
30	1		5				4				1	1	1	1
40			1				1					2		
50	1		1		1					3	1	3		
60	1									1		3		
70	2		3		2		2			1	3	2		2
90			1				1	1	1	1		4		5
100			2				2						1	1
110	-	-	12		1		5			1	1	2	1	2
120	-	-	-	-	-	-	-	-	-	-	-	-		1
130	-	-	-	-	-	-	-	-	-	-	-	-		

Egernia bos

Trip #	1		2		3		4		5		6		7	
Grid	A	RH	A	RH	A	RH	A	RH	A	RH	A	RH	A	RH
0														
10												1		
20	3		1											
30														
40			1											
50			3									1		
60														
70														
90														
100			1		1									
110	-	-					1							
120	-	-	-	-	-	-	-	-	-	-	-	-		
130	-	-	-	-	-	-	-	-	-	-	-	-		

FIGURE 2.

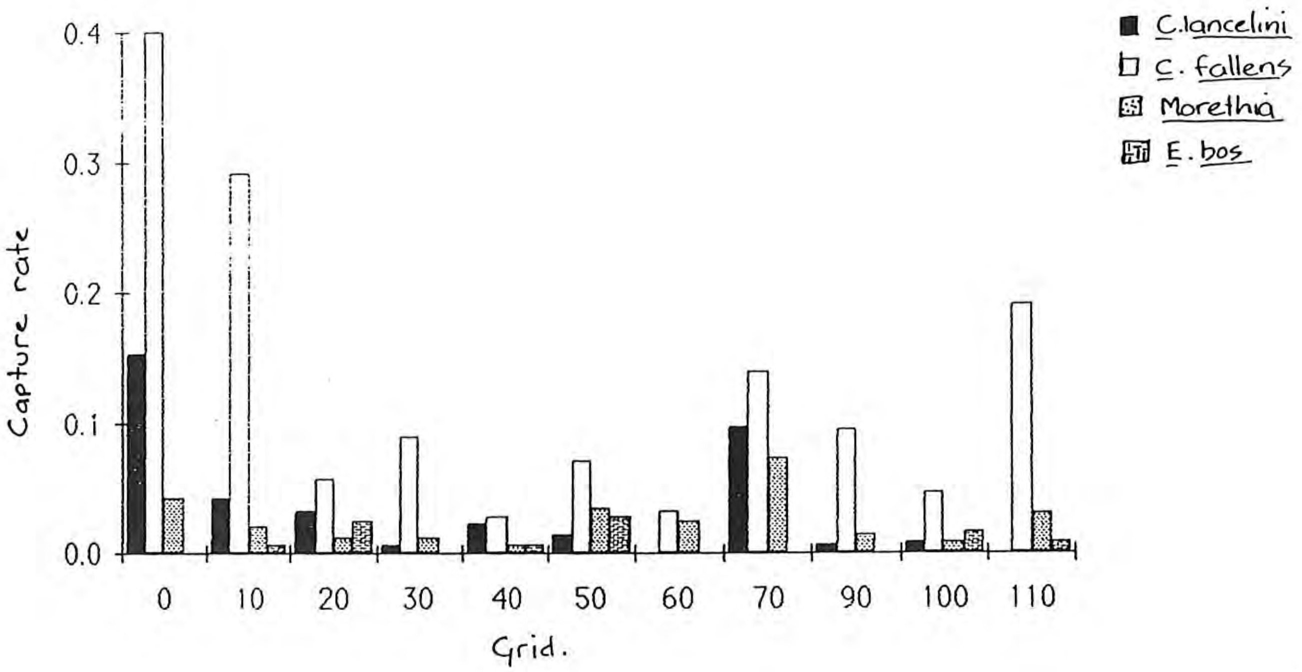


FIGURE 3.

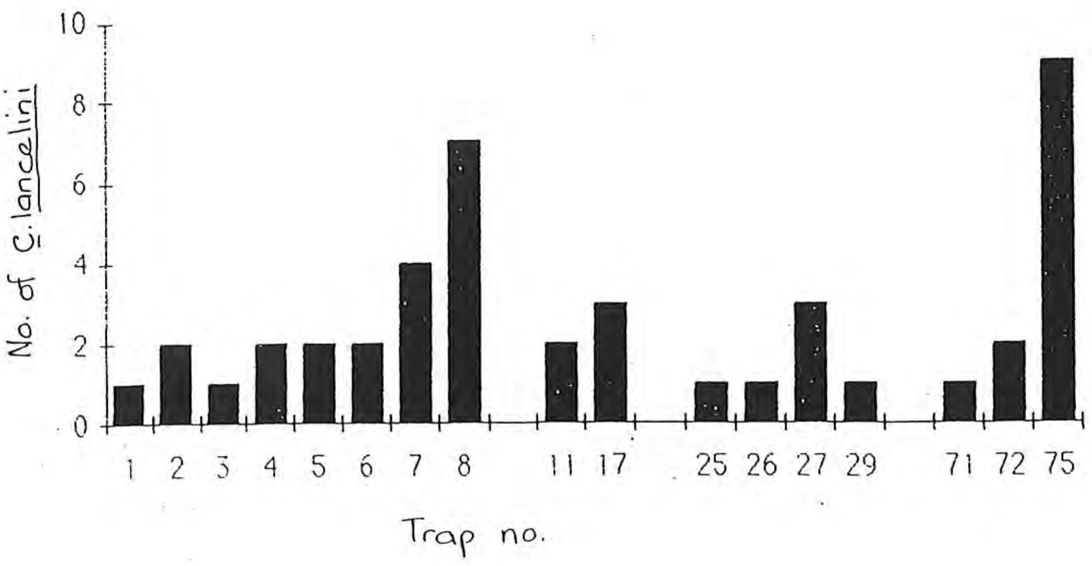


FIGURE 4.

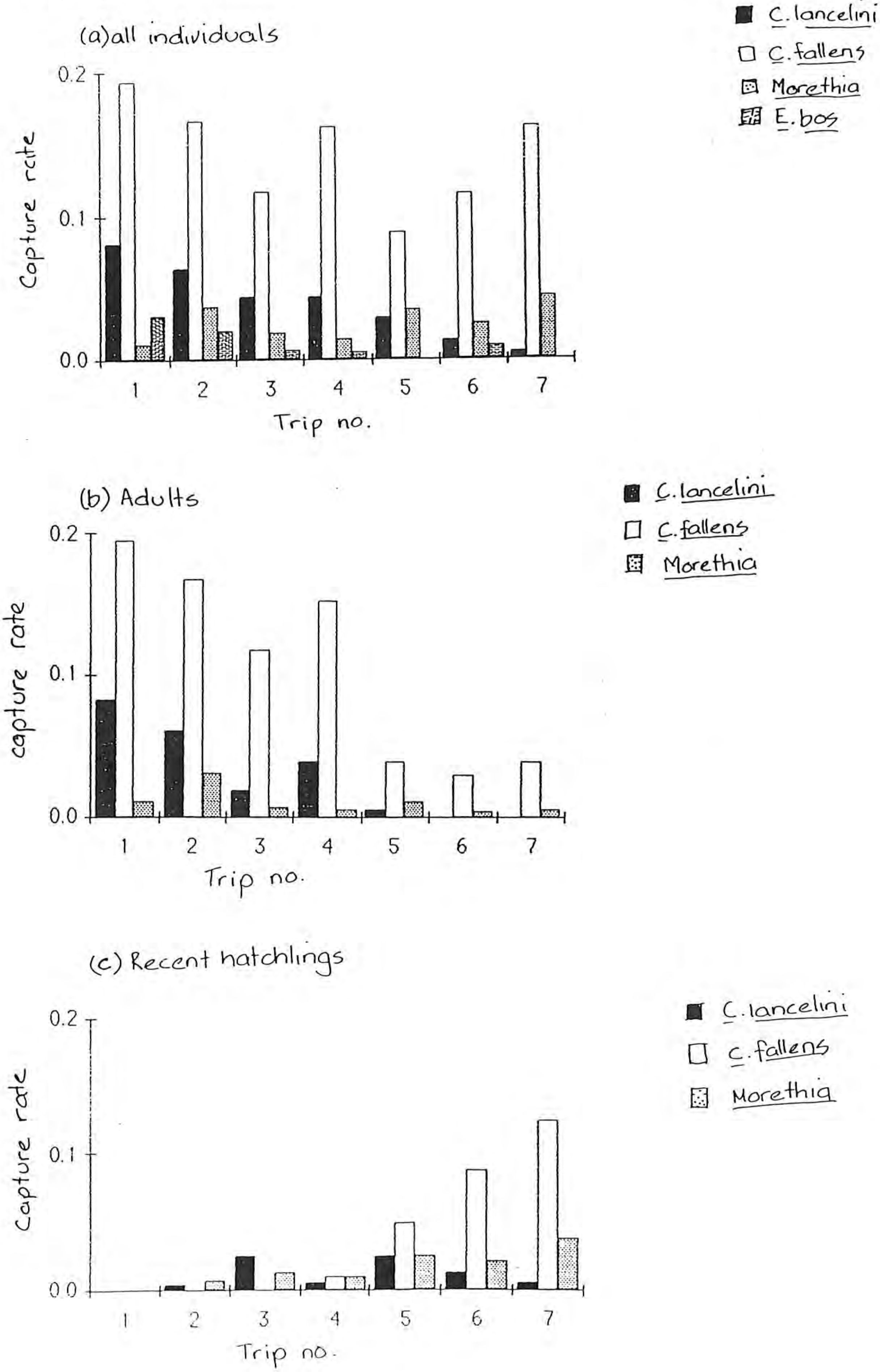

(a) all individuals
C. lancelini
C. fallens
Morethia
E. bos
capture rate
0.2
0.1
0.0
1
2
3
4
5
6
7
Trip no.
(b) Adults
C. lancelini
C. fallens
Morethia
capture rate
0.2
0.1
0.0
1
2
3
4
5
6
7
Trip no.
(c) Recent hatchlings
C. lancelini
C. fallens
Morethia
capture rate
0.2
0.1
0.0
1
2
3
4
5
6
7
Trip no.

FIGURE 5

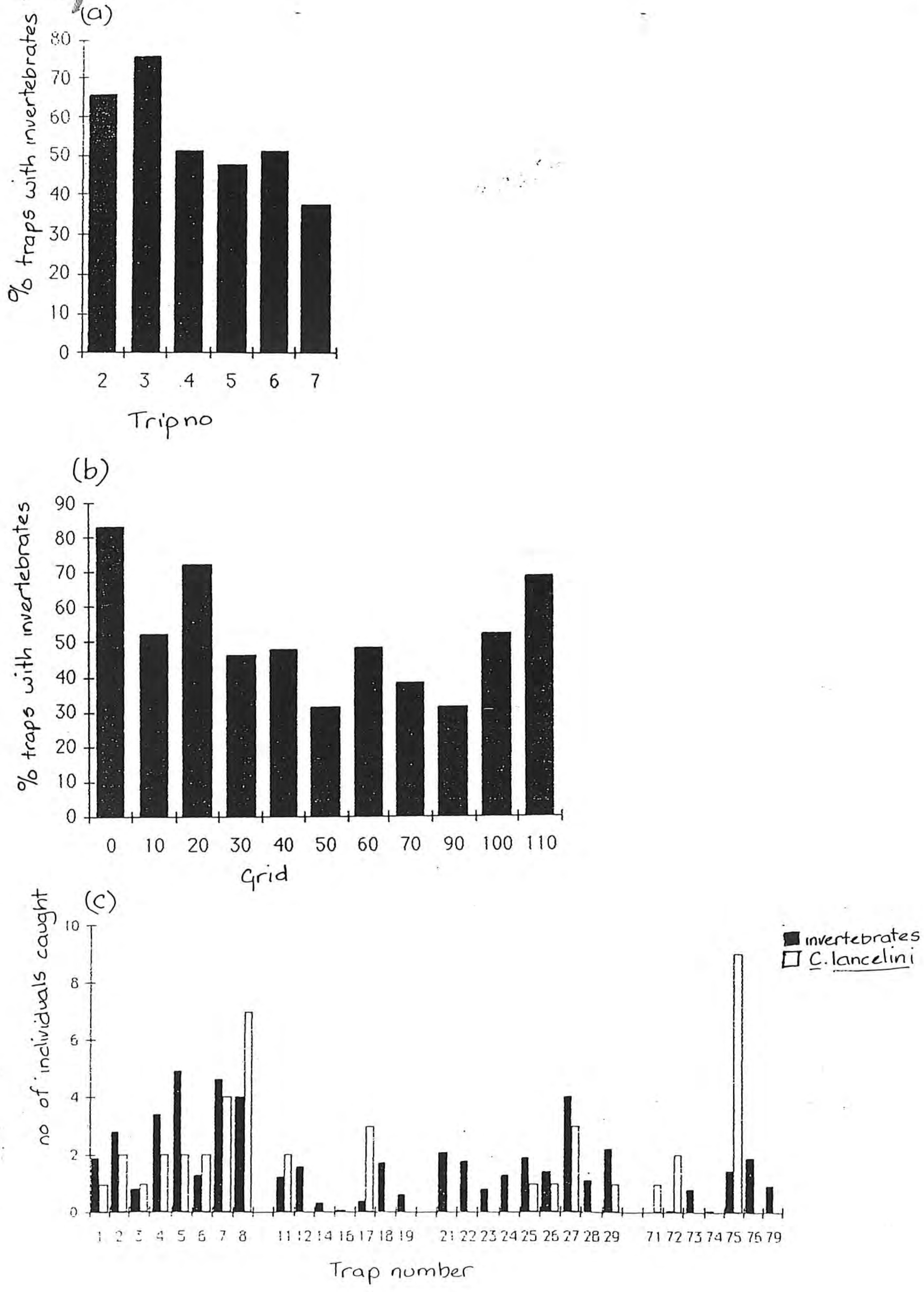

(a)
% traps with invertebrates
0
10
20
30
40
50
60
70
80
2 3 4 5 6 7
Trip no
(b)
% traps with invertebrates
0
10
20
30
40
50
60
70
80
90
0 10 20 30 40 50 60 70 90 100 110
Grid
(c)
no of individuals caught
0
2
4
6
8
10
1 2 3 4 5 6 7 8 11 12 14 16 17 18 19 21 22 23 24 25 26 27 28 29 71 72 73 74 75 76 79
Trap number
invertebrates
C. lancelini

FIGURE 6.

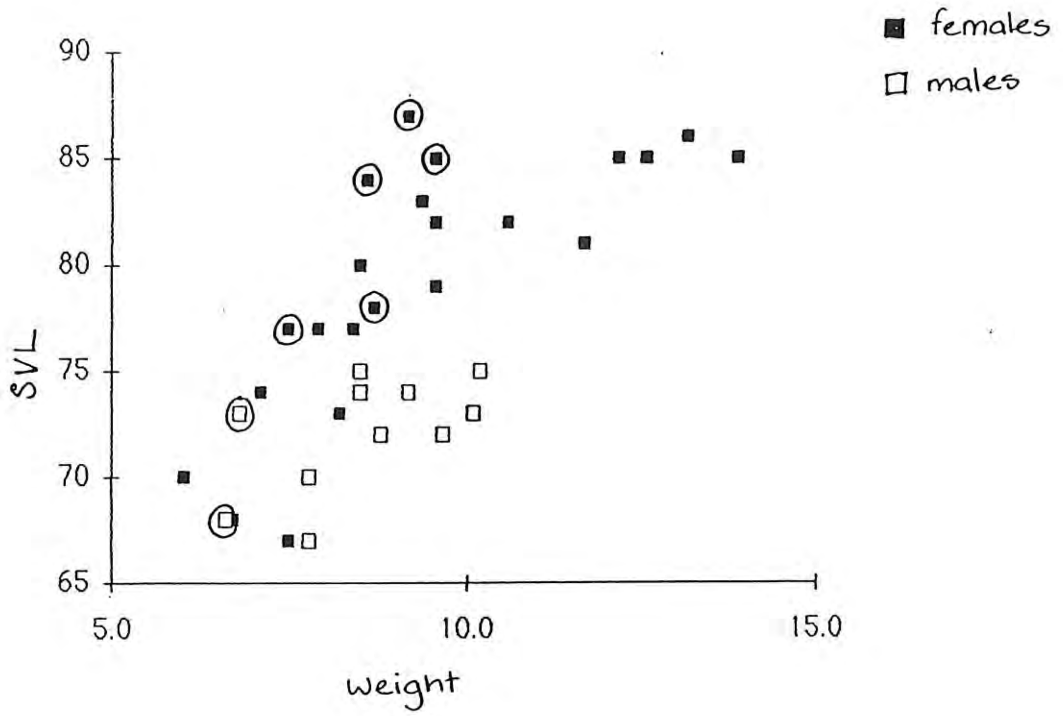
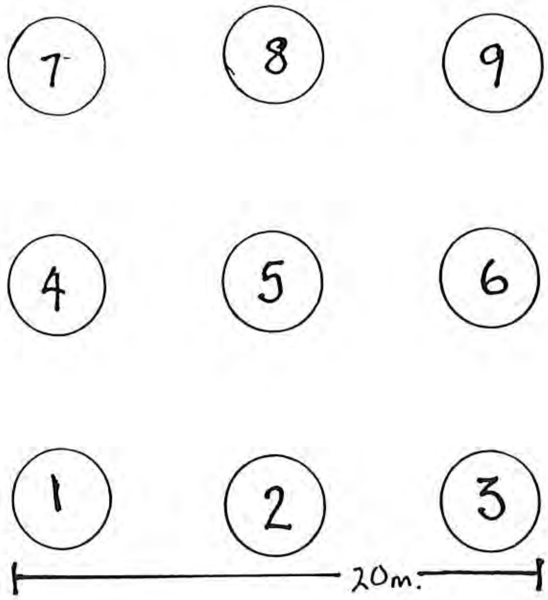


FIGURE 1.



Trap array

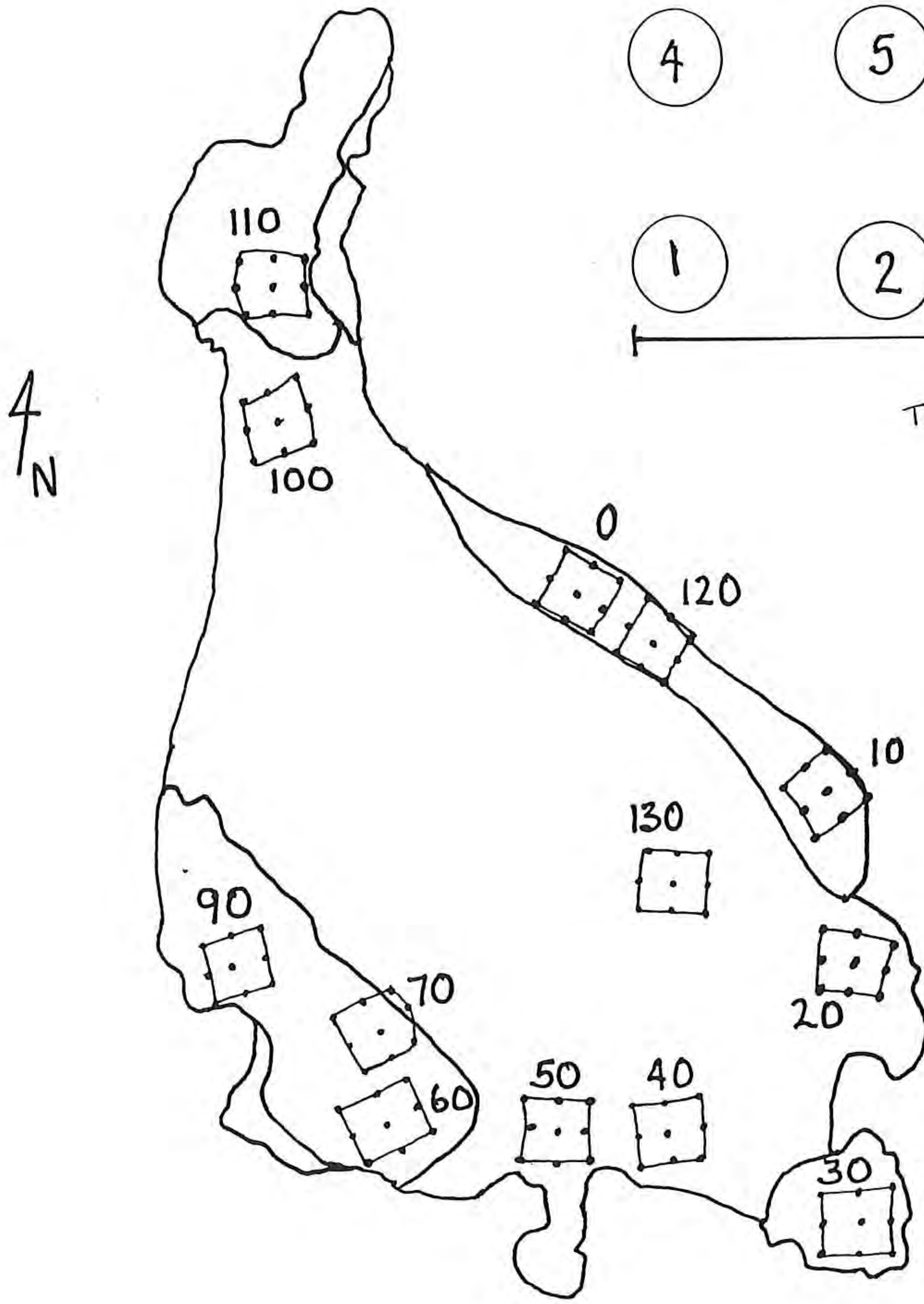


Table 1

Ctenotus lancelini

Trip #	1		2		3		4		5		6		7	
Grid	A	RH	A	RH	A	RH	A	RH	A	RH	A	RH	A	RH
0	3		8	1		4	4			1				
10	1		2		1		1	1						
20	3						1					1		
30	1													
40			1		1		1							
50									1	1				
60														
70			5		1		1			3		2		
90			1											
100			1											
110	-	-												
120	-	-	-	-	-	-	-	-	-	-	-	-		1
130	-	-	-	-	-	-	-	-	-	-	-	-		

Morethia

Trip #	1		2		3		4		5		6		7	
Grid	A	RH	A	RH	A	RH	A	RH	A	RH	A	RH	A	RH
0			2	2					1	1				
10			1					1					1	
20			1								1			
30			1									1		
40							1							
50						1		1				1		2
60						1				1		1		1
70	1		1		1					3		1		2
90			2											
100														1
110	-	-	1						1			1		1
120	-	-	-	-	-	-	-	-	-	-	-	-		1
130	-	-	-	-	-	-	-	-	-	-	-	-		

Ctenotus fallens

Trip #	1		2		3		4		5		6		7	
Grid	A	RH	A	RH	A	RH	A	RH	A	RH	A	RH	A	RH
0	5		11		7		8	1	5	2	1	2	4	9
10	7		11		7		7		2	1		2	1	3
20	2		3		1		1							2
30	1		5				4				1	1	1	1
40			1				1					2		
50	1		1		1					3	1	3		
60	1									1		3		
70	2		3		2		2			1	3	2		2
90			1				1	1	1	1		4		5
100			2				2						1	1
110	-	-	12		1		5			1	1	2	1	2
120	-	-	-	-	-	-	-	-	-	-	-	-		1
130	-	-	-	-	-	-	-	-	-	-	-	-		

Egernia bos

Trip #	1		2		3		4		5		6		7	
Grid	A	RH	A	RH	A	RH	A	RH	A	RH	A	RH	A	RH
0														
10												1		
20	3		1											
30														
40			1											
50			3									1		
60														
70														
90														
100			1		1									
110	-	-					1							
120	-	-	-	-	-	-	-	-	-	-	-	-		
130	-	-	-	-	-	-	-	-	-	-	-	-		

FIGURE 2.

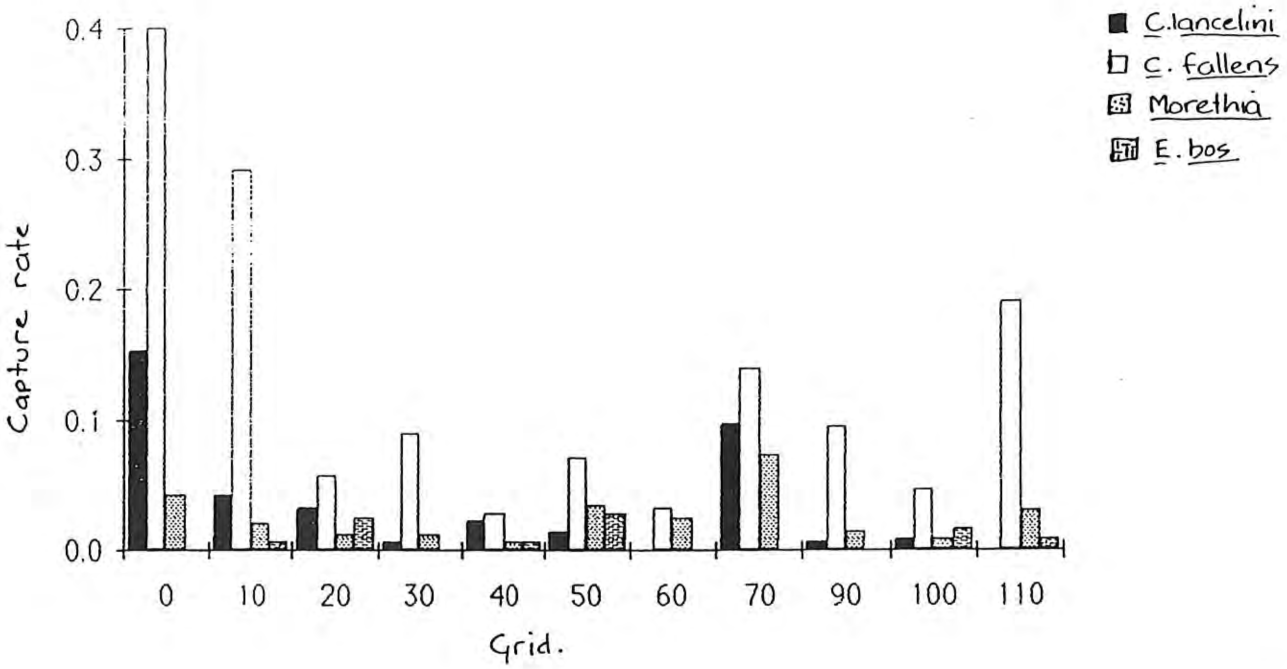


FIGURE 3.

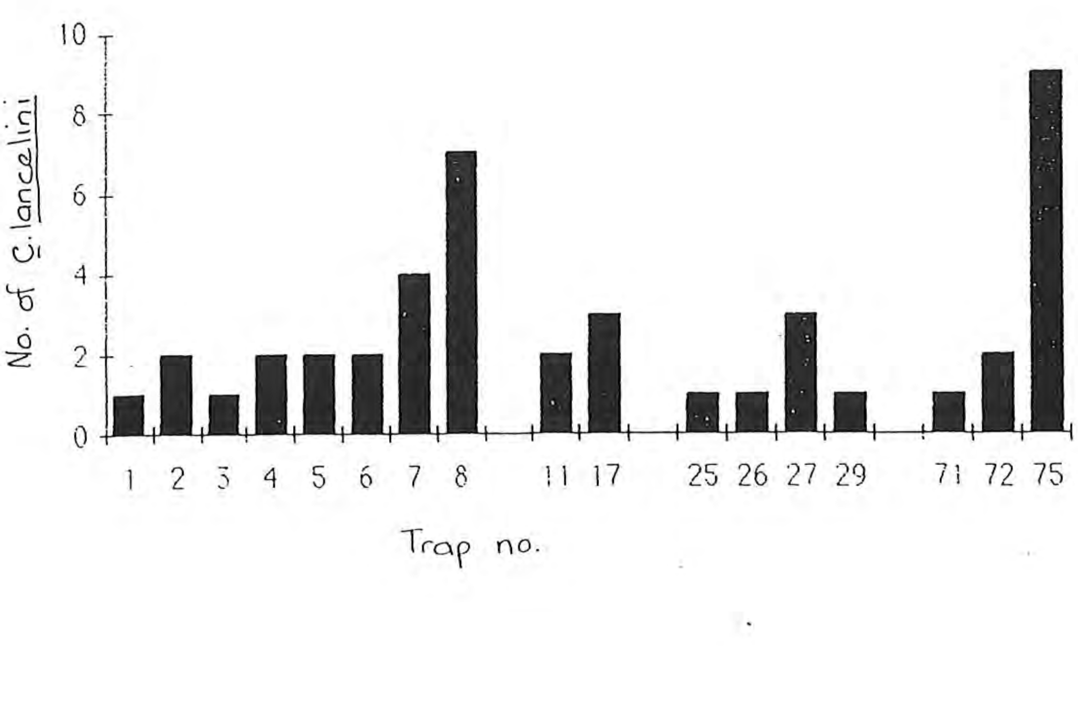
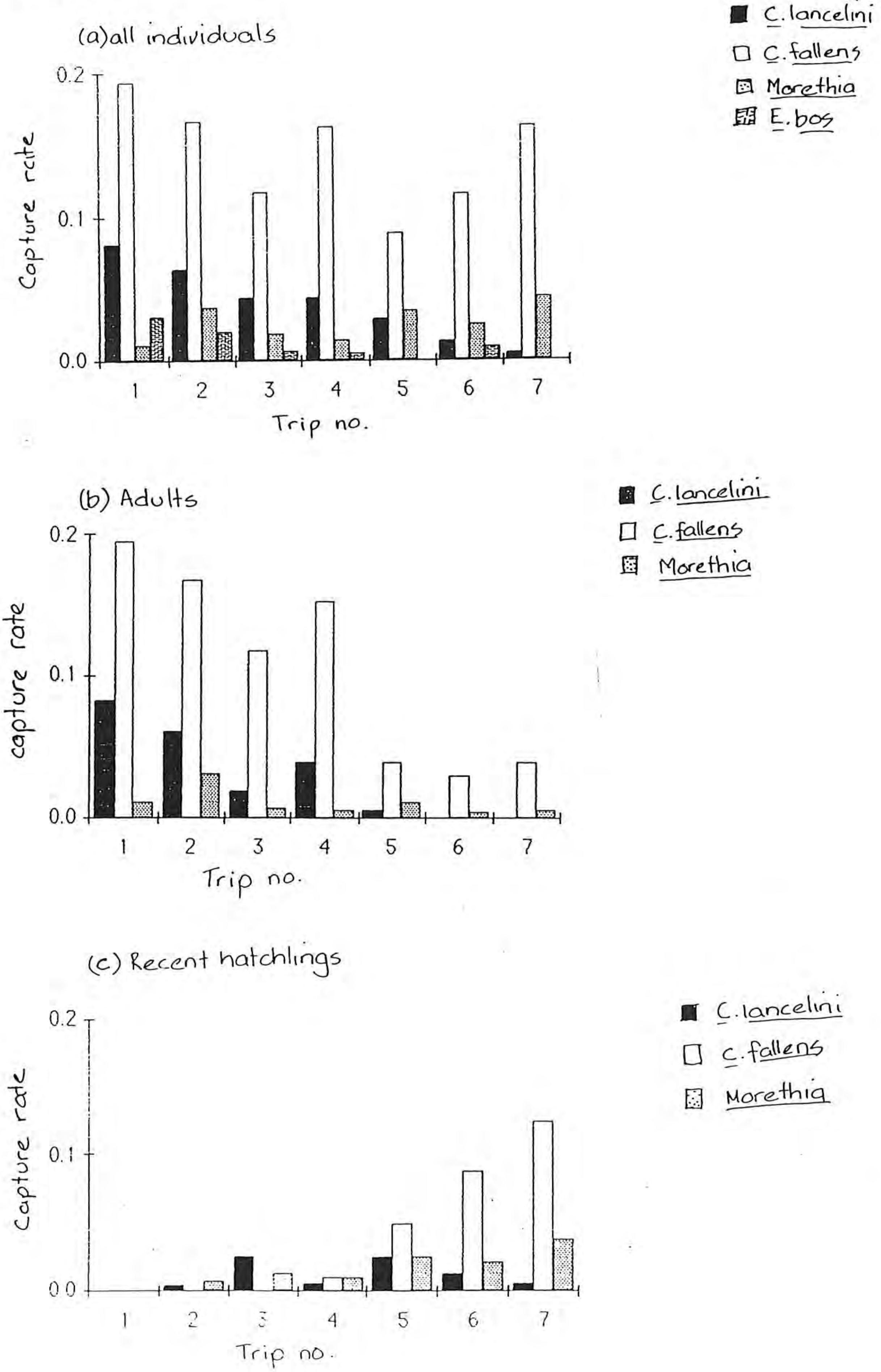


FIGURE 4.



(a) all individuals
capture rate
0.2
0.1
0.0
1
2
3
4
5
6
7
Trip no.
C. lancelini
C. fallens
Morethia
E. bos
(b) Adults
capture rate
0.2
0.1
0.0
1
2
3
4
5
6
7
Trip no.
C. lancelini
C. fallens
Morethia
(c) Recent hatchlings
capture rate
0.2
0.1
0.0
1
2
3
4
5
6
7
Trip no.
C. lancelini
C. fallens
Morethia

FIGURE 5

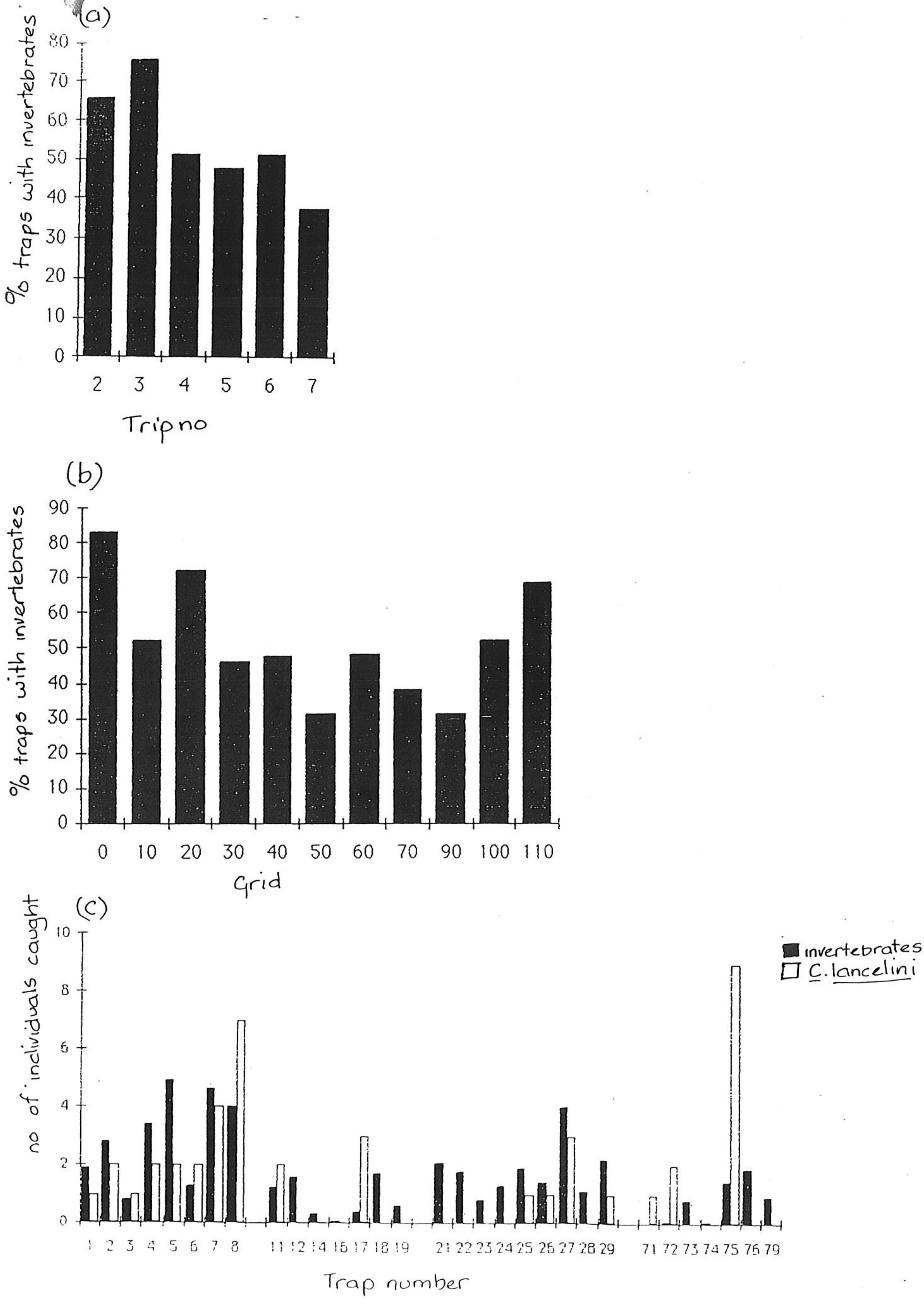

(a)
% traps with invertebrates
0
10
20
30
40
50
60
70
80
2 3 4 5 6 7
Trip no
(b)
% traps with invertebrates
0
10
20
30
40
50
60
70
80
90
0 10 20 30 40 50 60 70 90 100 110
Grid
(c)
no of individuals caught
0
2
4
6
8
10
invertebrates
C. lancelini
1 2 3 4 5 6 7 8 11 12 14 16 17 18 19 21 22 23 24 25 26 27 28 29 71 72 73 74 75 76 79
Trap number

FIGURE 6.