Biometrical and ecological data from a Netherlands population of *Anguis fragilis* (Reptilia, Sauria, Anguidae)

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Abstract. Slow worms (*Anguis fragilis*) were caught, measured, marked and released over a period of three years. A number of them was recaptured. In this way information was gathered about biometry, tail loss, above-ground presence, movements, and habitat selection. Animals were present above ground in the daytime. Most captures were made during the mid-afternoon hours in August, mainly of females. The Slow worms showed a high site tenacity. They prefer certain vegetation types in the forest area.

Introduction

Most information about Slow worms (*Anguis fragilis* L., 1758) originates from captive animals (e.g. Hornung 1896, 1897), or from specimens in museum collections from different populations (e.g. Wermuth, 1950). Also reports have been made of finds of great numbers in winter habitats (Collett 1918, Mertens 1947, Smith 1973) or under objects in the vegetation (Simms, 1970); however, no animals were measured. Detailed information about habitat requirements is scanty. General views of the Slow worm’s life history and ecology are given by Rollinat (1946), Petzold (1971), Smith (1973) and Dely (1981).

It proves hard to establish the presence and abundance of this very secretly living species (partly fossorial). I known of only one field survey that has been carried out rather systematically (Fellenberg, 1981).

During the period 1978-1980 the author made a survey of the distribution and habitat selection of Lacertid lizards, aimed at nature conservation and management. Attention was also paid to the Slow worm, casually though. Yet, in view of the hidden way of life of this species, the number of specimens caught was surprisingly high, so that it was possible to gain information about biometry, tail loss, above-ground presence, movements, and habitat selection. The data presented in this paper come from one single wild population.
Study area

The study area of about 500 ha (a part of the forest Amerongsche Bosch) is situated in the southeastern part of the Utrechtse Heuvelrug, a hill ridge in the province of Utrecht in the centre of The Netherlands. It consists of a mainly wooded push moraine with podzolic soils. Highest and lowest point respectively are 69.2 and 8.2 m above sea level. All vegetations in the Amerongsche Bosch are climax, developing, substitute, or degradation stages of the oak-birch forest (Querco roboris-Betuletum). The major part of the area is covered with conifer plantations in small plots, and as a result the study area has a very dense system of paths. The structure of the study area is fairly varied in consequence of the present management, which aims both at wood exploitation and at natural forest development: in some parcels conifers (Picea, Pinus and Pseudotsuga) are grown in cycles of 80-120 years, while in others conifers are cut down in favour of birch and oak. One can find side by side most stages in the succession from bare grounds to mature forest.

Material and methods

From the beginning of April until half October the study area was visited almost daily. Field work was done from sunset until sundown and spread over the hours of the day as evenly as possible. Slow worms were localized by eye sight and caught by hand. All captures were made above ground, no animals were dug up. For individual recognition the animals were branded with a cordless soldering iron (Isotip, Wahl Clipper Corp.), provided with a microtip. According to a code, tiny point-shaped marks were placed on the ventral scales. The conspicuity of the marks decreased strongly in the course of time. However, they remained observable throughout the survey period. Slow worms were treated at the catching site and released immediately afterwards at the same spot. At each capture the following data were recorded: sex, mark, pregnancy, length (snout-vent, tail, tail regeneration), state of the tail (complete or broken), date, time of day, locality (according to a coordinate system with an accuracy of 1 m), and vegetation characteristics.

Weather data were obtained from a station, situated along the same hill ridge, at a distance of 24 km.

Time was recorded as or converted into Central European Summer Time.

The nomenclature of plants follows Van der Meiijden et al. (1983).

Results and Discussion

Numbers

During the survey period 110 different specimens of Slow worms were captured (99 adults and 11 subadults). Only once the blue-spotted form was found: a male of 160 mm snout-vent-length (SVL).
The total time spent on the reptile field work was 1686 hours. This is rather low, because of long periods of cold weather and rain. Consequently, the mean capturing success of Slow worms was one capture in 9.9 hours of field work.

All animals of SVL < 120 mm were considered subadult, because most of the Slow worms of ≥ 120 mm could be sexed. Schreiber (1912) considers Slow worms of ca. 250 mm body length (BL, BL = SVL + tail length TL) as sexually mature. Smith (1973) gives a maximum BL of 230 mm for animals at the end of their 3rd year.

It is known that the sexes cannot always be distinguished on the basis of external characteristics only (cf. Wermuth 1950). In my study mostly the colour pattern of the scales combined with the shape of head and trunk was used for sexual determination (the pileus length was not measured). In many cases, sexual determination was facilitated by males extruding their hemipenes and by females being visibly gravid. Sometimes it was not possible to determine the sex with 100% certainty.

The group of adults consisted of 19 males, 66 females and 14 individuals of unknown sex. So for the sexed animals the sex ratio was 0.29 for the first captures. Also Gregory (1980), Smith (1973), Spellerberg & Phelps (1977), Street (1979), and Van de Bund (1964) observed more females than males above ground.

The total number of captures was 170 (73 in 1978, 22 in 1979 and 75 in 1980), respectively on 44, 21 and 49 specimens; among these were 60 recaptures of 30 different specimens. All recaptures were adult females, except for 1 adult animal that could not be sexed. Two Slow worms were recaptured 5 times. Of all females caught (66), 33 were visibly gravid at the first capture. However, it should be noted that determination of pregnancy only by sight may have been difficult in females with a low number of embryos (especially the young ones, cf. Rollinat, 1946).

No explanation can be given for the difference in number of captures between the three years, because the searching intensity was equal in every year. No relationship could be demonstrated with the weather conditions. Also within the group of females, the percentage of specimens that is gravid in one year is different over the three years: 0.31, 0.43 and 0.87 respectively in 1978 (n = 32), 1979 (n = 7) and 1980 (n = 31) (3x2 test of independence using the G-test, P < 0.005). As the number of captures in 1978 and 1980 were almost equal, these data lead to some doubt if all Slow worms in this population have a one-year reproduction cycle, as mentioned for central France by Rollinat (1946) and Saint Girons (1963). Because in 1980 only 4 out of 31 adult females never were visibly gravid, it is likely that the greatest part of the adult females joined in the reproduction in 1980.

The number of recaptures is too low for estimating the population density. Remarkably few juvenile and subadult Slow worms have been observed. Only once a newly born animal was caught, in spite of special searching activities at places where late in the season gravid females were found. The small number of young Slow worms observed may indicate a more hidden way of living of this group, which was also mentioned by Dely (1981), Hornung (1896, 1897) and Smith (1973). On the other hand, as Slow worms can get very old—up to 46 years (Fuhn & Vancea, 1961)—, only few juveniles would be expected.
Length, weight and tail loss

Data about lengths are presented in Table 1. For both SVL and BL, males are significantly smaller than females (Mann-Whitney U-test; in both cases P<0.001). There are no differences in SVL/TL ratio between males and females with a complete tail.

Table 1. Lengths at first capture. SVL = snout-vent-length, BL = total length of Slow worms with a complete tail, SVL/TL = ratio SVL/tail length of Slow worms with a complete tail.

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>mean SVL in mm</th>
<th>maximum</th>
<th>minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>adult males</td>
<td>19</td>
<td>142.7 ± 14.9</td>
<td>179</td>
<td>120</td>
</tr>
<tr>
<td>adult females</td>
<td>66</td>
<td>156.4 ± 11.9</td>
<td>185</td>
<td>131</td>
</tr>
<tr>
<td>adults, sex unknown</td>
<td>14</td>
<td>144.9 ± 11.1</td>
<td>168</td>
<td>121</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>mean BL in mm</td>
<td>maximum</td>
<td>minimum</td>
</tr>
<tr>
<td>adult males</td>
<td>12</td>
<td>262.1 ± 14.1</td>
<td>301</td>
<td>258</td>
</tr>
<tr>
<td>adult females</td>
<td>27</td>
<td>330.2 ± 25.3</td>
<td>385</td>
<td>270</td>
</tr>
<tr>
<td>adults, sex unknown</td>
<td>5</td>
<td>299.0 ± 17.3</td>
<td>330</td>
<td>279</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>SVL/TL</td>
<td>maximum</td>
<td>minimum</td>
</tr>
<tr>
<td>adult males</td>
<td>12</td>
<td>0.922 ± 0.033</td>
<td>0.993</td>
<td>0.870</td>
</tr>
<tr>
<td>adult females</td>
<td>27</td>
<td>0.922 ± 0.040</td>
<td>1.000</td>
<td>0.843</td>
</tr>
<tr>
<td>adults, sex unknown</td>
<td>5</td>
<td>0.933 ± 0.037</td>
<td>1.000</td>
<td>0.888</td>
</tr>
</tbody>
</table>

Little information was obtained about growth. Between the first and the last capture, growth was generally less than 5 mm (SVL), which was within the estimated measuring error of 2-5%. Only two females showed clear growth: one increased 12 + 6 mm (SVL + TL) (from 165 + 175 to 177 + 181 mm) in 672 days; the other 13 + 13 + 0 mm (SVL + TL unbroken part + TL regenerated part) (from 134 + 112 + 5 to 147 + 125 + 5 mm) in 709 days.

In literature, relatively much information exists about scalation, blue-spotted morphs and systematics of the Slow worm. Also many records have been made of the maximum sizes of Slow worms in different geographic areas (summarized in Dely 1981). Other data about lengths are very scarce and they mostly concern single specimens, never populations. Compared with the available data, the lengths as well as the SVL/TL ratios recorded in this study, do not essentially differ from those, mentioned in literature about the nominal race (e.g. Wermuth, 1950; Stugren et al., 1962; Dely, 1981; Fellenberg, 1981).

Slow worms were weighed in 1980 only. Figure 1 gives the weights in classes of 1 g. Mean weights of animals with a complete tail are shown in Table 2. Females are heavier than males (the lightest female is heavier than the heaviest male). However, this is based on only 5 males, and they were all very young (SVL 120-140 mm). Between first and last capture no difference of weight could be measured. Adult females
and adults of unknown sex showed a significant correlation between SVL and weight (animals with complete tails) (Spearman rank correlation coefficient; for females P < 0.01, for the other group P < 0.02), which was actually expected for the adult males too.

Table 2. Mean weights of adult Slow worms with a complete tail, caught in 1980 (all captures).

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>mean weight ± SD</th>
<th>maximum</th>
<th>minimum</th>
</tr>
</thead>
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<tr>
<td>adult males</td>
<td>5</td>
<td>8.5 ± 1.5</td>
<td>11.4</td>
<td>7.4</td>
</tr>
<tr>
<td>adult females</td>
<td>28</td>
<td>19.4 ± 4.6</td>
<td>26.0</td>
<td>13.4</td>
</tr>
<tr>
<td>adults, sex unknown</td>
<td>7</td>
<td>13.2 ± 1.8</td>
<td>17.0</td>
<td>11.3</td>
</tr>
</tbody>
</table>

The males in my study area have a very low weight, due to their young age. In Table 2, only the Slow worms with a complete tail are presented. The maximum weight for males with a broken tail is somewhat higher: 13.7 g (SVL = 165 mm, BL = 295 mm). However, these values are normal for The Netherlands. Van Buggenum & Levels (1980) found a range of 7.5-30 g in males from another Netherlands study area. Apparently, I did not catch old males. In literature, there are almost no further data about weights. Two records have been found: Fellenberg (1981) mentions
a female of 28.5 g from Westphalia (BL = 43.6 cm), and McCarthy (1977) got a male of 13.7 g (BL = 34 cm) from Ireland (the values in his paper have been misprinted; McCarthy, pers. comm.). Both weights are about the same as the maximum weights recorded here.

At the first capture, 56 Slow worms (= 50.9%) had a broken tail (Table 3). Once a female was recaptured after 24 days with a newly broken tail; all other Slow worms recaptured kept their primary tail during the survey period. From the group of animals with a broken tail at the first capture, only once a female with a newly broken tail was recaptured. During the survey tail breakage was never brought about. Relative numbers of primary tails at first capture of males and females do not differ significantly (Fisher's exact test for independence, P > 0.05).

Table 3. Number of Slow worms with a complete tail at first capture.

<table>
<thead>
<tr>
<th></th>
<th>number of captures</th>
<th>number with a complete tail</th>
<th>percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>adult males</td>
<td>19</td>
<td>12</td>
<td>63.2</td>
</tr>
<tr>
<td>adult females</td>
<td>66</td>
<td>27</td>
<td>40.9</td>
</tr>
<tr>
<td>adults, sex unknown</td>
<td>14</td>
<td>5</td>
<td>35.7</td>
</tr>
<tr>
<td>subadults</td>
<td>11</td>
<td>10</td>
<td>90.9</td>
</tr>
<tr>
<td>total</td>
<td>110</td>
<td>54</td>
<td>49.1</td>
</tr>
</tbody>
</table>

From the 56 Slow worms with a broken tail, 50 had a regenerated part of the tail. Maximum length of that part was 11 mm in two gravid females of 175 + 55 mm and 170 + 44 mm (SVL + TL). These Slow worms had lost more than half of the original tail (cf. Table 1). Bryant & Bellairs (1967) found the same in their Slow worms with maximum regrowth. The second female was recaptured after 731 days; only 1 mm growth of the regenerated part could be assessed. Another female showed no increase in length of that part; it stayed 5 mm long in a period of 724 days. A significant correlation was found between the SVL and the length of the regenerated part of the tail (Kendall rank correlation coefficient test, P < 0.01), which indicates that Slow worms regain a longer regenerated part of the tail as they grow older, or, more likely, that the regenerated part keeps growing along with the animal. Bryant & Bellairs' study was directed to tail regeneration. My results correspond well with theirs on captive animals: tail regeneration is very slow and yields only a short stump; in fact the wound only heals. The question arises why there is no tail regrowth such as in other lizards. A shortened tail certainly influences the locomotion of the Slow worm on bare soils. But as the Slow worm mostly lives inside the vegetation where it can quickly disappear (this paper), it may have less need for a long tail. Apparently, the tail does not have an essential function for fat storage.

During the survey period only two animals lost a piece of tail, while the tail breakage percentage over all Slow worms is rather high (50.9%). This may reflect the longevity of the Slow worm. Tail breakage may be attributed to the sexual activity of the Slow
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worms. Fighting often occurs among males (Smith, 1973; Street, 1979), and the female is bitten by the male during copulation (Rollinat, 1946). In both activities, there is a great risk for tail breakage. Therefore, the animals have a great chance losing their primary tail during the first years of sexual activity. Indications for this were found in testing a correlation between the length of the adults and the proportion of broken tails (t-test, 0.05 < P < 0.125). In addition to a more hidden way of living, also this may explain the high proportion of complete tails in subadults. The impact of tail breakage, caused by predators, is supposed to be rather constant during the Slow worm’s life.

Above-ground presence

The Slow worms observed in this study were visible in or on the vegetation or on the bare soil. When they were inside the layer between the soil and the top of the (dense) vegetation (e.g. for chasing), they have not been noticed.

Animals were caught throughout the whole season. Mating was never observed. In Table 4 the number of captures is given per month, per hour class, and for the distinguished group of animals. The mid-afternoon hours in August provided most captures, mainly females.

No correlation could be demonstrated between above-ground presence and weather (monthly data of air temperatures, hours with sunshine, mm rainfall).

Captures were made from March 22nd until October 9th. This agrees well with data from Dely (1981), Petzold (1971), Rollinat (1946), and Smith (1973). As my main survey period covered the beginning of April till half October, I have only little information about Slow worm activity in the rest of the year. Dely and Petzold, writing about animals from western Europe mention activity in the beginning of November, and Smith observed many Slow worms in March. In this respect, it is remarkable that in this study so few Slow worms were caught in April. The length of the hibernation period appears to be comparable to that of the sympatric lizards *Lacerta agilis* and *L. vivipara* (Van Nuland & Strijbosch, 1981). My study suggests that after hibernation the males are first in above-ground activity.

In contrast with its English name “Slow worm” and in spite of its osteoderm armour, the Slow worm really can be fast. Several times I observed that on warm days Slow worms disappeared into the vegetation in a flash, a behaviour that can be compared with the fleeing behaviour of the skink *Chalcides chalcides*. Also Simms (1970) and Street (1979) mention a sometimes surprising speed. This behaviour may lower the chance of observation on warm days.

The above-ground absence of Slow worms during the ‘warm hours’ on summer days, as mentioned by Gislén & Kauri (1959), Petzold (1971) and Dely (1981), and the nocturnal way of life by Saint Girons & Saint Girons (1956), does not appear from my data. When searched carefully, Slow worms really are found on ‘warm hours’, even more than in the early and the late hours. During the field work the Slow worms appeared to be above-ground between 8.45 and 19.45. These times are influenced by the
<table>
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<th>Hour Class</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
</tr>
</thead>
<tbody>
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<td>Adult Males</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Adult Females</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total Males</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total Females</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 4: Number of captures (exceptions included) per hour class per month and per sex per month.
researcher's activities because little time was spent before 8.00 and after 20.00. However, during these early and late hours Slow worms never were observed. In this respect, also the remark of Hornung (1897), that the animals he held in captivity, were no longer visibly active at the beginning of the dark, shows the probability of a diurnal above-ground activity.

The annual cycle of the Slow worm (Rollinat, 1946; Saint Girons, 1963), makes clear that above ground presence, as recorded here, must be explained in terms of thermo-regulation. After hibernation, the males are in need of heat energy for finishing their spermatogenesis before the mating starts. In summer, the females bask in full sunshine for stimulating development of the embryos. This also can be found from my data: 37% of the males was observed in May, 82% of the females in July and August (most of them were visibly gravid by then), and very few juvenile and subadult animals have been observed.

For thermo-regulation, the weather must play an important role. Therefore, it will determine, apart from internal factors, the above-ground presence of the Slow worm. The three summers of this survey were gloomy and cold. One might speculate that, as a result, the Slow worms were in need of emerging any time the sun was shining, so that the numbers observed were relatively high. On the other hand, if they react on warm weather, more animals might have been seen in warmer summers. So it remains hard to judge about the abundance of the Slow worms in the study area.

Movements

All recaptures were made within the same year of the preceding capture, except 4, which were made of animals marked in 1978 and recaptured in 1980. Never two or more individuals were found together. The number of all recaptures with relation to movements and time intervals is given in Figure 2. Distances were measured as the crow flies. The largest distance recorded was 130 m (after 672 days), the fastest displacement was 80 m in 7 days. The movements of the Slow worms indicate a high site tenacity in this area.

Habitat

In The Netherlands the Slow worm mainly lives in wooded parts of the diluvial territory (Central, East and South Netherlands). Most records of the Slow worm originate from the Utrechtse Heuvelrug (where the study area is situated), the Veluwe and Southern Limburg (Van de Bund, 1964). His data demonstrate a strong relationship between the Slow worm records and the distribution of forests: 57% of all records were made inside forests, in forest edges or on coppice banks (he does not mention the forest types), 16% concerned dry heath. The remaining records came from wet heaths, road verges, slopes with grass vegetation, gardens, railroad embankments and unkempt places.
The captures in the study area were made inside as well as in the edges of the parcels. All recaptures were made within the same parcel and vegetation type as the first capture of the same specimen. The majority of the observations (85%) was made in plantations of *Picea* (several species, *P. abies* or *P. sitchensis* or *P. omorika*) or *Pseudotsuga menziesii*. From this group, 97% was found in young, rather open plantations of ages varying from 4 to 15 years (Figure 3). The trees are mostly lower than 5 m and at such a distance from each other (1-3 m), that the ground between the trees is directly shone upon by the sun on many places. The herb layer locally consists of a very dense vegetation of *Deschampsia flexuosa*, which grows very bumpy, or of *Calluna vulgaris*. Also *Vaccinium myrtillus* is found. Between the conifers there is a fast growing of *Betula pendula*, which is cut down in winter time. There are also bare spots between the conifers with dead branches or with some low mosses which hardly contribute to the vegetation structure. In many places pods of *Carex pilulifera* occur.

The remaining Slow worms from the spruce-fir forests were found in an older developing stage of this type of plantation of ages from 13 to 30 years. The trees are
much higher (ca. 10 m) and form a very dense vegetation. The lowest tree branches form an almost closed layer close to the ground, but here and there still glades occur. In general, the herbs have been substituted by mosses.

In the conifer plantations the developing series of the vegetation varies from bare ground to dense forest. Slow worms never were caught in both extreme stages, but right in the intermediate stages. Sometimes extra light is provided in the somewhat older stages by clearcutting of trees. As a result of earlier tillage, extra structural variation occurred in the soil as well as in the vegetation, which makes that this burrowing species may have favourable conditions of life.
11% of all observations were made in a vegetation of composite structure, dominated by *Rubus*. It is an abandoned garden, where the vegetation consists of grasses, annual and perennial herbs and very dense, up to 2 m high shrubs of brambles.

The remaining captures (4%) were made at the edges of other forest types, such as mixed forest of *Betula pendula* and *Pinus* (*P. sylvestris* or *P. nigra*), young plantation of *Larix kaempferi*, oak coppice (*Quercus robur*), and at the edge of a heathland of *Calluna vulgaris*, *Erica tetralix* and *Molinia caerulea*. It is quite interesting that this last vegetation type has such a low score here. In other areas in The Netherlands I have made many observations of Slow worms in open heathland vegetation.

From all captures, 71.3% was made in or near *Deschampsia flexuosa* (57.9% pure and 13.4% in combination with other plant species). Eight Slow worms were caught on bare soil, six of them near *Calluna* and two near *Deschampsia*. Once, in September, a live Slow worm was caught on a nest of wood ants (*Formica* species).

I did not find indications that males, females and subadults differ in selecting special vegetation types.

In conclusion, the Slow worm’s habitat in the area is characterized by forests of low trees (<5 m), or higher trees with glades in between, or by forest edges with a south to southwest exposition. Inside the forests a bush layer fails and in the herb layer is a variety of open spots and dense plant growth. A strong preference exists for places with Wavy Hair-grass (*Deschampsia flexuosa*).

It should be noted that within the study area Slow worms were not found in all potential forest habitats. In the summer of 1981, a ten of adult Slow worms was found together under a pile of beech leaves at the edge of a dense beech forest, situated at ca. 5 km from the study area. This type of forest, dark without bush and herb layer (*Fagetum nudum*) also occurs in the Amerongsche Bosch, but Slow worms never were observed there. Maybe the exposure of a vegetation type to sun and wind plays an important role in determining the suitability of a certain type as habitat for Slow worms.

An important relationship exists between the actual forest management in the area and the distribution of Slow worm habitats since the forest management (unconsciously, in respect of its effects on Slow worms) takes care of the maintenance of the intermediate stages in the development of conifer forests: by clearcutting and by spreading the ages of the plantations. In this way always appropriate stages are available for the Slow worm population.

If we assume that the Slow worm’s above-ground activity in the daytime is a criterion for its presence, the data presented here indicate that they do not inhabit the whole territory surveyed, but that they prefer certain vegetation types.

**Conservation**

Most of the Netherlands species of reptiles have been found to decrease in number (Stumpel, 1981). However, this could not be established for the Slow worm, as the
Biometrical and ecological data of *Anguis fragilis* distribution data are very fragmentary (Bergmans, 1981; Van de Bund, 1964). I have the impression that on a national level this species is not yet threatened, although modern land use by man dissipates populations locally. Fellenberg (1981) comes to the same conclusion for the neighbouring German state of Westphalia. More knowledge about the habitat selection aspects will provide a nature management with special emphasis on the Slow worm's habitat.

Acknowledgements. I am indebted to M. van Bergen, J.L.V. Broers, P.M.J. Clerx, A.R.M. de Mooy, H.T.M. Peeters and P.P.M. Thissen, who assisted in collecting data from the field. Thanks are due to Dr. P.F.M. Opdam and Dr. H. Strijbosch for valuable discussions, and to Dr. J.J. van Gelder and Dr. H.E.J. Wijnands for comments on the manuscript.

References


