OBSERVATIONS ON *STEGANACARUS MAGNUS* : DIFFERENCES BETWEEN THE INSTARS

BY

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Introduction

In an earlier paper Elmes and Webb (1972) showed that there was considerable variation in size of adult *Steganacarus magnus* (Nic.) (Cryptostigmata), a fact that has also been noted by Cancela da Fonseca (1970). An analysis of the frequency distributions of the fresh weights of adult *S. magnus* showed a distinctly bimodal pattern and this Elmes and Webb attributed to sexual dimorphism. The smaller individuals, which were without eggs and prelarvae, were males, and the larger individuals, which contained eggs and prelarvae in their reproductive tracts, were females. From these analyses they proposed that weight provided the simplest character for distinguishing the sexes of adults of this species.

A similar analysis has now been made for the larva and three nymphal instars of *S. magnus*. Webb (1977) has shown in his paper on the life cycle of this species that, for populations living in a coniferous forest soil, the juvenile instars are spent within the scales of the pine cones. By dissecting these scales it is possible to obtain large numbers of the juvenile stages. The first part of this paper describes the morphological changes that take place from one juvenile instar to the next, while in the second part morphometric differences between the instars are described and analysed. The value of recognising many of these differences lies in the fact that it is frequently necessary to distinguish between the different instars for ecological and experimental studies, and the choice of method depends on whether or not the mite is subsequently required alive or dead.

In this paper, and others of the same series, the convention has been adopted of collectively calling the larva, proto- deuto- and tritonymphs the juvenile instars. The use of immature has been avoided since this term has already been used (Webb and Elmes 1972) to designate age classes in the adults.

All of the animal material that has been examined in this paper has been obtained from heathy coniferous soils with a high degree of podsolisation. These soils are characteristic of certain parts of south east Dorset, England and have been more fully described by Chapman and Webb (1978). The juvenile mites were obtained by dissecting the scales of the cones of the Scots Pine (*Pinus sylvestris* L.).

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Acarologia, t. XX, fasc. 1, 1978.

Morphological Differences

In this section it is not intended to provide full taxonomic description of the changes which take place as development proceeds through successive instars. The features to be described are those which have been found to be of the greatest value for distinguishing between the instars for experimental and ecological work. There are three of these features namely, the number of genital papillae (or suckers), the setation of the genital plates and the setation of the anal plates.

Unlike many of the primitive oribatids, the number of pairs of genital papillae in *S. magnus* increase by one pair at each moult, from a single pair in the protonymph to three pairs in the tritonymph ; the adult also has three pairs (Table 1). These papillae can be easily seen in cleared specimens of all the juvenile instars.

TABLE I

The distribution of genital papillae, genital setae and anal setae in the juvenile instars of *Steganacarus magnus* (Nic.).

	No. pairs Genital Papillæ	No. pairs Genital Setae	No. pairs Pseudanal Setae	No. pairs Adanal Setæ	No. pairs of Anal Setae
Larva	0	0	2		
Protonymph	1	1	3		
Deutonymph	2	4	4	3	
Tritonymph	3	7	4	3	2
Adult	3	9	4	3	2

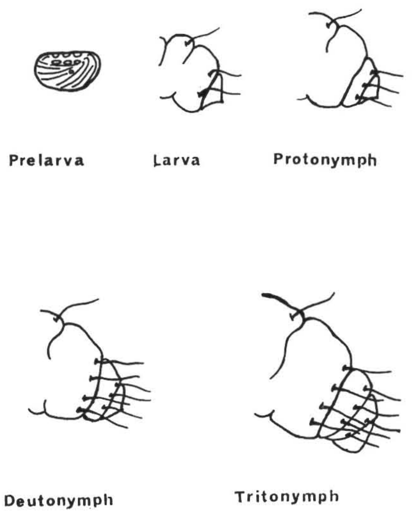
The number of pairs of both genital and anal setae increase throughout successive instars. These changes are set out in Table 1 and are illustrated in Figures 1 and 2. The single pair of genital setae in the protonymph increases to seven pairs in the tritonymph and to nine pairs in the adult. In the juvenile instars the genital setae are arranged in a row along the inner edge of the genital plate and the additional pairs of setae are added anteriorly during development. In the adult these setae are arranged in a row of four pairs along the inner edges of the genital plate and the remaining five pairs form a group on the inner surface of the anterior edge of the plate. These setae are almost hidden when the mite is in a normal position for observation, and can only be seen clearly when the genital plates are removed from the mite.

Anal setae increase during development as additional segments are added to the notogaster at each moult. The pseudanal setae increase from two pairs in the larva to four in the adult and there are two and three pairs respectively of anal and adanal setae in the tritonymph and the adult. There is of course, a major change in the setal patterns accompanying the moult from tritonymph to adult. In the nymphal instars setation is distinct and the additional segments with their rows of setae are added posteriorly. In the adult there is a reorientation of the setae, and the anal plates bear the adanal and anal setae along their inner edges. The anterior pair of setae are small and difficult to see and the pseudanal setae are arranged, surrounding the anal plates, on the notogaster.

TABLE 2

The frequency classes and corresponding class boundaries for hysterosomal length of all instars of Steganacarus magnus (Nic.).

Length Class (mm)		Lv	N1	Numbers of N2	N3	Ad
0.10 - 0.14	0					
0.15 - 0.19	1					
0.20 - 0.24	2	1				
0.25 - 0.29	3	6		1		
0.30 - 0.34	4	20	8	1		
0.35 - 0.39	5	12	4	0	1	
0.40 - 0.44	6	14	20	2	2	
0.45 - 0.49	7	7	20	8	5	
0.50 - 0.54	8	4	21	22	4	
0.55 - 0.59	9	2	9	24	10	
0.60 - 0.64	10		7	37	14	
0.65 - 0.69	11		3	24	23	
0.70 - 0.74	12			15	47	
0.75 - 0.79	13			7	25	
0.80 - 0.84	14			2	36	
0.85 - 0.89	15			1	27	
0.90 - 0.94	16			1	26	
0.95 - 0.99	17				19	4
1.00 - 1.04	18				19	9
1.05 - 1.09	19				4	18
1.10 - 1.14	20				6	17
1.15 - 1.19	21				1	17
1.20 - 1.24	22					32
1.25 - 1.29	23					7
1.30 - 1.34	24					32
1.35 - 1.39	25					66
1.40 - 1.44	26					29
1.45 - 1.49	27					28
1.50 - 1.54	28					10
1.55 - 1.59	29					4
1.60 - 1.64	30					1
1.65 - 1.69	31					
1.70 - 1.74	32					
Number (n)		66	92	145	269	274
Mean Length (mm)		0.38	0.49	0.62	0.81	1.31
± SD		0.08	0.09	0.10	0.15	0.14



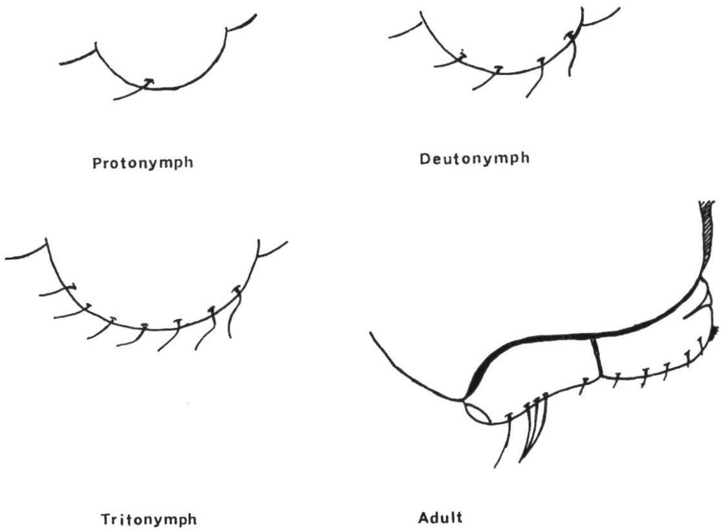


FIG. 1. — The changes in setation of the anal plates for the nymphs of *Steganacarus magnus* (Nic).

FIG. 2. — The changes in the setation of the genital plates of *Steganacarus magnus* (Nic.) during development from protonymph to adult.

For practical separation of the instars of *S. magnus* the number of genital papillae, which are easily seen and counted, is the simplest character to use. If the papillae are difficult to see or further evidence is required observation of the genital and anal setae can be made ; of these the genital setae are the most easily counted.

Hysterosomal length

As the juvenile instars develop the hysterosoma gradually lengthens. The changes in length were examined in a large sample of 572 individuals which represented the larva and all nymphal instars. The length of the hysterosoma, when viewed laterally was measured with a low power steroscopic microscope with an eye-piece scale that had 50 divisions to one millimetre. These measurements were made with the mites resting on their sides upon the microscope slide. A cover slide was not used since it was thought that this would cause compression of the body of the mite and lead to inaccurate measurements. After the specimens had been measured they were cleared and identified to instar. The number of pairs of genital papillae, genital setae and anal setae were also recorded.

TABLE 3

The fresh weights of the instars of *Steganacarus magnus* (Nic.). Data for adults from Elmes and Webb (1972).

	Lv	N1	N2	N3	Ad	Ad
Mean	19.16	30.71	68.04	232.90	159.00	335.00
± SD	11.06	10.81	41.05	118.51	-	-
n	19	24	27	38	-	-

The frequency distributions of the hysterosomal length are given in Table 2 and shown in Figure 3 the former also contains the mean values. These data are similar to those collected from adults by Elmes and Webb (1972) and the two sets of data have been combined for analysis into a single body of data representing 846 individuals. The analyses to be presented deal only with the lengths of the hysterosoma.

The lengths were grouped into 32 classes each of 0.125 mm covering the length range 0.100 mm to 1.740 mm. Analysis by probability paper (Harding 1949) failed to show any bimodality in the frequency distribution of lengths for the juveniles, although this had been demonstrated for the adults by Elmes and Webb (1972). The distributions of hysterosomal length for the larvae, proto- and deutonymphs have normal distributions, whereas those of the tritonymphs are platykurtotic and, although not differing significantly from a normal distribution, have a suggestion of bimodality. This perhaps, represents the onset of sexual dimorphism by the individual nymphs. Thus the population of tritonymphal lengths may be divided at class 13, representing the range 0.75 — 0.79 mm, and it seems possible that, as in the adults, the smaller individuals are destined to be males and the large ones females.

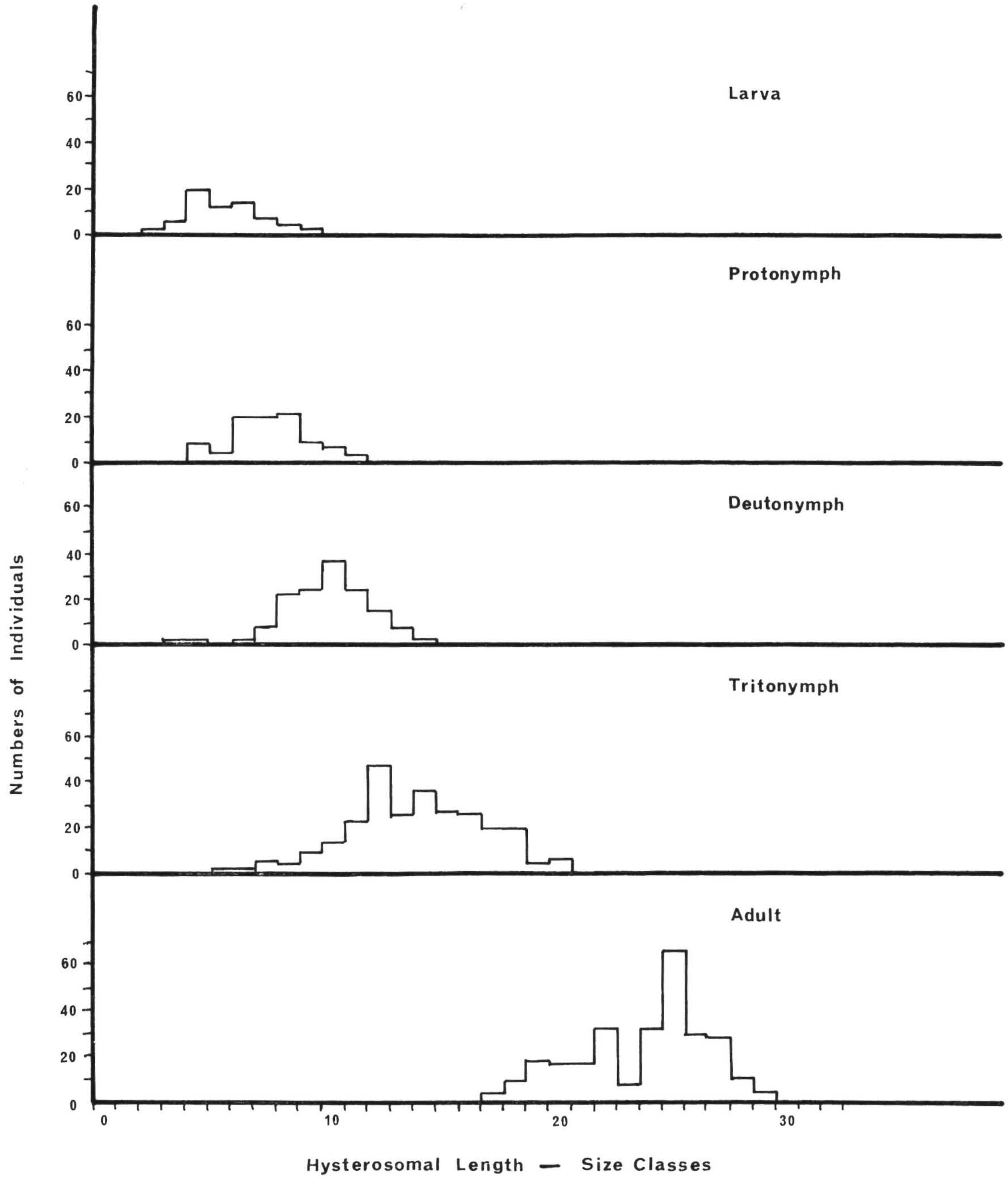


FIG. 3. — Frequency histogram of hysterosomal lengths of all instars of *Steganacarus magnus* (Nic.). Lengths are in arbitrary size classes of 0.05 mm, see Table 2.

Fresh weight

The fresh weights of 108 juvenile *S. magnus* were measured using an electromicrobalance (Beckman Type LM 600). The means and standard deviations of these weights are given in Table 3. Similar weights for mature adults, taken from Elmes and Webb (1972), have been included for comparison. Fresh weight approximately doubles between each instar from the larva to the deutonymph ; less between the larva and protonymph and slightly more between the protonymph and deutonymph. By contrast the tritonymph, with a mean weight of 232 μgm is almost three and a half times heavier than the deutonymph ; a weight which is heavier than that which would be expected if weight increased exponentially throughout successive instars.

The weight differences between the instars of *S. magnus* are of a similar order to those described by Luxton (1975). He reviewed the available information for a number of species of oribatid and came to the conclusion that each nymph was about twice the fresh weight of the previous and that tritonymphs were about half the adult weight. *S. magnus* partly fits the pattern, but the weight range of the tritonymphs overlaps that of the adult males. Were it possible to identify the sex of the tritonymphs no doubt the variability of tritonymphal weights could be reduced.

Weight/Length relationships

It is often impossible to measure directly the fresh weight or biomass of mites. In such instances it is useful to be able to calculate weight from a linear body measurement. Elmes, and Webb (1972) in their paper analysing lengths and weights, showed that in adult *S. magnus* weight (W μgm) was related to length by, $W = 137L^3 - 15$.

In this case the lengths were transformed by cubing because it was found that the regression obtained from this equation fitted the trend of the data closest. Elmes and Webb felt justified in using this cube transformation since it was considered that, as the animals approximated to a sphere, weight could be expected to vary as the cube of the length.

A similar analysis has been carried out on a sample of 61 individuals representing in approximately equal proportions, all the juvenile instars of *S. magnus*. Each individual was weighed live and then transfered to a microscope slide and the length of the hysterosoma measured taking similar precautions to those described previously. The scatter diagram obtained from plotting hysterosomal length against weight is reproduced in Figure 4. To this diagram has been fitted a regression line the equation of which is,

$$W = 193.3L^3 + 3.2$$

where W is weight in μgm and L hysterosomal length in mm. A value of $r = 0.962$ (P 0.001) was obtained for this regression. In this case it was also found that a cube transformation of the hysterosomal lengths gave the best fit to the trend of the data, although this at first appears less likely since the juveniles have a body shape less spherical than the adults.

Fresh weight/dry weight ratio

The relationship between fresh weight and dry weight of all stages of *S. magnus* was investigated in a sample containing 47 individuals. Each of these was weighed fresh and then reweigh-

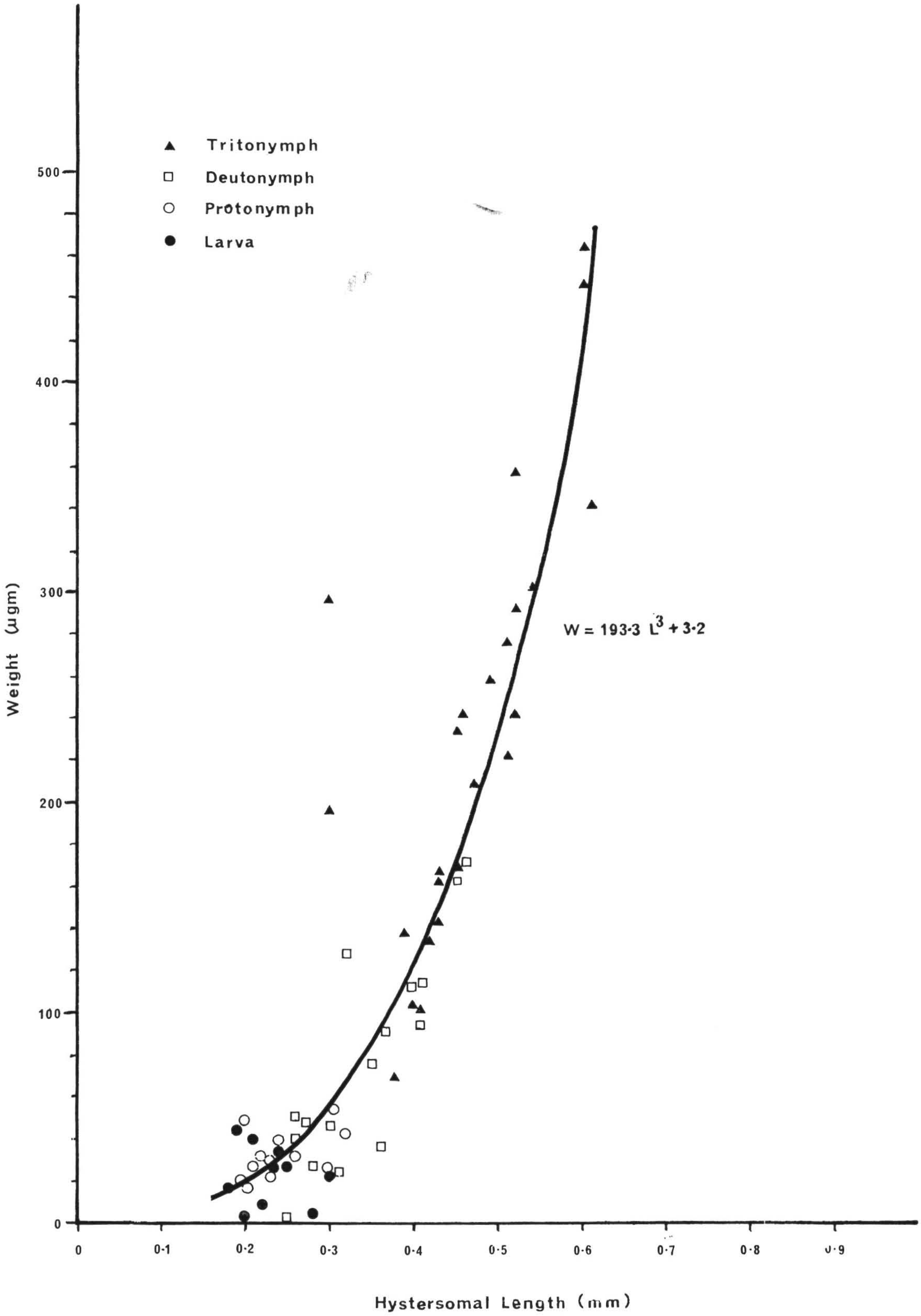


FIG. 4. — The relationship between hysterosomal length (mm) and weight (µgm) for the juvenile instars of *Steganacarus magnus* (Nic.). The fitted line represents the regression of the cube transformed data and has the equation : $W = 193.\ 3L^3 + 3.2$.

ed after drying for three days in a desiccator containing silica gel. As in previous experiments all the weighings were carried out on a electro-microbalance with a sensitivity better than 0.2 μgm. Similar sets of fresh and dry weights were obtained from a sample of 50 mature adults.

Linear regression equations obtained expressing dry weight in μgm in terms of fresh weight also in μgm were ;

$$D.Wt = 0.244\ W.Wt + 5.08 \ldots \text{ Juveniles}$$
$$D.Wt + 0.509\ W.Wt - 1.37 \ldots \text{ Adults}$$

These relationships show that in the juveniles the water content is 70 % of the fresh weight whereas in the adults, which posses a heavily chitinised exoskeleton, it is reduced to 50 %. LUXTON (1975) has noted that oribatids show a wide variation in water content and that the usual range is 50-70 %. His own figures of *S. magnus* agree closely with those above.

DISCUSSION

The features of the juvenile stages of *S. magnus,* especially those of identity and biomass, described in this paper are essential before estimates of population productivity can be made. Such estimates it is hoped will form the subject of future papers in this series.

The morphological differences between the instars call for no comment save that they are typical of those for oribatids.

There have been few comparable studies on the morphometrics of the juvenile instars of oribatids ; LEBRUN (1968) has carried out a similar study of *Nothrus palustris* (C. L. K.). The nymphs of *S. magnus* can be separated by either weight or hysterosomal length. Neither method gives conclusive results because of overlaps in the frequency distributions. Weight is perhaps the simplest character to measure and has the advantage that the animals can be used for further study. The same is true of hysterosomal length but this is less easy to observe than weight. For correct identification of the instars morphological characters must be used.

SUMMARY

This paper describes the changes that take place during development in morphology, hysterosomal length, fresh weight and dry weight of the instars of the oribatid mite *Steganacarus magnus* (Nic.). It also examines the relationship between hysterosomal length and fresh weight and between fresh weight and dry weight.

RÉSUMÉ

Cette publication décrit les différences entre la morphologie, la longueur de l'hysterosoma, le poid humide et le poid sec de tous les stases de *Steganacarus magnus* (Nic.). (Oribate). On analyse aussi la relation entre le poid humide et la longueur de l'hysterosoma et entre le poid humide et le poid sec.

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Paru en Janvier 1979.