

SOME OBSERVATIONS ON THE BIOLOGY AND STRUCTURE OF *ORNITHODORUS SAVIGNYI*, ANDOUIN.

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(With 3 Text-figures.)

CONTENTS.

	PAGE
Introduction	17
SECTION I. Biology of <i>O. savignyi</i>	18
Experimental records relating to females kept at different temperatures	18
Oviposition	20
No evidence of parthenogenesis	20
Longevity of female tick	20
Duration and number of nymphal stages at 30° and 37° C.	21
(a) Experimental data	21
(b) Discussion of data	21
Duration and extent of engorgement	22
The influence of moisture on vitality and ecdysis	22
SECTION II. Structure of <i>O. savignyi</i>	23
Dimensions of egg	23
Dimensions of unfed stages	23
Changes in external anatomy undergone during development (a) hypo- stome, (b) leg and spiracle	24

INTRODUCTION.

SOME observations on the biology and structure of *Ornithodorus moubata* have been recorded in a recent communication to this journal (Cunliffe, 1921) and in the following pages all references to this species refer to these observations, unless otherwise stated. Prof. Nuttall received living material of *O. savignyi* from Dr J. H. Ashworth in 1911 (from Aden, *Quick Lab. Cat. No.* 1575) and again in 1913 (no data, *Cat. No.* 2011). These stocks being available for breeding experiments, a few observations on the biology and structure of this species were made in the years 1913-14.

Even at the present time, details of the life-cycle of *O. savignyi* appear to be unknown. Howlett (1916) and Fletcher (1919) have both stated that this

tick was being studied at Pusa, but their results are apparently as yet unpublished. Nuttall and Warburton (1908) only note that "there are at least two nymphal stages, if not more." These facts and also that *O. savignyi* is a potential disease carrier justify the publication of these incomplete notes, made under laboratory conditions. This investigation did not yield the same amount of information as was obtained in the case of *O. moubata*, as the two were run together, and it was not possible to rear successfully large numbers of individuals of both species. As would be expected, the results of this second investigation are, for the most part, in agreement with those of the first, and where confirmation is complete, discussion of the records is omitted for economy of space, the reader being referred to the paper on *O. moubata*.

SECTION I. BIOLOGY OF *O. SAVIGNYI*.

It is unnecessary to recapitulate the experimental procedure, which was the same throughout as that adopted for *O. moubata*. Similar also was the aim of the investigation, namely, the determination of the number of nymphal stages passed through by this tick before reaching maturity, of the effect of temperature and moisture on the duration of the stages and of the changes taking place in the external anatomy of the ticks at each stage of development. As before, some notes were made on oviposition, copulation, longevity and engorgement. Females, with their progeny, from each stock were reared separately, but their records, being similar, are not shown separately in the following synopses of results.

Experimental records relating to females kept at different temperatures.

Three series of female ticks were maintained at 22°, 30° and 37° C. respectively, but only the second series bred at all successfully, as shown in Synopsis I.

Females and progeny maintained at 22° C.

A series of six females, which emerged from the last nymphal stage between May and July, 1913, although they fed well and were fecundated on one or more occasions, failed to oviposit until about the 400th day. The larval yield was too small to promise success in rearing and the experiment was discontinued. Females which emerged about the same time from the same stock, reproduced very successfully at 30° C. However, it is considered that a repetition of this experiment would show that 22° C. is not too low a temperature for reproduction by this species.

Synopsis I. *Females and progeny maintained at 30° C.*

Time reckoned in days from date of emergence of female.

No. of ♀	Date of emergence	Times of feeding	♂ added	Copu- lation observed	Commence- ment of oviposition after ♂ added	Oviposition			Death of ♀
						Period of life	No. of eggs	No. of larvae*	
40	20. vii. 13	14	37	37	47	84-85	29	nil	393
—	—	38	—	—	—	105	4	nil	—
—	—	79	—	—	—	135	6	nil	—
—	—	115	—	—	—	148-150	32	nil	—
—	—	172	—	—	—	191-195	77	10	—
—	—	277	—	—	—	295-296	26	17	—
41	26. vi. 13	5	69	70	15	84-85	43	27	412
—	—	69	—	—	—	88	18	11	—
—	—	103	—	—	—	92-94	3	nil	—
—	—	138	—	—	—	123-124	44	30	—
—	—	194	—	—	—	129-130	23	17	—
—	—	301	—	—	—	145	6	5	—
—	—	—	—	—	—	156	3	3	—
—	—	—	—	—	—	212-219	59	49	—
42	26. vi. 13	5	69	—	16	85-94	128	90	—
—	—	69	—	—	—	120	20	15	—
—	—	103	—	—	—	125-126	25	11	—
—	—	139	—	—	—	155-158	80	49	—
—	—	196	—	—	—	229	4	nil	—
—	—	298	—	—	—	—	—	—	—
43	23. vi. 13	2	74	74	20	94	8	6	420
—	—	72	—	—	—	97	10	8	—
—	—	106	—	—	—	100	9	9	—
—	—	144	—	—	—	128	29	25	—
—	—	197	—	—	—	134-136	58	37	—
—	—	303	—	—	—	165-166	45	21	—
—	—	—	—	—	—	182	10	nil	—
—	—	—	—	—	—	229	10	nil	—
44	20. v. 13	17	103	104	17	120-124	68	47	249
—	—	103	—	—	—	155-157	21	7	—
—	—	137	—	—	—	165	2	nil	—
—	—	175	—	—	—	189	9	nil	—
—	—	228	—	—	—	—	—	—	—
16	25. iii. 13	24	19	20	20	49-50	89	77	242
—	—	78	—	—	—	90	25	17	—
—	—	155	—	—	—	—	—	—	—
—	—	196	—	—	—	—	—	—	—
—	—	234	—	—	—	—	—	—	—
17	20. iii. 13	29	37	37	17	54-55	82	65	396
—	—	55	—	92	—	67	48	38	—
—	—	160	—	—	—	69-72	64	46	—
—	—	201	—	—	—	75	3	nil	—
—	—	295	—	—	—	95-96	46	43	—
—	—	—	—	—	—	101	13	13	—
—	—	—	—	—	—	179-180	91	76	—
—	—	—	—	—	—	214	16	11	—
—	—	—	—	—	—	251-252	39	32	—
—	—	—	—	—	—	264	15	7	—
18	25. iii. 13	24	24	25	16	40-41	55	41	394
—	—	50	—	108	—	49-50	62	57	—
—	—	78	—	—	—	60-61	76	42	—
—	—	155	—	—	—	65	34	12	—
—	—	196	—	—	—	67	20	12	—
—	—	203	—	—	—	96	26	12	—
—	—	290	—	—	—	118	8	nil	—
—	—	—	—	—	—	173	19	14	—
—	—	—	—	—	—	207	11	nil	—

* The subsequent history of these larvae is summarised in Synopsis II.

Females and progeny maintained at 37° C.

Two separate series of females were maintained at this temperature, the first set being started in November 1912, and the second in July 1913. Out of a total of 11 females only four oviposited, the records being as follows: ♀ 1, 92 eggs after 19–28 days (from date of emergence) followed by 14 eggs after 69 days; ♀ 2, 100 eggs after 16–17 days; ♀ 3, 8 eggs after 46 days followed by 56 eggs after 78–86 days; ♀ 4, 71 eggs after 69–74 days. These females were fed for another six months without further oviposition taking place and they were then discarded. Larvae emerged from 65 per cent. of the eggs, but reference to Synopsis II, in which their subsequent history is summarised, will show that none of them succeeded in passing the third nymphal stage at this temperature.

Oviposition.

When first deposited the egg is yellow in colour; it rapidly turns brown, more slowly becomes pitchy-brown and finally, in the course of three or four days, becomes jet-black. The agglutinative coating soon loses its efficacy in this species. The data, relating to oviposition, are summarised in the following table, minimum, maximum and mean results being shown:

	Ticks maintained at 30° C.		
	Minimum	Maximum	Mean
No. of days before oviposition occurred after ♂ was allowed access to ♀	15	20 (aberrant case 47)	17
No. of eggs deposited after each feed (when oviposition occurred)	4	174	62
No. of days between dates of feeding and oviposition commencing or recommencing	5	35	18
No. of days over which oviposition extended after each feed	1	50	9
No. of eggs deposited by a ♀	100	417	219
Percentage of fertile eggs		62 %	

The mean results are very closely comparable with those obtained in the case of *O. moubata* (at 30° C.), except that the number of eggs oviposited by the female is less by 40 per cent.

No evidence of parthenogenesis.

Parthenogenetic reproduction did not occur during the course of these experiments. Virgin females, which emerged in October 1913, were fed repeatedly, and maintained at 30° C. between meals, but they failed to oviposit during the following eight months. On the other hand, it has been shown that gorged females oviposit regularly about 17 days after the males are allowed access to them (at 30° C.).

Longevity of the female tick.

When performing their normal functions and maintained at 30° C., seven females lived for minimum, maximum and mean periods of 292, 420 and 358 days respectively. Under similar conditions at 22° C., the female had an average life of 775 days (three individuals).

Duration and number of the nymphal stages at 30° and 37° C.

(a) Experimental Data.

Some of the progeny of each female were reared in separate batches to the adult stage, to establish the duration and number of the nymphal stages. The records are summarised in Synopsis II, minimum, maximum and mean periods, together with the numbers of individuals observed, being given. As in *O. moubata*, the larva¹ passes into the first nymphal stage without previous engorgement; from the first nymphal stage onwards, the periods required for ecdysis are reckoned from the date of the previous meal and not that of the previous moult.

Synopsis II. *Duration of stages in days.*

Stage	Ticks kept at 30° C.				Ticks kept at 37° C.			
	Min.	Max.	Mean	No. of individuals observed	Min.	Max.	Mean	No. of individuals observed
Egg to larva	7	28	12	709	7	11	8	231
Egg to 1st ☉	13	32	19	630	11	20	15	198
1st to 2nd ☉	8	30	11	348	5	11	8	121
2nd to 3rd ☉	9	18	12	184	7	11	8	8*
3rd to 4th	☉ 7	49	14	116				
☉ or adult	♂ 21	33	29	3†				
4th to 5th	☉ 11	25	15	63				
☉ or adult	♂ 13	22	17	29				
	♀ 16	20	17	6				
5th to 6th	☉ 15	26	17	6				
☉ or adult	♂ 14	23	18	14				
	♀ 15	19	17	12				
6th to 7th	☉	No record						
☉ or adult	♀ 15	—	15	2				

* These eight individuals were the only survivors out of 121 second stage nymphs and as third stage nymphs they refused to feed.

† Probably abnormal.

(b) Discussion of Data.

As with *O. moubata*, males appeared after four to six and females after five to seven ecdyses, 63 per cent. of the males appearing after the fifth ecdysis and 60 per cent. of the females after the sixth ecdysis. As, however, only 66 individuals were reared to maturity, these percentages may require correction. The mean minimum periods required for the metamorphosis of an individual from egg to adult, at 30° C., under laboratory conditions, are

(1) for males, 60 (*corrected*), 73 or 89 days according to whether the individual undergoes four, five or six moults;

(2) for females, 73, 88 or 103 days, the number of moults varying from five to seven.

These periods are longer by an average of 27 days than in the case of

¹ The larva normally frees itself from the egg shell, but is otherwise inactive. In some cases, however, the species approaches *O. moubata*, inasmuch as the larva may undergo ecdysis without throwing off the shell. The feeble development of the hypostome, legs and claws and also the absence of eyes is doubtless correlated with the passiveness of this stage.

O. moubata, reared under similar conditions. An increase in temperature of 7° C. (from 30° C.) only reduced the period required for the production of third stage nymphs by 26 per cent.

Duration and extent of engorgement.

An experiment, similar to that carried out with *O. moubata*, was conducted with this species, ten nymphs of different stages being kept under observation until they reached maturity. Their weights before and after engorgement and the times of attachment to the host were accurately recorded. Again there was no regularity in the time of attachment, observation on 29 individuals of all stages giving minimum, maximum and mean times of 10, 74 and 26 minutes respectively, at room temperature, about 16° C. The figures are in agreement with those of Drake-Brockman (1915). The mean time recorded for *O. moubata* was 48 minutes, thus *O. savignyi* is apparently a more rapid feeder. Of the ten nymphs under observation, only four reached maturity, one being male and three female. In the female series, the mean increase in weight in grams was (a) before the final moult, 0.0647, and (b) after the moult 0.2202; the corresponding figures for the solitary male were (a) 0.0528, and (b) 0.0246. None of these figures were reached by *O. moubata*.

The influence of moisture on vitality and ecdysis.

A similar experiment to that carried out with *O. moubata* proved that, for this species also, excess of moisture is injurious to the individual. A batch of 33 first stage nymphs from the same female was divided into three lots, which between meals were maintained at 30° C. in saturated, moist and dry atmospheres respectively. A summary of the experimental records¹ is given in the following table, in which are shown the minimum and maximum number of days required for ecdysis, with the mean in brackets and the number of individuals observed in square brackets:

Atmosphere	2nd ☉	3rd ☉	4th ☉	5th ☉	6th ☉	% of ticks which matured
Saturated	9—13 (11) [11]	11—14 (13) [11]	23—48 (40) [7] 1 ♂	21 [1]	—	9 %
Moist	7—8 (8) [11]	9—32 (12) [11]	10—18 (12) [11] 2 ♂	11—17 (14) [4] 1 ♂	—	27 %
Dry	7—9 (7) [11]	9—13 (10) [8]	11—16 (12) [8] 1 ♂	10—14 (12) [5] 2 ♂, 1 ♀	13—17 (15) [2] 1 ♀	45 %

Excess of moisture was therefore a decidedly unfavourable factor, as under this condition only 9 per cent. of the ticks matured, whereas in the dry atmosphere 45 per cent. matured. The ecdysis period was not markedly affected by the presence of moisture (*vide* Synopsis II), until after the third nymphal stage was attained, when the lack of vitality was indicated by a lengthening of this period.

¹ The 1st nymphs were fed on 17. i. 13 and the 5th nymphs were fed or offered a meal on 13. vi. 13.

SECTION II. STRUCTURE OF *O. SAVIGNYI*.

Observations on the dimensions of the egg and unfed specimens of the different stages and the changes in form undergone during development by the hypostome, the fourth tarsus and the spiracle are included in this section.

Dimensions of the egg.

A total of 179 eggs were measured immediately after deposition by four different females, the minimum, maximum and mean measurements of length \times breadth being 1.0×0.9 , 1.8×1.4 and 1.4×1.1 mm. respectively. The minimum and mean measurements of the eggs of this species equal the mean and maximum measurements of those of *O. moubata*.

Dimensions of unfed stages.

As no records of the dimensions of the different stages appear in the literature on this species, measurements of material bred under control from one stock are summarised in Synopsis III. The number of individuals preserved was, in several cases, too small to give very accurate results, although as far as possible extreme examples were chosen for preservation.

Synopsis III. *Dimensions of stages.*

Measurements in mm. to nearest tenth, from unfed specimens preserved shortly after emergence in 70 % spirit.

Stage	Min. Length \times Breadth	Max. Length \times Breadth	Mean Length \times Breadth	No. of individuals observed
Larva	1.2 \times 1.0	1.5 \times 1.2	1.4 \times 1.1	52
1st \odot	1.3 \times 1.0	1.8 \times 1.4	1.5 \times 1.2	107
2nd \odot	1.5 \times 1.1	2.6 \times 1.9	2.1 \times 1.5	119
3rd \odot	2.2 \times 1.5	3.6 \times 2.6	3.0 \times 2.1	16
4th \odot	3.1 \times 2.3	5.6 \times 3.9	4.4 \times 3.1	14
♂ from 3rd \odot	5.2 \times 3.8*	6.0 \times 4.3	5.7 \times 4.0	3
5th \odot	3.9 \times 2.8	6.5 \times 4.6	5.6 \times 3.9	7
♂ from 4th \odot	5.2 \times 3.5	6.7 \times 4.6	6.0 \times 3.9	25
♀ from 4th \odot	7.0 \times 4.9*	7.8 \times 5.6	7.4 \times 5.2	4
6th \odot	5.0 \times 3.4	8.5 \times 5.7	6.7 \times 4.8	6
♂ from 5th \odot	5.8 \times 3.8	7.4 \times 5.6	6.5 \times 4.7	15
♀ from 5th \odot	6.7 \times 4.7	9.2 \times 6.7	8.1 \times 5.7	14
7th \odot	—	—	—	—
♀ from 6th \odot	6.4 \times 4.4	9.3 \times 6.7	7.8 \times 5.5	2

* Probably not true minima.

As in *O. moubata*, there is considerable variation in the size of individuals of any one stage, maximum measurements in one stage exceed minimum measurements in the succeeding stage, and males of any one stage are only slightly larger, whereas females are distinctly larger, than nymphs of the equivalent stage. In *O. moubata*, the greatest growth took place in the second nymphal stage but in this species it would appear to be spread equally over the second and third nymphal stages, the percentage increases in length being 7.3 (larva to 1st \odot), 40.0, 42.8, 46.7, 27.3, 19.7 (5th to 6th \odot), while the

corresponding increases in breadth are 9.1, 25.0, 40.0, 47.7, 25.8 and 23.1 per cent. respectively. The percentage increases in length and breadth from nymphal to adult stages correspond closely in both species, e.g. the percentage increases in length \times breadth in *O. moubata*, from fourth nymph to male, are 32×28 —while in *O. savignyi*, the increases are 36 per cent. \times 26 per cent.

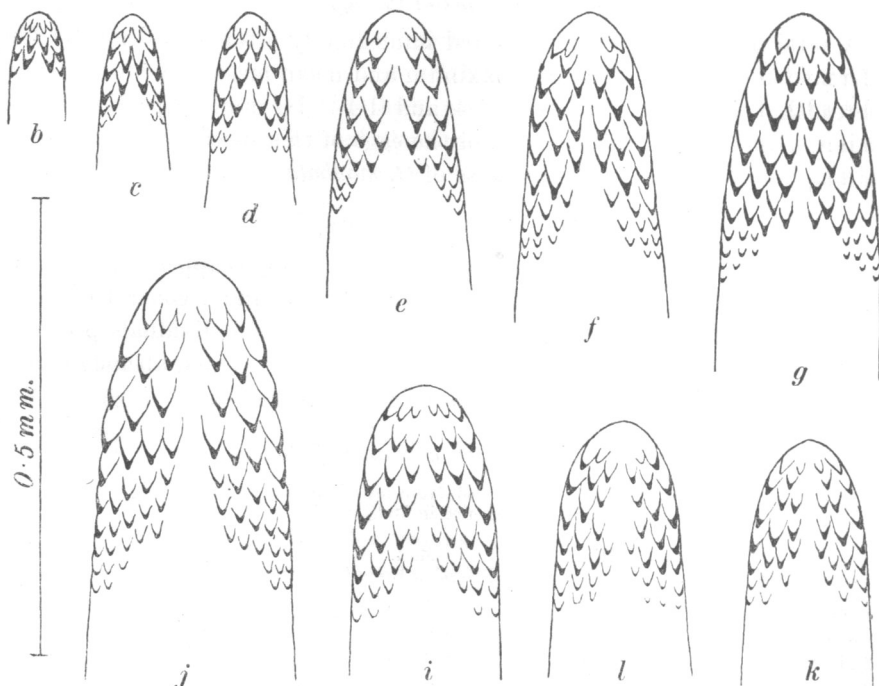


Fig. 1. *Ornithodoros savignyi*, hypostomes in ventral aspect: (b) to (g) of 1st to 6th stage nymphs; (i) and (j) of females from 4th and 6th stage nymphs; (k) and (l) of males from 3rd and 5th stage nymphs. (N. C. del.)

Changes in external anatomy undergone during development.

(a) The Hypostome. Fig. 1.

The changes in the dentition of the hypostome during the development from first nymph to adult are indicated in Fig. 1, (b) to (g) representing the nymphal organs arranged in order of development, (i) and (j) the hypostomes of females emerging from fourth and sixth nymphs, and (k) and (l) of males from third and fifth nymphs respectively.

On comparison with the hypostomes of *O. moubata*, it will be observed that in this species also several proximal rows and the distal row of teeth are equally poorly developed and their arrangement difficult to determine, that in the first and second nymphal stages the number and arrangement of the teeth are very similar, but that in the later stages the number of teeth is considerably less, owing to the presence of smaller numbers of rows and files. The changes taking place during development consist of an increasing com-

plexity of dentition, correlated with an increasing size of hypostome and they are of much the same order in both species.

In many cases the teeth are not arranged symmetrically on the two sides of the hypostome, the rows on one side appearing to alternate with the rows on the other side.

(b) The Legs and Spiracle. Figs. 2 and 3.

Outlines of the terminal portions of the fourth legs and of the spiracular plates are shown in Figs. 2 and 3 respectively, for the following stages, namely, first to sixth nymph (*a*) to (*f*); males from third and fifth nymphs (*h*) and (*i*); and females from fourth and sixth nymphs (*j*) and (*k*).

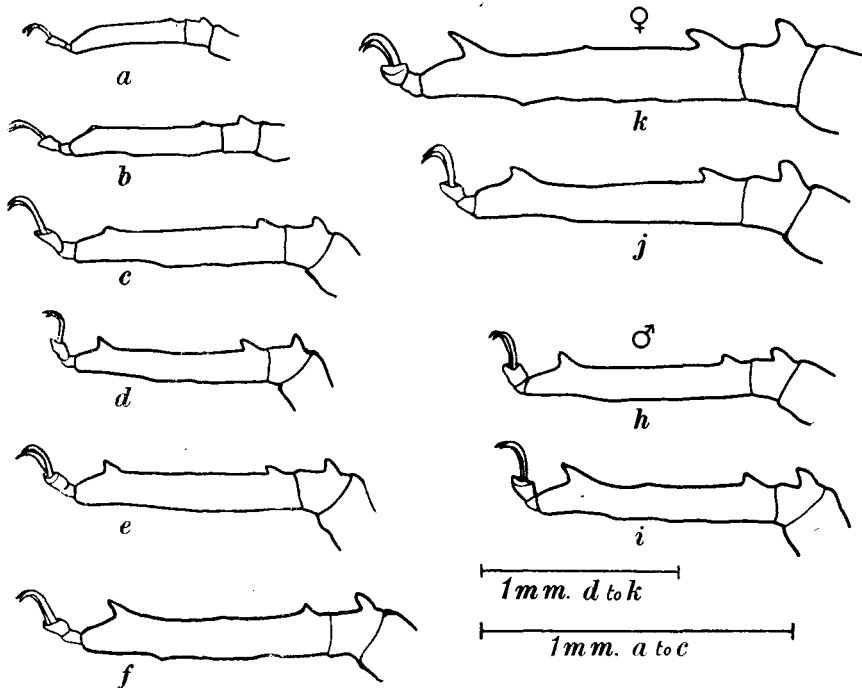


Fig. 2. *Ornithodoros savignyi*, tarsi of fourth legs, in lateral aspect: (*a*) to (*f*) of 1st to 6th stage nymphs; (*h*) and (*i*) of males from 3rd and 5th stage nymphs; (*j*) and (*k*) of females from 4th and 6th stage nymphs. (N. C. del.)

The degree of development of these structures at each stage is similar in the two species, *O. savignyi* and *O. moubata* and needs no further discussion.

SUMMARY OF RESULTS.

1. The biology, as studied under laboratory conditions, of *O. savignyi* is very similar to that of *O. moubata*.
2. Females may oviposit over 400 eggs, of which at least 60 per cent. may be fertile; parthenogenesis does not occur.
3. An increase in temperature of 8° C. (from 22° C.) decreases the longevity

of the female from 775 to 358 days, *i.e.* by 45 per cent.; an increase of 7° C. (from 30° C.) reduces the period required for the production of third stage nymphs by 26 per cent. At 30° C., the mean minimum periods required for metamorphosis are 60 days for males and 73 days for females (*cf.* *O. moubata*, 36 days for males and 45 days for females). Reproduction was inhibited at 37° C.

4. Moisture is an unfavourable factor, decreasing the vitality of the individual at each stage of growth.

5. Changes in external anatomy undergone during development are similar to those already described for *O. moubata*.

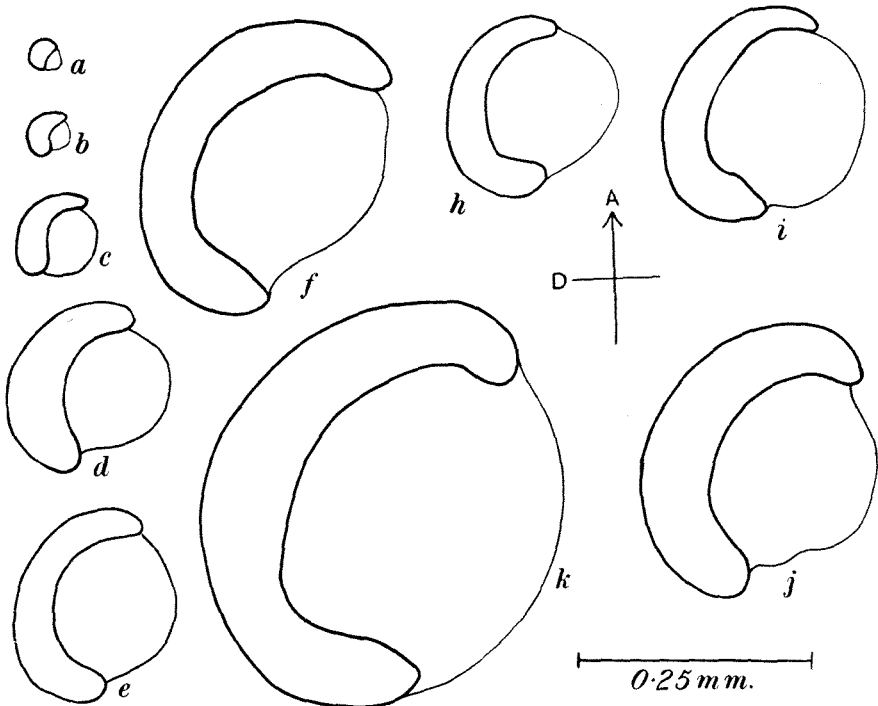


Fig. 3. *Ornithodoros savignyi*, outlines of cribriform plates of spiracles: (a) to (f) of 1st to 6th stage nymphs; (h) and (i) of males from 3rd and 5th stage nymphs; (j) and (k) of females from 4th and 6th stage nymphs. (N. C. del.)

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