ON THE ECONOMIC STATUS AND BIONOMICS OF *SMINTHURUS VIRIDIS*, LUBB. (COLLEMBOLA).

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(PLATE XIV.)

The inclusion of species of the order Collembola among the list of injurious insects has, from time to time, given rise to considerable scepticism among those concerned with economic entomology. It is, therefore, thought desirable to place on record controlled experiments which leave no doubt as to the depredations of one species, *Sminthurus viridis*, Lubb., of this primitive group of insects. Further, our knowledge of the bionomics of Collembola is so scanty that data obtained with reference to the life-history and habits of this particular species may be of interest.

Geographical Distribution and Description.

Sminthurus viridis, Lubb. (fig. 1) is the only British species now included in the genus *Sminthurus*, of the subglobular forms (Symphypleona) of Collembola. This

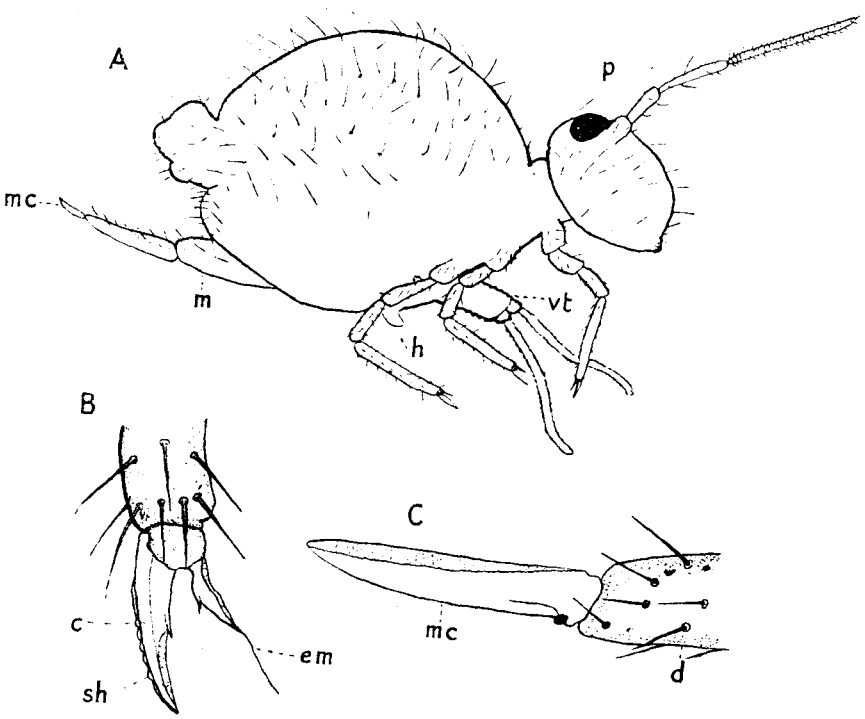

Fig. 1. *Sminthurus viridis*, Lubb.: A, adult, ×40; *p*, pigment surrounding eyes; *vt*, ventral tube with extended warted vesicles; *h*, hamula; *m*, mandibles of furcula; *mc*, mucro; B, foot of left posterior leg, ×270; *c*, tarsal claw; *em*, empodium; *sh*, membranous sheath; C, furcula, ×270; *d*, dentes; *mc*, mucro.

greenish yellow springtail is found commonly, especially in spring and autumn, on grassland and clover leas all over the British Isles, while its distribution abroad is very wide, it being recorded from Australia, New Zealand, and the whole Palaearctic region. The average size of adult specimens is 2·0–2·5 mm.; the head is anteriorly

obtuse, the angle enclosing the mouth-parts, which are adapted for both biting and sucking. The eyes, situated on a patch of black pigment on the posterior half of the head, stand out in contrast to the green body. The 4-jointed antennae, slightly anterior in position to the eyes, are also green except for the terminal segment, which is reddish in colour and is marked off into a series of about 20 constrictions, each with a whorl of fine hairs around its circumference. The thoracic segments are very much reduced, being telescoped between the head and the abdomen, the latter comprising about two-thirds the size of the entire insect. The legs are five-jointed and terminate in two unequal tibio-tarsal claws (fig. 1, B).* The abdomen, subglobular in form, bears ventrally the characteristic appendages of Collembola; the ventral tube is long and its walls are covered with warted prominences; the *hamula* or "catch" on the 3rd segment is well developed, as also is the *furcula* or "spring" with its stout *manubrium* and elongate *dentes* and *mucrones* (fig. 1, C). The whole body and legs are covered with fine hairs, and there are no glandular openings on the furcal segment.

Sminthurus viridis is phytophagous in its feeding habits, despite the fact that many of its related species are saprophytic. Lubbock[1] in 1873 stated that "some species of *Smynthurus* live on leaves"; this was the first indication that Collembola may be of economic importance. *Sminthurus viridis* is omitted in Theobald's[2] list of injurious species of Collembola in 1910, but it is possible that some of the previous records of damage by *Sminthurus* sp. may have referred to this particular species. The first authentic record of damage by this species appears to be that of Lea[3] in 1920, when under the popular name of "lucerne flea" it was reported to cause considerable damage to that particular host-plant in South Australia. Subsequent reports (1921–1924) from the same area have been published, and among its host-plants are lucerne, clover, Cape dandelion, beans, potatoes, sugar-beet, oats, barley, and grasses. *Sminthurus viridis* was declared a pest under the Plant Diseases Act, 1924, in New South Wales.[4] It is interesting to note also that under the new scheme of the Empire Marketing Board (1927) for the distribution of parasites of insect pests to the Colonies, one of the first demands was that from Australia for parasites of this insect. In Great Britain, however, its economic significance appears to have been overlooked, and probably owing to its elusive habits, its depredations have been included among those of species of *Apion*, *Hypera*, etc.

Experimental Evidence of Damage.

During an investigation of the economic position of Collembola the writer was able to make detailed observations regarding the occurrence and habits of *Sminthurus viridis* on clover leas at Rothamsted. On witnessing, under a hand-lens, several specimens feeding on clover leaves and realising the enormous numbers present, it became desirable to estimate, at least qualitatively, the amount of damage caused by these insects. A series of 15 flower-pots containing uniform, insect-free soil, was set up; each was covered by means of a lamp-glass (basal diameter 3½ inches) and, after 50 seeds of wild white clover (*Trifolium repens*, L.) had been sown in each, the top of the lamp-glass was closed by a cap consisting of a circular iron ring (5 in. diameter) covered with fine muslin. These pots were placed in the insectary, where conditions were comparable to those out of doors except that watering was necessary. The clover seeds germinated in 5 days and were allowed a further 5 days to develop before being infested with the Collembola. At this period the 10 most uniform pots of clover were selected for experimental work. The average number of *Sminthurus viridis* for that particular surface area in the field was ascertained by taking 40 counts within the lamp glass on the clover lea on Little Knott field; 6 proved to

* Specimens mounted in Keilin's medium eveal a wavy membranous sheath (*sh*) adjacent to the outer edge of the upper claws.

be the average number of individuals per unit area. On 16th March 1926 a quantity of *Sminthurus viridis* was swept from the field and 6 adult specimens were placed in each of the 5 clover pots in the insectary; the 5 remaining being kept as controls. On the following day the clover in the infested pots showed obvious evidence of damage, and individuals of *Sminthurus viridis* were observed feeding indiscriminately on the upper and lower surfaces of the leaves. Later observations showed that frequently the outer epidermis, upper or lower as the case may have been, was left untouched, giving a skeletonising effect as seen in Plate xiv, fig. 2. There was ample evidence that feeding took place during both day and night, and under very warm dry conditions feeding and movement were confined to the base of the herbage. The effect of attack by these few individuals was soon evident and is clearly seen in the photographs (Pl. xiv, fig. 1) taken on 5th May. One control and 2 infected pots are shown and illustrate the extent of damage caused to clover by 6 individuals of *Sminthurus viridis* for a period of 10 weeks. It should be added that the pots were observed daily and the six individuals counted; in the event of death of an individual another specimen was added. The marked effect was very evident at the end of 15 weeks, when the clover, under the favourable conditions of the control pots, outgrew the height of the lamp-glasses.

This conclusive evidence, together with personal observations in the field, convince one of the damage this species may do, especially on young clover leas. The fact that *Sminthurus viridis* has been observed by the writer to feed also on turnips, mangels, barley, oats, wheat and grasses, makes it possible for this insect to exist on other crops in the rotation and thus tide over arable conditions and be present when the field is laid down to clover or grass.

Realising the fact that *Sminthurus viridis* had several host-plants, experiments were set up with a view to discovering, if possible, whether this species was selective in its feeding habits. Ten large earthenware dishes, 8 inches in diameter, were filled with insect-free soil, and 20 seeds of each of the following grasses or clovers of a common seed mixture were sown in separate rows: Wild white clover (*Trifolium repens*, L.), late-flowering red clover (*Trifolium pratense*, L.), perennial rye grass (*Lolium perenne*, L.), Italian rye grass (*Lolium italicum*, A.Br.), cocksfoot (*Dactylis glomerata*, L.), timothy (*Phleum pratense*, L.). The dishes were then covered with large glass cylinders, 7 inches in diameter, closed in above by muslin caps. When the seedlings had become fully established 20 specimens of *Sminthurus viridis* were introduced into each cage. Feeding took place more or less indiscriminately, except that the wild white clover showed evidence of greater attack in the earlier stages. The insects were allowed to feed for 14 days, after which the grasses and clover plants were examined individually. Counts of damaged plants at this stage gave no significant difference, as specimens of all the species were found to be attacked. These negative results were surprising in view of the fact that ample evidence was obtained in the field by sweeping that there was a greater preponderance of *Sminthurus viridis* on patches of clover over those areas where little clover existed. It may be, however, that the conditions of confinement in these cages prevented any selective habit being established. Specimens of *Sminthurus viridis* have been swept from grassland at Rothamsted in every month of the year, and thus the damage caused by this pest over such a period must be considerable.

Control Measures.

It is regretted that up to the present no opportunity for investigating a practical method of control has occurred, but from general observations it is thought desirable to suggest the following methods. Sweeping of infected areas with tarred sacks, as used against another species *Bourletiella hortensis* on mangels,[5] would no doubt reduce the numbers considerably, but the presence of the "nurse crop" prevents

this from being done at the critical stage in the life of the young seedling clover or grass. The extremely delicate structure of *Sminthurus viridis*, and the presence of destroyed specimens on stones and elsewhere following a heavy rolling, suggest that this operation, together with chain-harrowing would assist in reducing the numbers of springtails. By arranging tarred sacks in front of the roller, the efficiency of this method would be increased. In this connection it may be of advantage to note that Spafford[6] recommends close grazing by sheep and chain-harrowing as a means of reducing the numbers of the lucerne flea in New South Wales. In exceptional cases, such as greenhouse attack, or heavy local infestation, dusting with 5 per cent. nicotine sulphate has afforded a control.[7] No insect parasites have, as yet, been bred from Collembola, so that it remains for predatory enemies to keep these insects in check. The chief of these, so far as the writer is aware, is a small black spider (unidentified as yet). The scarcity of *Sminthurus viridis* on Little Knott field at Rothamsted, when these spiders were present, was very evident; its sudden method of approach is extremely efficient in capturing its prey. The remark by several farmers that black spiders were eating their clover is no doubt associated with this fact.

Bionomics.

Apart from the fact that Collembola undergo no metamorphosis, little is known regarding the life-history of this primitive group of insects. During the present

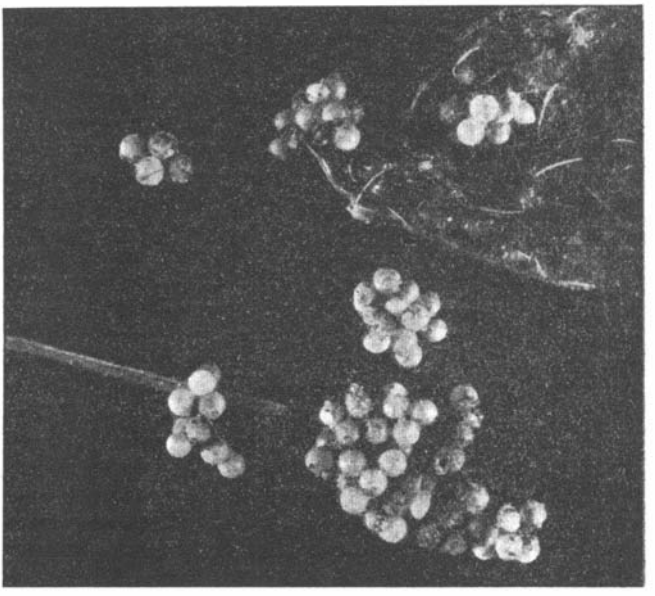

Fig. 2. A typical batch of eggs of *Sminthurus viridis* laid on damp decayed leaves. × 15.

investigation many interesting observations have been made on the habits of *Sminthurus viridis*; these are included here as a preliminary account, as it is hoped to carry out a more detailed study of this subject later.

As previously stated, specimens of *Sminthurus viridis* have been collected in the field during each month of the year. Specimens caught in the field were periodically brought into the insectary, where they were placed on clover leaves in small glass dishes, lined with filter-paper which was kept continually damp. Under these

conditions eggs were easily secured. Oviposition was observed each month from March 1926 to November 1926, observations having been unavoidably suspended for the remaining months. The eggs (fig. 2) are pale yellow in colour, with smooth delicate chorion, and 0·25 mm. in diameter at the time of oviposition. During oviposition the female stands with legs spread well apart and lowers its head until it touches the filter-paper, its antennae being held in a dorso-posterior position. A yellow substance slowly issues from its anal end, which is raised; the mass being originally without definite shape gradually assumes a spherical appearance. With the yellow globule protruding the female raises its head and lowers its anal end until the spherical mass touches the filter paper. The mass, or egg as it proves to be, adheres to the surface, and the female after vigorous movement eventually releases itself. During this process the egg, and subsequently a batch of eggs, become covered with excreta issuing from the anus, which in some cases completely hide the eggs. This, no doubt, accounts for the fact that it is extremely difficult to discover eggs in the field. After oviposition the female turns round and touches the egg with its antennae and feet. The eggs are laid in batches varying in numbers from 2 or 3 to 30 or 40, according as to whether the female is disturbed or not during oviposition. Eggs are usually laid on damp decaying leaves and other moist surfaces at the base of herbage; occasionally they were found singly on the underside of the lower clover leaves.

The dishes in the laboratory were retained at an average temperature of 15° C., and damp conditions were maintained continuously. The average diameter of the egg at oviposition is 0·25 mm. The diameter gradually increases, and when at 0·27 mm., 20–25 days after oviposition, the eyes and antennae are visible through the delicate chorion. Shortly after this stage an equatorial split occurs, which widens as the two halves of the chorion are gradually forced apart. Under the conditions mentioned, hatching took place between 35 and 40 days after oviposition. Emergence is effected by the anterior half of the chorion being pushed off by the head of the individual, and frequently vigorous movement is necessary before the insect frees itself from the egg. The spring, or furcula, is at first fully extended, but immediately the individual is free, it retracts its furcula under its abdomen, after which it is capable of movement by leaping. Its size on emergence is 0·4 mm. Specimens have been observed feeding a day after emergence. Gradual growth takes place until the individual becomes mature in about 8–10 weeks, according to atmospheric conditions. No mating was observed, nor has any ever been recorded among Collembola. It is hoped that further observations may yield information on this matter.

Whereas in all elongate species (Arthropleona) of Collembola cast skins are exceptionally common among the haunts of these species, none were observed in the case of *Sminthurus viridis*. Despite lengthy observations with a view to witnessing this phenomenon, no indication of moulting was seen.

The writer is grateful to Dr. A. D. Imms for the valuable advice and facilities rendered during this investigation.

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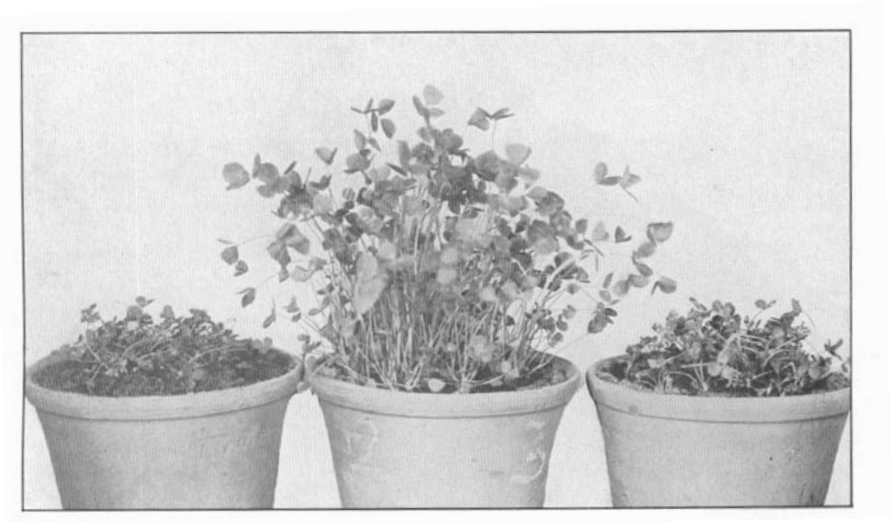

Fig. 1. Experimental pots containing 50 plants of wild white clover, showing the damage caused by six specimens of *Sminthurus viridis* in ten weeks; the middle pot is the control.

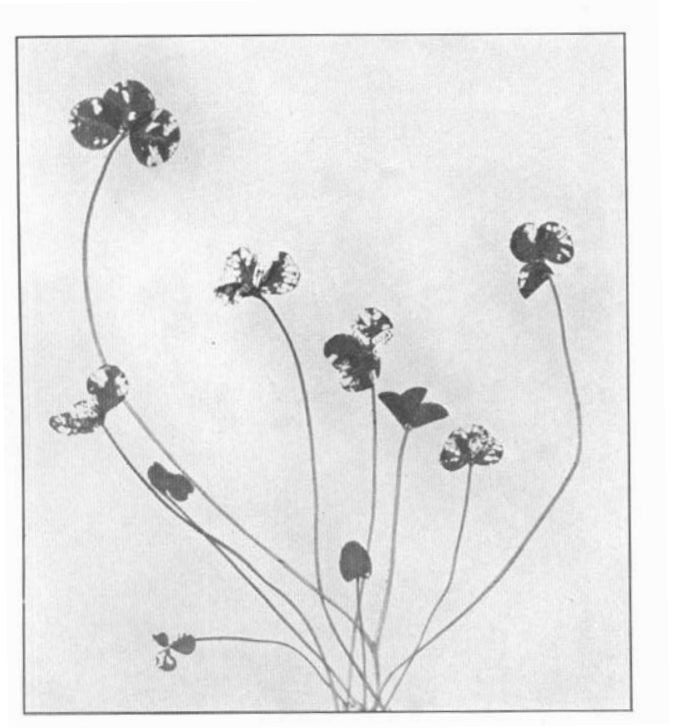

Fig. 2. Leaves of wild white clover (*Trifolium repens*) showing damage under controlled conditions caused by *Sminthurus viridis*, Lubb.