BIONOMICS OF WEEVILS OF THE GENUS *SITONA*[1] INJURIOUS TO LEGUMINOUS CROPS IN BRITAIN

BY DOROTHY J. JACKSON, F.E.S.

PART II.

SITONA HISPIDULA F., *S. SULCIFRONS* THUN AND *S. CRINITA* HERBST.

(With 5 Text-figures and Plate III.)

A. *SITONA HISPIDULA* F.

SITONA HISPIDULA F. is widely distributed throughout Europe and America and is a recognised pest of leguminous crops in both continents. It is also recorded by Allard (1) from Western Siberia. In America its depredations appear to be only of recent date, as prior to 1876 this species was not known to occur, but in that year it was observed in New Jersey, and in 1889 its sudden spread in America was noted by Schwarz (15). It has since extended westward, and its first appearance in California was recorded by Van Dyke (20) in 1917.

In the British Isles it is common and widely distributed, and wherever present, is injurious to clover and lucerne, though the damage caused by it in this country has hitherto escaped recognition. The life-history of this species has been investigated by Wildermuth (22) in America, but in Europe only a few observations have been recorded by Brischke (4) in Western Prussia. Hitherto no account of the life-history of this species in Britain has been published.

Food-plants.

All species of clover (*Trifolium*), lucerne (*Medicago sativa*), medick (*Medicago lupulina*); rarely upon peas.

At Wye, Kent, this species was common upon lucerne in most months of the year; it also occurred on temporary clover leys, in fields of perman-

[1] The name *Sitona* Germ. is here adopted in place of *Sitones* Schoenh. on account of priority, Germar (9) having named this genus *Sitona* in 1824. Schoenherr (16) in 1826 and again in 1834 (17) also uses this name, but in 1840 (18) changed it to *Sitones*.

ent pasture and amongst clover in waste places in the same locality. Only one or two specimens occurred upon peas. In the north of Scotland it is locally abundant amongst clover in the fields and by the roadsides. In Russia and America this species is principally recorded as a pest of clover and lucerne, but in Maryland, Cory (5) mentions it as attacking newly planted Lima beans. Petit (12) observes that *S. hispidula* was so numerous upon lucerne in Michigan that entire fields were destroyed by it. Wildermuth (22) considers that the larvae of this species may sometimes feed upon the roots of grass, but no confirmation of this has been obtained in the present research. Bargagli (2) mentions the occurrence of *S. hispidula* on *Galega officinalis*.

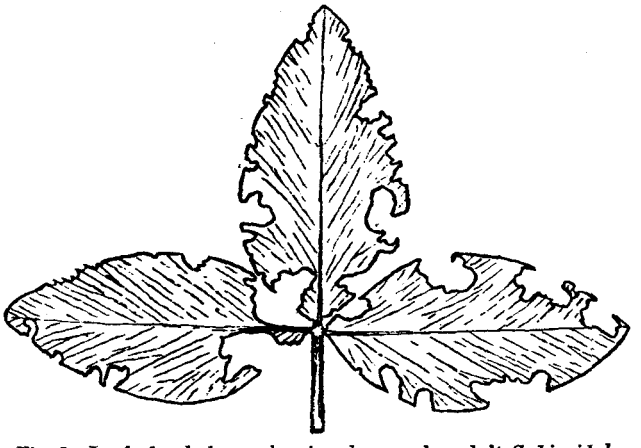

Fig. 1. Leaf of red clover showing damage by adult *S. hispidula*.

Nature of Damage.

Damage by adults. (Fig. 1.) The adults of *S. hispidula* feed upon the leaves of clover and lucerne but are rarely present in sufficient numbers to cause serious damage. They commence to feed at the edge of the leaf by biting out very small notches which are usually deepest between the veins, so that the eaten portion has often a jagged appearance. The beetles frequently continue to feed at the same place upon the leaf, thereby enlarging the original excavation and forming irregular indentations of various sizes.

Damage by larvae. (Figs. 2 and 3.) Though larvae of *Sitona* are to be found very commonly damaging roots of clover in the field it is not easy to determine to which species they belong, as at present there is no comparative description of the larvae published, and also when dug up from the field they are difficult to rear. The injury was therefore determined

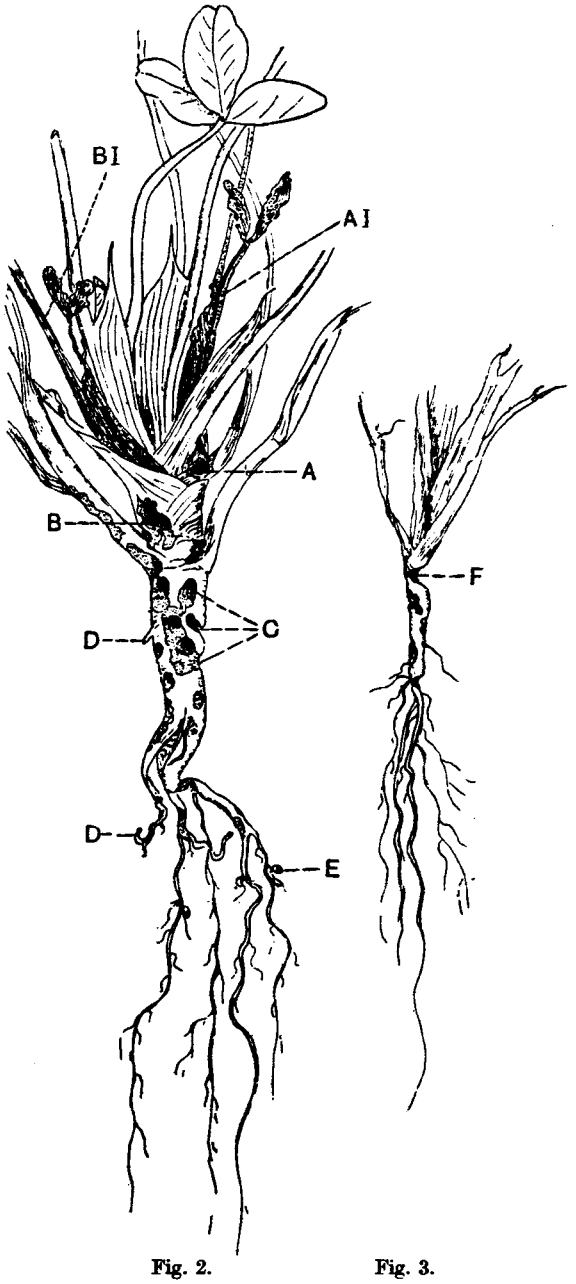

Fig. 2. Fig. 3.

Fig. 2. Plant of red clover with root damaged by larvae of *S. hispidula*. *A* and *B* = holes at base of plant bored by larvae and causing death of shoots *A* 1 and *B* 1. *C* = holes bored on root. *D* = side rootlets eaten by larvae. *E* = root nodule eaten by larva.

Fig. 3. Young plant of red clover almost bitten through at *F* by larvae of *S. hispidula*.

by breeding experiments. Eggs were introduced into pots of clover covered with muslin (10, p. 283, Plate XVIII, fig. B). In uninfected pots the clover remained strong and healthy, but in pots infected with eggs of *S. hispidula* much of the clover died before the larvae had ceased feeding owing to the damage they had inflicted upon the roots and the plants that survived were thin and weak. The larvae bored deep holes all over the main root and when half grown they were sometimes found entirely buried in the root. The portion of the root just below the crown of the plant was frequently chosen for attack with the result that the shoot immediately above the damaged area died. In all the larger plants so affected the outer shoots were dead from this reason whilst in small plants the whole root was sometimes bitten through at this point. The surface of the main roots were also gnawed in patches, the side rootlets were bitten off and the nodules destroyed. The gnawed portions of the root decayed and turned brown.

Field observations indicate that the greater part of the injury is done in June and July when the larvae are most abundant and plants of clover with the roots injured as described above have been dug up from the fields in these months and from the larvae that were found beside them adults of *S. hispidula* were duly reared.

Description of Adult.

Black, clothed on the dorsal surface with scales of various shades of brown and ochreous and with long erect setae on the elytra. Length 3·3–4·7 mm.

Head. Eyes flat, scarcely projecting from the sides of the head. Forehead between the eyes completely flat but with a narrow central furrow which is continued upon the rostrum.

Pronotum. Broader than long, sides strongly rounded. Covered with large diffuse punctures between which are smaller punctured dots, and bearing numerous short raised setae pointing forwards. Scales rather broad and closely placed, of uniform colour, but varying in different specimens; purplish brown or greyish brown. Raised setae black or white. Broad subdorsal bands and a narrow interrupted dorsal line composed of bright ochreous or whitish scales are usually present. The anterior coxal cavities separated from the presternal line by an area equal to the breadth of the presternum[1] (Fig. 5).

[1] Reitter (13) in his key to the genus *Sitona* makes use of the character afforded by the position of the anterior coxal cavities in regard to the transverse furrow behind the anterior edge of the prosternum. This furrow which he calls "die Abschnürungslinie hinter dem Vorderrande der Vorderbrust," I here designate as the presternal line and the area between it and the anterior margin as the presternum.

Elytra. Rather broad and short with striae of large punctures and with conspicuous raised setae, black and white, pointing backwards and arranged in lines. These setae are as long or slightly longer than the breadth of an interval between two striae. Scales much variegated in colour in the same specimen, occurring in darker and lighter groups.

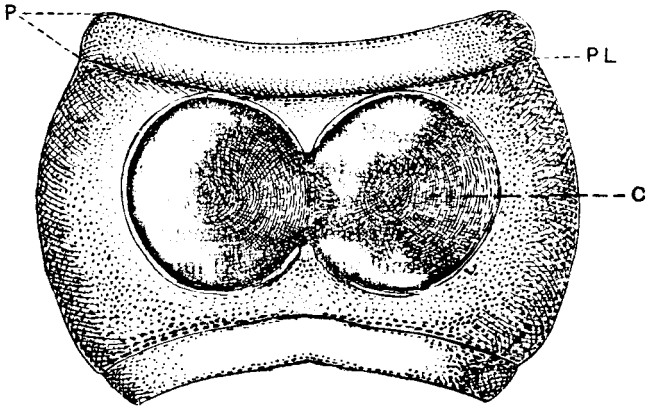

Fig. 4. Prosternum of *Sitona regensteinensis* Herbst with coxae removed. ×60. *P* = presternum. *PL* = presternal line. *C* = coxal cavity.

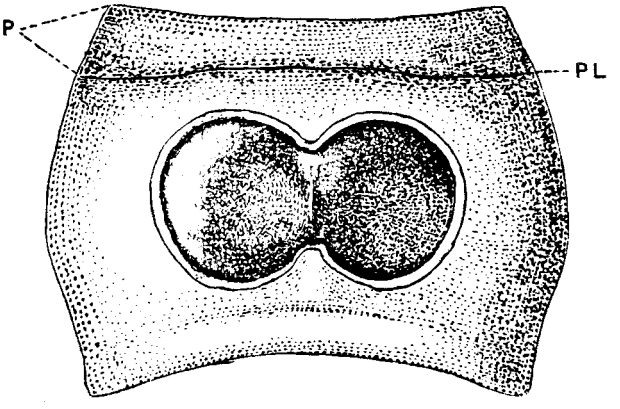

Fig. 5. Prosternum of *Sitona hispidula* F. with coxae removed. ×60. *P* = presternum, *PL* = presternal line.

Coloration varies in different specimens from dark purplish brown mottled with ochreous to pale greyish brown variegated with silvery grey. There is frequently a light patch upon the shoulders.

Undersurface. Clothed with ochreous or whitish scales and flat setae. The scales on the meso and metasternites and on the abdomen are plumate in structure.

Legs. Femora black but reddish at the base and extreme apex and bearing pale scales and long flat setae. Tibiae and tarsi red clothed with similar setae.

Antenae. Dark red with pale setae.

External Sexual Differences.

The sexes can readily be distinguished by examination of the posterior abdominal segments which are similar in structure to those of *S. lineata.*

On Distinguishing Sitona hispidula *from other British Species of* Sitona.

Owing to the difficulty usually experienced in identifying the weevils of this genus, and in order to supplement the key already given, the species which might most easily be confused with *S. hispidula* are here enumerated and some additional characters for their distinction are given.

S. tibialis Herbst and *S. lineella* Gyll. Bristles more depressed and much shorter than in *S. hispidula*, not being as long as breadth of an elytral interval.

S. crinita Herbst and *Waterhousei* Walt. Eyes prominent, projecting from the sides of the head.

S. regensteinensis Herbst. Anterior coxal cavities reaching presternal line (Fig. 4).

S. humeralis Steph. No upstanding setae. Forehead excavated between the eyes.

The Reproductive Organs of Sitona hispidula.

The reproductive organs of *S. hispidula* are similar in structure to those of *S. lineata*, but in the male differences occur in the shape of the genitalia. In the newly emerged female of *S. hispidula* the ovarian tubules are scarcely developed and the terminal chambers are very small, just as in the immature female of *S. lineata*, but unlike this species, the reproductive organs of both sexes attain full growth 6 to 8 weeks after emergence.

Alary Dimorphism[1].

In the course of dissection of *Sitona hispidula* F. it was observed that two forms of the species existed, one with fully developed wings (Plate III, fig. 1) and the other with very small vestigal wings of a peculiar shape (Figs. 2 and 3) and incapable of flight. The brachypterous wings vary in

[1] A similar case of alary dimorphism is described by Dr David Sharp in the Carabid *Pterostichus* (*Omaseus*) *minor* Gyll in *The Entomologist*, vol. 46, 82–87, 1913.

size and in distinctness of venation in different specimens, but no intermediate forms between Figs. 3 and 1 have yet been observed. The genitalia of the two forms have been examined and no differences have been detected, and moreover in captivity brachypterous males have mated with fully winged females.

In a separate article a description will be given of the structure of the two types of wings and of the modification of the metatergum in the brachypterous form.

Up to the present brachypterous specimens have only been taken in two localities, from Wye, Kent, and in Ross-shire. In the former district fully winged specimens predominated. In Ross-shire, around Evanton, only the brachypterous form has been found[1], but further north at Kildary fully winged specimens have also been taken. The macropterous form has been taken from the following localities: Crowborough, Sussex; Brandon, Suffolk; Tring, Herts.; Haslemere, Surrey; Kingussie, Inverness-shire; Invershin, Sutherland. The distribution of the two forms appears to have no relation to latitude or altitude, nor is the short winged type rare in localities where it occurs. Thus at Swordale, Evanton, about 500 feet high the latter form is abundant, yet at Invershin about 40 miles north near sea level, and at Balavil, Kingussie at an elevation of over 700 feet, *S. hispidula* is equally common, but all the specimens so far examined have been of the long-winged type.

The Egg.

The eggs vary slightly in shape and size from 0·41 mm. by 0·37 mm. or 0·46 mm. by 0·34 mm. to 0·49 mm. by 0·34 mm. They are similar in colour and shape to those of *S. lineata*. The first laid eggs of *S. hispidula* are pointed at both ends and twice as long as broad.

The Larva.

The larva closely resembles that of *S. lineata*, but the colour of the body, especially in the immature larva, is not as white as in that species, but more translucent and greyish. Slight differences occur also in the structure of the head by means of which it is possible to separate the larvae of the two species, and it is hoped to describe these fully in a later paper. No eye spots are present. The full grown larva measures about 6 mm.

The Pupa.

The pupa is similar to that of *S. lineata* and measures about 5 mm.

[1] Since writing the above a single ♀ of the fully winged form has been collected in this locality.

Life-History.

The life-history of most of the *Sitona* which breed upon clover is complicated by the long period of egg-laying of each female, with the result that the development of the progeny of the same parent extends over a considerable time. The life-history of *S. hispidula* may be thus summarised. There is only one generation in the year. The imagines lived about 12 months. They emerged from the pupal stage from July to September and commenced to lay eggs six to eight weeks after emergence. A few eggs were laid during the winter and vigorous oviposition recommenced in spring. Towards the end of June egg-laying decreased, and during July most of the weevils died. Eggs laid late in autumn did not hatch till the following spring, but a few of the September eggs and all those laid in spring and summer hatched in 25 days. No success was obtained in rearing the few larvae which hatched in autumn from the first laid eggs, but those which hatched in the following spring and summer fed up in from 11 to 14 weeks, pupated, and emerged as adults four weeks later. The last few eggs laid by the old females in July produced full fed larvae and pupae in the end of October, but these perished during the winter. Thus it will be seen that the principal period during which the larvae occur is in the summer from the end of April until August, those larvae which hatch before the winter from the first laid eggs and those which hatch late in the following summer from the last laid eggs of the same parents being few in number and uncertain in attaining maturity. The winter is thus passed almost entirely in the egg and imaginal state.

Detailed Observations on Life-History and Habits.

The life-history has been ascertained by field observations and breeding experiments. These may be placed in three groups according as they relate (1) to the imagines, (2) to the length of the egg stage, and (3) to the length of the larval and pupal period.

I. *The Imagines.*

Length of Life and Period of Oviposition.

(*a*) *Field Observations.*

Adult *S. hispidula* were obtained from various localities at different times of the year. If sexually mature the females laid eggs readily in the boxes in which they were collected. They were never subjected to artificial temperature. If immature, the beetles were sleeved in muslin bags upon

pots of clover kept out of doors and the date of oviposition observed. The results of these observations are here tabulated.

Date	Locality where collected	Condition	Remarks
1921 July 27th to Aug. 1st	Wye, Kent	Not laying eggs. Ovaries quite immature.	Fairly common.
1919 Aug. 11th to Sept. 1st	Bournemouth	Not laying eggs. Ovaries immature.	Sleeved on clover and commenced laying eggs from middle to end Sept.
1919 Sept. 4th to 8th	Sudbury, Suffolk		
1920 Sept. 16th	Invershin, Sutherland	Some laying eggs and others not, ovaries of some mature, of others immature.	Very common.
1921 Sept. 20th	Evanton, Ross-shire		
1918 Oct.	Wye	Laying eggs.	Common.
1921 Jan. 31st and Feb. 5th	Evanton	Laying a few eggs.	
1921 Mar. 13th	Haslemere, Surrey	Laying eggs.	Common.
1918 } 1919 } April and May	Wye	„ „	„
1921 April and May	Evanton	„ „	„
1918 June	Wye	„ „	Scarce.
1921 June	Evanton	„ „	„
1919 July 30th	Sudbury	Laying a few eggs. Ovaries typical of very old female.	Only one old female obtained, easily distinguishable from the new generation by condition of reproductive organs.

(*b*) *Experiments.*

In order to determine the length of life and the period of oviposition adults collected at Wye in October 1918 and laying eggs were sleeved on clover growing in pots out of doors. On January 27th, during deep snow, some of the beetles were removed to a glass dish which was left in one of the pots, and two or three eggs were laid in it, but many of the beetles died, doubtless owing to insufficient protection from the severe frost. During the winter many of the remaining weevils in the pots died, but those that survived laid eggs in April and throughout May. By the end of May some had ceased oviposition and by June 22nd only a few individuals were still laying eggs, and still fewer in the beginning of July. By the middle of the month most of them had died, though one or two survived till August.

Period of emergence of imagines. This was determined by breeding experiments to be described later in which the weevils emerged during August and September. When sleeved on clover they commenced oviposition on October 22nd, about a month later than the specimens in

the field, but similar experiments tend to show that *Sitona* take longer to develop when bred in captivity.

Habits.

During fine weather in September and October the beetles are most abundant and may be obtained by sweeping clover or lucerne. They are very active on sunny days at this time of the year and are frequently to be met with on palings or stone walls. It is probable that the principal migration to the new fields occurs at this time. At Invershin, Sutherland, from September 16th to 21st, 1920, several hundred beetles of this species were observed upon the walls of a wooden building adjoining fields of grass and hay. On sunny afternoons numbers were seen crawling up from the ground, but despite careful watching I failed to observe any specimens flying on to the wall, although all the specimens examined from this locality proved to have fully developed wings. The weevils dropped down from the woodwork at the slightest touch. They were equally common on the walls in the shade as in the sun, but were rare on the stonework of the house. Many got in at the windows. *Sitona sulcifrons*, a very common species with brachypterous wings also occurred upon the walls but in much fewer numbers. The following year on revisiting this district on a fine day on September 21st no such swarms were observed, though the weevils were very common on the clover. This activity of the imagines in autumn is not confined to the winged individuals, but has also been observed in brachypterous specimens at Swordale, Ross-shire. In France, Bedel (3) has made some interesting observations upon a migration of *Sitona gemellata* in the end of September and beginning of October.

In the winter the adults of the *S. hispidula* continue to feed, and even during continuous frost in January and February, they were to be found in the fields in Ross-shire lying on the surface of the ground beneath freshly eaten clover leaves. On sunny days in March and April the beetles may be seen walking on the clover leaves but are more frequently taken at the base of the plant. They are also active at night. They lay their eggs indiscriminately wherever they happen to be resting.

Number of eggs laid. The number of eggs laid by a single female from the commencement to the end of oviposition has not been ascertained, but the following experiments carried out in the laboratory show the number of eggs laid by two females after hibernation. Artificial conditions are doubtless responsible for the greatly prolonged life of the female in the first experiment. This has happened with other *Sitona*

kept indoors and regularly fed, and no corroboration of such a prolonged life has been obtained by field observation or outdoor experiments.

		Apr. 14th to 30th 1919	May	June	July	Aug.	Sept. and Oct.	Nov.	Dec. to end Apr. 1920	May and June 1920	Total
1st ♀	No. of eggs laid	43	193	171	159	106	120	27	27	77	924
2nd ♀	„ „	63	148	Oviposition ceased							211

As a rule from two to five eggs are laid daily, but as many as twelve per day have been observed.

II. *Length of the Egg Stage.*

In order to determine the length of the egg stage, eggs laid between certain dates were placed on damp earth in small dishes and the latter kept in tins containing a layer of wet moss, the tins being kept out of doors or in an unheated room. The result of these observations may be tabulated as follows:

Locality from which parent beetles were obtained	Date of oviposition	Date of hatching
Bournemouth	Sept. 17th to Oct. 8	A few larvae only on Oct. 12th.
Inversbin	Sept. 22nd to Oct. 13	Oct. 31st to Nov. 2nd three larvae only. Feb. 16th to April 25th, 42 larvae, the majority hatching in March.
Wye	Oct. 13th to 16th	Two larvae only on Nov. 18th.
Sudbury	Oct. 16th to 31st	Mar. 27th to Apr. 12th.
Evanton	May 6th to 10th	Commenced May 31st.

III. *Length of Larval and Pupal Stages.*

The time occupied in the development of larvae resulting from eggs laid at different times of the year has been ascertained by means of the following breeding experiments, in which, except when otherwise stated, the eggs were placed at the roots of clover growing in sleeved pots out of doors. It was necessary to duplicate many of these experiments to observe the habits and development of the larvae, owing to the disturbance of the soil this involved. The length of the egg stage being already known and the pupal stage lasting about four weeks the length of the larval stage can be deduced when the imagines emerge by subtraction of these periods.

1. *Development of the Autumn-laid eggs.*

(*a*) *The Autumn Hatching Larvae.*

Eggs laid September 17th to October 8th, 1919 produced a few newly-hatched larvae on October 12th. Eggs and larvae placed in pot on

October 12th. *December 5th*—soil of pot thoroughly searched but no larvae found.

(*b*) *The Spring Hatching Larvae.*

Eggs laid	Results
Sept. 17th to Oct. 18th, 1919	*Aug. 31st*, 1920. Imagines emerged.
Oct. and Nov., 1919	*June 2nd*, 1920. Larvae 2·2–3·3 mm. long occurring 1 or 2 inches below the surface soil, close to the small fibrous roots, and destroying the root nodules.
,, ,,	*July 3rd*, 1920. Larvae half to full grown. Injuring main root of clover.
,, ,,	*July, end.* Pupae.
,, ,,	*Aug. 19th.* Imagines.
	LARVAL PERIOD. 15–16 weeks.

2. *Development of the Spring and Summer Laid Eggs.*

Eggs laid	Results
Apr. 14th to 24th, 1919[1]	*June 14th.* Larvae 1·6 mm. long to 2·7 mm.
,, ,,	*July 9th.* Larvae 2·5–3·5 mm.
,, ,,	*July 28th.* Fully grown larvae.
,, ,,	*Aug. 12th.* Pupae.
,, ,,	*Aug. 26th to Sept. 1st.* Imagines.
	LARVAL PERIOD. About 11 weeks.
May, 1919	*Sept. 17th.* Imagines.
June 21st to July 21st[1]	*Oct. 31st.* Full grown larvae. Pupae. *Nov. 28th.* Pupae. Failed to rear adults.

The above experiments have been carried out in Ross-shire. It is probable that in the south of England the larvae develop more rapidly, as in fields at Wye, Kent, full grown larvae and pupae of this species were found on June 15th, from which imagines were reared from the beginning to the 21st July. From the field in Ross-shire pupae were obtained from July 5th to August 11th and adults reared from them from the end of July to the end of August. It was noticed that when larvae were reared in Ross-shire in a glass-house, the temperature being raised by the sun alone, the larval period occupied only eight weeks. During the winter and early spring repeated search was made for larvae of this species both in the south of England and the north of Scotland in localities where the adult was common, but always without success; *Sitona puncticollis* and *S. flavescens* being the only species found in the larval stage at that time.

Life-History in America.

In America, according to Wildermuth (22) the life cycle of this species occupies a very much shorter time. Thus the egg stage lasts 13 days, the

[1] These eggs were placed at the roots of clover previously planted out of doors in one of the large breeding cages already described (10, pp. 283–284, Plate XIX).

larval period 17–21 days and the pupal stage 8–10 days. Only one generation has been observed in the year.

NATURAL ENEMIES.

In America (6, 11) many birds have been observed feeding on the adults.

Insect Parasites.

No insect parasites have hitherto been recorded from *Sitona hispidula*, but in the course of this research three Braconids[1], *Perilitus rutilus* Nees, *Perilitus aethiops* Nees and *Pygostolus falcatus* Nees (the dark variety described by Ruthe) have been bred from the adult beetles. Single Hymenopterous larvae have been found on several occasions within the body of the beetles.

Protozoan Parasites.

Gregarines have frequently been observed in the alimentary canal of adult *Sitona hispidula* and also of *S. puncticollis*. Dr H. M. Woodcock has most kindly examined those from the latter species and has identified them as belonging to the genus *Gregarina*. Those from *S. hispidula* appear to be the same.

Fungus Parasite.

The fungus, *Botrytis bassiana* (Balsamo) Montagne appears to be the most serious natural enemy of this species and attacks both adults and larvae.

B. *SITONA SULCIFRONS* THUN.

Sitona sulcifrons is recorded by Reitter (13) as occurring throughout Europe and in the Caucasus and its injuries to various leguminous crops have been observed in France, Germany and Russia. In the British Isles it is widely distributed and is often exceedingly common upon red clover, especially in the north of Scotland. So far as I am aware, no observations have been recorded regarding the life-history of this species or the habits of the larvae.

Food-plants.

All species of clover (*Trifolium*) also bird's-foot trefoil, *Lotus corniculatus*. In France, Girard (24) records this species as damaging peas, and Allard (1) mentions its abundance on lucerne. According to Rushkovsky (26) peas, clover, lucerne and buckwheat are attacked by it in Russia. Rye (27) records the abundance of this species on lucerne on the south coast of England, but this I have not yet been able to corroborate.

[1] I am much indebted to Mr G. T. Lyle for his identification of these and other Braconids mentioned in this paper.

Nature of Damage.

Damage by Adult. The adults of *Sitona sulcifrons* feed upon the leaves of clover in the same way as those of *Sitona hispidula*. As a rule, however, the eaten areas are more regular than in that species and more or less U-shaped. From July to October nearly every clover leaf in certain fields of first and second year "seeds" in Ross-shire showed the characteristic notches eaten by this species, but the damage was never sufficient to check the growth of the plant. The adults could often be swept from the clover in numbers in this locality and out-numbered those of any other species of *Sitona*. In Kent, *S. sulcifrons* appears to be less generally distributed, but was abundant in temporary clover lays on the Downs at Wye, though rare at a lower elevation.

Damage by larvae. The larvae appear to feed principally upon the root nodules of the clover and they sometimes damage the small fibrous roots which bear them. Unlike the larvae of *S. hispidula* they have never been observed attacking the main root. The larvae occur in the soil to a depth of about 2 inches.

Description of Adult.

Black, sparingly covered with copper coloured scales and flat setae which are frequently abraded. Size 2·9 to 4·2 mm.

Head. Eyes prominent projecting from the sides of the head and with their dorsal edge higher than the level of the central furrow which runs down the middle of the forehead to the rostrum. The forehead between the eyes is not flat but gradually slopes downwards from the eyes on each side to meet the central furrow. Punctuation and scales very similar to pronotum.

Pronotum. Broader than long, covered with fairly closely placed punctures which, though comparatively large, are shallow. Sparingly clothed with flat copper coloured or ochreous setae, resembling scales but hair-like in width, and with indications of lighter dorsal and subdorsal lines composed of similar but more closely placed setae interspersed with elongated scales of pale yellow or copper. Anterior coxal cavities just reaching presternal line.

Elytra. Rather broad and short. Punctured striae most conspicuous anteriorly but becoming obsolete towards the apex. Individual punctures comparatively large. Intervals with finely punctured dots. Sparingly covered with elongated, usually copper coloured scales interspersed, especially on the sides, with flat setae of the same colour. Pale yellow or silvery scales occur in groups producing a variegated effect.

Sides and under-surface. A broad stripe of large pale scales extends along the sides of the thoracic segments commencing behind the eyes. The scales on the posterior portion of this band and also those on the ventral surface of the thorax are plumate in structure. Abdominal sternites covered with long whitish flat setae and a few plumate scales.

Legs. Femora black with pale flat setae and a few scales; tibiae and tarsi light red with similar setae.

Antennae. Light ferruginous, with pale setae, club darker.

External Sexual Differences.

The posterior abdominal segments differ in structure according to the sex as in *Sitona lineata.*

Species liable to be confused with S. sulcifrons *and characters which distinguish them.*

S. suturalis Steph. Eyes depressed and not projecting dorsally from the level of the forehead.

S. lineata L. Forehead, though with central furrow, quite flat between the eyes.

S. humeralis Steph., *S. punctlcollis* Steph., *S. flavescens* Marsh and *S. cylindricollis* Fahraeus. Anterior coxal cavities not reaching presternal line.

S. sulcifrons is not likely to be confused with the bristle-bearing species of *Sitona.*

Wings of S. sulcifrons. (Plate III, Figs. 4 and 5.)

Specimens of *sulcifrons* collected from various parts of England and Scotland have proved on examination to have brachypterous wings (Fig. 5). These, however, are totally different in shape to those of *S. hispidula.* They are of nearly equal breadth throughout and are evenly rounded at the apex. They measure from 1·28 mm. long by 0·38 mm. broad to 1·44 mm. long by 0·49 mm. broad. The wings show even less trace of venation than those of *S. hispidula,* only a small portion of the costal and sub-costal nervures at the base of the wing being discernible. The wings are extremely delicate and often to be found folded irregularly into a narrow strip beneath the elytra.

A curious variation in the shape of the wings has been observed in a specimen collected at Invershin, Sutherland. In this (Fig. 4), the wing is very long and narrow, measuring 1·6 mm. long by 0·34 mm. broad and is narrowed towards the apex.

In relation to the vestigial character of the wings of *S. sulcifrons*, it is interesting to note that this species is often more abundant throughout the clover in first and second year "seeds" than any winged *Sitona* of the same habits, showing that impossibility of flight is no check to the local dispersal of the species. More information is required as to how much such winged species as *S. flavescens*, *puncticollis* and *hispidula* fly, and any observations on this point would be gratefully received. These species are very active upon their legs, but up to the present I have rarely observed any of them on the wing, and it seems probable that in many cases they may migrate to new crops in the same manner as *S. sulcifrons*.

The Egg.

The egg is similar to that of *S. lineata*. It varies slightly in size and shape from 0·37 mm. by 0·27 mm. to 0·41 mm. by 0·31 mm.

The Larva.

The larva is very like that of *S. lineata* and measures when full grown about 4·9 mm.

The Pupa.

The pupa measures from 3·2 mm. to 4·9 mm.

Life-History.

Sitona sulcifrons is a smaller species than *S. hispidula* and the egg, larval and pupal stages are all a little shorter. The reproductive organs of the adult also mature more quickly. Otherwise the life-history of this species much resembles that of *S. hispidula* and has been determined by similar breeding experiments and field observations which will be summarised as briefly as possible.

I. *The Imagines.*

Length of life and period of Oviposition. Newly emerged specimens, sexually immature, were taken in Suffolk in the end of July, and in Ross-shire on August 10th. Sleeved upon clover, oviposition commenced on September 12th and 25th respectively, and this was corroborated by field observations. Placed in pots of clover covered with muslin out of doors in Ross-shire, the majority survived the winter, and some lived until the following August. In the field, the beetles continue to feed during the winter, and even lay a few eggs. In April and May oviposition recommences vigorously, but few eggs are laid in June and still fewer in

July. In August, specimens of the old generation are rare in the field. The habits of the adults are similar to those of *S. hispidula*.

Emergence. In the breeding experiments the weevils emerged during August and September and commenced oviposition on September 17th.

II. *Length of Egg Stage.*

Locality from which parents were obtained	Date of oviposition	Date of hatching
Sudbury, Suffolk	Sept. 12th to Oct. 1st	Mar. 18th to 30th
Wye, Kent	Oct. 13th	Mar. 22nd to 27th
Evanton, Ross-shire	Nov. 19th to 27th	Apr. 2nd to 12th
Wye	Dec. 15th to 24th	Apr. 3rd to 24th
„	May 27th to June 2nd	June 19th to 25th

From the above it will be seen that unlike *S. hispidula* none of the eggs laid in autumn by the newly emerged beetles hatched till the following spring.

III. *Length of Larval and Pupal Stages.*

The pupae occur in cells about $\frac{1}{2}$ inch below the surface of the earth. The pupal stage lasts about 24 days. The larvae developed as follows:

1. *From Autumn Laid Eggs.*

Locality where experiment was carried on	Date of oviposition	Results
In pots and large breeding cages in Ross-shire	Oct. and Nov., 1918	May 5th, 1919. Larvae 1·35 mm. long.
	„ „	June 30th. Some larvae full-grown, one pupa.
	„ „	July 17th to Aug. 25th. Emergence of imagines.
		Larval period. About 13 weeks.
In breeding cage at Wye, Kent	Oct. 13th to 30th, 1918	July 5. Full-grown larva and pupa.

2. *From Spring and Summer Laid Eggs.*

Locality	Date of oviposition	Results
Breeding cage, Ross-shire	Apr. 19th to May 6th, 1919	July 14th, 1919. Larvae 3–5 mm. long.
	„ „ „	Aug. 19th. Full-grown larvae and pupae.
	„ „ „	Aug. 23rd to beginning of Sept. Imagines.
		Larval period. About 11 weeks.
Pots, Ross-shire	May, 1919	July 28th, 1919. Small to half-grown larvae.
	„ „	Sept. 26th. Imagines.
„ „	June 6th to 13th	Nov. 23rd. Imago.
„ „	July 9th to 30th	Dec. 1st. 15 full-grown larvae, 10 of them dead. None survived.

In the above experiments larvae occurred from April to December. They were most common from June till the middle of August and at this

time they were abundant also at roots of clover in the fields in Ross-shire. The larvae obtained in the above breeding experiments in December died during the winter. It will be seen that they were the product of eggs laid in July and under natural conditions only a very few eggs are laid at this time. No larvae of this species have been found in the fields in winter though repeated search has been made in localities where the adult is common. A small *Sitona* pupa, probably of this species was, however, obtained on January 4th and it is possible that a few individuals, resulting from eggs laid late in the summer, may pass the winter in the pupal stage. Larvae of this species obtained from the fields in July gave rise to imagines from July 30th to October 1st.

Insect Parasites.

Insect parasites of *Sitona sulcifrons* appear to be rare and none have hitherto been recorded. Two Braconids, *Perilitus cerealium* Hal. and a species of *Liophron* have, however, been bred from adult *S. sulcifrons* and single Hymenopterous larvae have occasionally been found within the body of the beetles.

Fungus Parasite.

Similar to that of *S. hispidula.*

C. *SITONA CRINITA* HERBST.

Sitona crinita is one of the principal species mentioned by Miss Ormerod (35) and Curtis (31) as attacking peas and beans in England, and for this reason it has been included in the present research. So far, however, I have not found it sufficiently abundant on any crop to cause injury, but its profusion upon tares in the south of England is recorded by Walton (37) and Rye (27) and Mr S. R. Ashby tells me that he has found it very commonly upon vetches in Kent and in Cambridgeshire. At Wye, Kent, I have found it generally distributed and sometimes common on tares, but never abundant. It frequented the same food plants as *S. lineata* but was always vastly outnumbered by that species. It is rare in Scotland. Abroad it is widely distributed, occurring according to Allard (1), Reitter (13) and Henshaw (33), throughout Europe, in Central and East Asia, North Africa and America. It is recorded in Russia (26, 32, 36) as a pest of cultivated Leguminosae, and only in that country has its life-history been investigated (32).

Food-plants. Tares (*Vicia sativa*), lucerne (*Medicago sativa*), medick (*Medicago lupulina*), sainfoin[1] (*Onobrychis sativa*) all species of clover;

[1] Mr P. Harwood tells me he has taken *S. crinita* in abundance on sainfoin near Newbury in August, 1907.

less commonly upon peas and beans. Mr G. Fox-Wilson informs me that he found *Sitona crinita* seriously damaging the young flowers of *Cytisus biflorus* at Wisley on October 14, 1920.

Other recorded Food-plants. Rushkovsky (26) records this species from buckwheat in Russia, and Bainbridge Fletcher (30) from indigo and senji in India.

Nature of Damage.

The weevils eat semi-circular patches from the edges of the leaves. The larvae feed upon the root nodules and when nearly full grown they also occasionally bore channels in the main root close to the surface of the ground. The young larvae up to 2 mm. in length are to be found entirely buried in the root nodules, but when larger they feed freely upon them. An infected nodule can often be recognised by one end being darker owing to the excrement accumulated in it, and by the presence of a small hole through which the larva has entered.

Description of Adult.

Black, clothed with greyish white or ochreous scales and with raised setae on pronotum and elytra. Size 3·3 to 4·5 mm.

Head. Forehead broad, eyes very prominent. A central furrow commencing opposite the middle of the eyes is continued upon the rostrum and the area on either side of this furrow is slightly excavated. Unlike *Sitona Waterhousei* Walt., the breadth of the head across the eyes is barely twice the breadth of the rostrum at the apex. Pubescence and sculpturing as in pronotum.

Pronotum. A little broader than long, but much narrower than the elytra. With large deep closely placed punctures and evenly covered with broad ochreous or whitish scales and with short bristles. Narrow dorsal and broad sub-dorsal stripes are formed by lighter and more closely placed scales. Anterior coxal cavities separated from collar line by an area as broad as presternum.

Elytra. Shoulders prominent, sides almost parallel. With striae of medium-sized punctures; intervals minutely pitted. Scales similar to pronotum. Raised setae longer and backwardly directed, brown or white. Elytra frequently mottled with brown patches composed of long lineal brown scales; anteriorly often with indications of alternate darker and lighter longitudinal stripes (formed of darker and lighter scales) which may be continued to the apex of elytra.

Under-surface. Clothed with whitish ochreous plumate scales, and, on the abdomen, also with pale setae.

Legs. Femora black, those of 2nd and 3rd pair reddish at base and apex. Covered with pale scales and flat setae. Tibiae and tarsi ferruginous with pale setae.

Antennae. Rather short, ferruginous, with club darker.

External Sexual Differences.

Posterior abdominal segments similar in form to those of *S. lineata.*

Species liable to be confused with S. crinitus *and characters which distinguish them.*

S. Waterhousei Walt. Breadth of head across eyes 2½ times the width of the rostrum at the apex.

S. regensteinensis Herbst and *S. tibialis* Herbst. Anterior coxal cavities reaching presternal line.

S. lineellus Gyll. Forehead between the eyes quite flat.

S. hispidula F. See p. 98.

Wings of S. crinita.

All the specimens of *S. crinita* so far examined have had fully developed wings.

Eggs.

The egg measures from 0·34 by 0·26 mm. to 0·36 by 0·29 mm.

Larva.

The larva measures about 5 mm.

The Pupa.

The pupa measures from 3·8 to 4·9 mm.

Life-History.

The life-history of *S. crinita* is closely similar to that of *S. lineata* and can be summarised as follows:

Imagines. Newly emerged specimens, sexually immature, were obtained from peas in Suffolk on August 4th. Other specimens collected in September and October from lucerne, medick and seedling tares in Kent and Suffolk were also sexually immature. Sleeved upon clover out of doors these beetles laid no eggs till the following spring when oviposition commenced in May. Specimens collected in the field in April, May and June were laying eggs. The majority of the beetles collected from the field at this time died off before the autumn of the same year, but a few individuals have lived in captivity in the laboratory for over two years.

Length of egg and larval stages. Eggs laid on 4th June commenced hatching on June 26th. To determine the larval period eggs laid in the end of May were introduced into sleeved pots of beans. From these full-grown larvae and pupae were obtained on August 17th and the adults commenced to emerge from August 27th to September 19th. They laid no eggs till the following June.

Parasites.

A Braconid belonging to the genus *Perilitus* has been bred from an adult *Sitona crinita* and single Hymenopterous larvae have been found on several occasions within the body of these beetles.

The fungus *Botrytis bassiana* Balsamo (Montagne) attacks the adult beetles.

D. SUMMARY.

1. *Sitona hispidula* is common throughout Great Britain upon clover and lucerne.

2. The adults eat the leaves and the larvae damage the roots.

3. *Sitona sulcifrons* is frequently abundant upon "seeds" clover and the larvae feed upon the root nodules.

4. *Sitona crinita* frequents tares, clover, lucerne, etc., but is rarely sufficiently common to cause injury.

5. The adults of *S. hispidula* are either fully-winged or brachypterous and two forms of brachypterous wings have been observed in *S. sulcifrons*.

6. The life-history of these three species has been investigated in Britain for the first time.

7. There is only one generation in the year.

8. The adults live 12 months.

9. The period of oviposition and the length of the egg, larval and pupal stages varies according to the species.

10. The Braconids *Perilitus rutilus* Nees, *P. cerealium* Hal., *P. aethiops* Nees, *Pygostolus falcatus* Nees and a species of *Liophron* are recorded for the first time as parasites of the adult beetles.

11. The fungus *Botrytis bassiana* (Balsamo) Montagne attacks these species of *Sitona*.

REFERENCES.

Sitona hispidula F.

(1) *Allard, E. (1864). Séance du 23 Mars, *Ann. Soc. Ent. France*, IV, Series 4, 329–382.

(2) *Bargagli (1904). *Bull. Soc. Ent. Italy*, XXXVI, 8–10.

(3) Bedel, L. (1873). *Bull. Soc. Ent. France*, Séance de l'année 1873, CXCV.

(4) Brischke, G. S. A. (1876). *Entom. Monatsblätter* 1876, 38.

(5) Cory, E. N. (1915). Abstract in *Rev. App. Ent.* A. III, 709.

(6) Dean, G. A. (1916). "Insects injurious to Alfalfa," *Kansas State Agric. Coll., Div. of Coll. Exten., Manhattan, Bull.* No. 5, 36 pp., 39 figs.

(7) Fabricius, J. C. (1776). *Genera Insectorum*, 226.

(8) *Fowler, W. W. (1891). *Coleoptera of the British Islands*, V, 216–226.

(9) Germar, E. F. (1824). *Insectorum Species Novae*, I, 414.

(10) Jackson, D. J. (1920). *Ann. of App. Biol.* VII, 2 and 3, 269–298.

(11) Kalmbach, E. R. and Gabrielson, I. N. (1921). Abstract in *Rev. App. Ent.* A. IX, 305.

(12) Petit, R. H. (1917). Abstract in *Rev. App. Ent.* A. VI, 340.

(13) *Reitter, E. (1903). *Bestimmungs-Tabellen der europäischen Coleopteran*, LII Heft Curculionidae, 9 Theil Genus *Sitona* Germ. and *Mesagroicus* Schönh.

(14) Reppert, R. R. (1921). Abstract in *Rev. App. Ent.* A. IX, 389.

(15) Schwarz, E. A. (1889). *Proc. Ent. Soc. Wash.* I, 248–249.

(16) Schoenherr, C. J. (1826). *Curculionidum Disposito Methodica*, 134.

(17) *—— (1834). *Genera et Species Curculionidum*, II, Part 1, 96, 123 and 124.

(18) —— (1840). *Genera et Species Curculionidum*, VI, Part 1, 253.

(19) Stephens, J. F. (1831). *Illustrations of British Entomology*, IV, 134.

(20) Van Dyke, E. C. (1917). Abstract in *Rev. App. Ent.* A. V, 421.

(21) Webster, F. M. (1915). *U.S. Dept. Agr. Farmers' Bull.* 649, 1–8.

(22) Wildermuth, V. L. (1910). *U.S. Dept. Agr. Bur. Ent. Bull.* 85, Part 3, 29–38, figs. 15–19.

Sitona sulcifrons Thun.

(23) Bedel, L. (1873). *Bull. Soc. Ent. France*, Séance du 26 Mars 1873, I.

(24) Girard, M. (1880). *Bull. Soc. Ent. France*, Séance du 28 Juillet, 1880, XCIII.

(25) Reitter, E. (1916). *Fauna Germanica, die Käfer des Deutschen Reiches*, V, 71.

(26) Rushkovsky, I. A. (1914). Abstract in *Rev. App. Ent.* A. III, 481.

(27) Rye, E. C. (1865). *Ent. Monthly Mag.* I, 230.

(28) Thunberg, C. P. (1798). *Museum Naturalium Academiae Upsaliensis*, A. VI, 113, No. 4.

(29) Vassiliev, E. M. (1913). Abstract in *Rev. App. Ent.* A. I, 527.

S. crinita Herbst.

(30) Bainbridge, Fletcher (1917). *Report of the Proceedings of the Second Entomological Meeting, held at Pusa on 5th to 12th February*, 81 and 207.

(31) Curtis, J. (1883). *Farm Insects*, 347.

(32) Dobredeev, A. (1915). Abstract in *Rev. App. Ent.* A. IV, 139–140.

(33) Henshaw, S. (1885). *List of Coleoptera of America*, 136.

Fig. 1

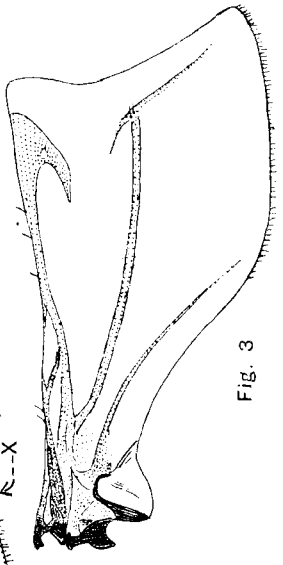

Fig. 3

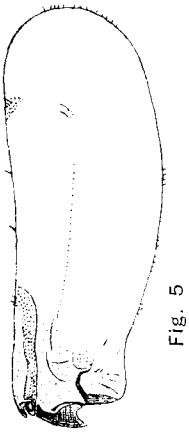

Fig. 5

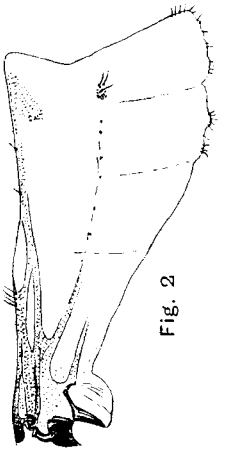

Fig. 2

Fig. 4

D. J. Jackson del.

(34) *HERBST, F. F. W. (1795). *Natur system aller bekannten Insekten, Der Käfer*, Part 6, 245 and 354.

(35) ORMEROD, E. A. *Reports on Injurious Insects*, 1879, 8; 1880, 5, 6; 1881, 38, 39; 1883, 57–59; 1884, 3–5; 1886, 80, 81; 1889, 15–18; 1892, 102–116.

(36) SOPOTZKO, A. A. (1916). Abstract in *Rev. App. Ent.* A. IV, 293.

(37) *WALTON, J. (1846). *Ann. and Mag. Nat. Hist.* XVII, 234.

* The references marked with an asterisk refer to works in which other species dealt with in this paper are included, and they will therefore be omitted from subsequent bibliographies.

EXPLANATION OF PLATE III

Fig. 1. Fully developed wing of *Sitona hispidula.*

Fig. 2. Brachpterous wing of *S. hispidula.*

Fig. 3. A larger form of same with clearer venation.

Fig. 4. Wing of a specimen of *S. sulcifrons* from Invershin, Sutherland.

Fig. 5. Normal wing of *S. sulcifrons.* All magnified 40 times.

A = anal; *C* = costa; *CH* = head of costa; *CU* = cubitus; *FP* = flexor plate, or 3rd axillary; *R* = radius; *SC* = subcosta; *SP* = scapular plate, or 1st axillary; *X* = point of transverse folding of wing. (Nomenclature according to A. D. Hopkins in "The genus Dendroctonus," *U.S. Dept. Agr. Bur. Ent. Technical Series*, No. 17, Part I, 1909.)

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