Bird, Ralph Durham

I. The life history of the Saskatoon saw-fly, Hoplocampa halcyon Nort. II. The external anatomy of Hoplocampa Nort. III. A preliminary ecological survey of the district surrounding The Entomological Laboratory at Treesbank, Manitoba.

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by

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I. The Life History of the Saskatoon Sawfly, Hoplocampa halcyon Nort.

2. The External Anatomy of Hoplocampa halcyon Nort.

3. A Prelimary Ecological Survey of the District Surrounding The Entomological Laboratory at Treesbank, Manitoba.

PART I.

THE LIFE-HISTORY OF THE SASKATOON SAWFLY, *Hoplocampa halcyon* (Norton).

by

R. D. Bird.

While carrying out investigations on the insects attacking our cultivated and native fruits in the summer of 1924, it was found that the saskatoon (*Amelancher spicata*) was severely injured by small larvae that bored in the fruit. As the saskatoon is probably used as a preserve more than any other native fruit, with the exception of raspberry and as the sawfly might also attack cultivated fruits, that are being introduced, a study of its life history was undertaken in the summer of 1925.

I would like to acknowledge help received in preparing the following notes from Mr. Norman Criddle in charge of the Treesbank entomological laboratory, To Mr. H. G. Crawford I am indebted for a criticism of the M.S. and to Mr. H. L. Viereck for indentification of the sawfly. Both the latter gentlemen are members of the Entomological Branch Ottawa.

Synonomy. This sawfly was originally described in 1861 by Norton (I) as *Selandria halcyon*. In 1911 Rohwer (6) transferred it to the genus *Hoplocampa*.

Distribution. This sawfly is probably found throughout the range of the saskatoon. Rohwer (6) gives records from Canada; New York; Washington, D.C.; Clementon, N.J.; and Norton (3) from Maine,

Massachusetts, Maryland, and Saskatchewan. It has been taken in Manitoba at Aweme, Douglas, Baldur, Birtle, Steep Rock, and Brandon.

Injury. In Manitoba H. halcyon has been found attacking only Amelancher spicata. Norton (3) says "Taken for successive years in Baltimore, by Mr. Uhler, on Amelancher canadensis." Konow (4,5) also gives A. canadensis as a food plant.

The injury done to the saskatoon by this sawfly is brought about by the feeding activities of the larvae that done to the developing fruit by the female while ovipositing being negligible. The larva on hatching immediately eats its way into the center of the growing fruit. As soon as one berry is eaten to a shell, the larva leaves it and enters another in the same cluster. Usually three berries, but sometimes four, are attacked before the larva becomes full grown and drops to the ground.

In the vicinity of Aweme, Man., the saskatoons were damaged to the extent of 25% in 1924 and 35% in 1925.

Methods of Study. Most of the data concerning the life history and behavior of the saskatoon sawfly was obtained by observing the insects out of doors. For studying the mating and oviposition habits of the adults a small cage was made by covering a mica chimney at one end with cheese cloth and placing it over a tumbler of water in which was a fresh branch of saskatoon flowers. Sphagnum or cotton was placed on the water to prevent the insects from drowning. Adults readily made themselves at home in this cage and their activities were easily observed. It was found that the branches could not be kept alive long enough for the eggs to hatch. Hence all further observations were carried out on the bushes outside.

DESCRIPTION OF LIFE STAGES.

(a) Egg. (Fig.1). The egg is elliptical in outline, but is not symmetrical as one side is somewhat flattened. In cross section it

is circular when removed from the plant tissues, but in its normal position it is slightly compressed by the pressure of the tissues. The chorion is membranous, thin, white, shining and flexible. The average measurements when newly laid are 0.75 mm. in length by 0.39 mm. in width.

The egg is deposited in a sepal of a saskatoon flower, usually under the inner epidermis (Fig 2 5) but sometimes under the outer. (Fig 6.) The long axis of the egg is parallel with that of the mother when ovipositing and the flattened side nearest her. Normally only one egg is laid in a flower, but sometimes two or three, in which case all perish but one.

The developing embryo can clearly be seen through the chorion, (Fig 4.) which enlarges considerably from the pressure within. In the spring of 1925 the eggs hatched 10 days after being laid. Possibly the average may be somewhat shorter as the weather was cold and rainy.

(b) Larva. To determine the number of instars of the larvae, the infected berries were examined daily. After moulting the head capsule could usually be found in the pile of excreta extruded from the entrance hole, but the remainder of the cast skin was missing, probably having been eaten.

The instars may be distinguished by the pigmentation of the dorsum of the four posterior segments and by size. The thoracic legs are short and are composed of a thick basal portion, three segments and a terminal claw. The antennae are short and four segmented. The labial palps are composed of three, and the maxillary palps of five, short segments.

Immediately upon hatching the larvae eat their way into the center of the fruit, (Fig. 7, x), always entering between the sepal on

which the egg was laid and the remains of the pistil.

In the first instar (Fig.8,~~f~~), the body is translucent, white and only slightly wrinkled. At first there is no pigmentation, but as the larva grows color develops. The head and labrum become a light brown; the mandibles a darker shade of brown. The maxillae and labium are colorless. The dorsum of the last two abdominal segments becomes black. Newly hatched larvae measure 1.4 mm. in length; when fully grown 3 mm.

After eight days the larvae moult, at which time they have usually devoured about one third of the berry. The excreta, which is voided through the entrance hole, makes quite a conspicuous pile on infested fruit. In some cases, when the fruit is small, it is eaten to a shell at the end of the first instar and the larva leaves it to enter a second immediately after moulting.

In the second instar (Fig.8,~~b~~), the head is blackish, but the labrum is only slightly pigmented. The thoracic legs, which before were colorless, are now grey. The dorsum of the last three abdominal segments is black. Otherwise as in the preceding instar. The length increases from 3.2 to 5 mm.

After a period of three days moulting takes place for the second time. The larvae have now devoured all but the skin of the first berry and entered the second, in all cases between the remains of a sepal and the pistil.

In the third instar (Fig.8,~~c~~), the head and labrum are brown, the mandibles blackish and the thoracic legs not pigmented. The dorsum of the last four abdominal segments are black. Otherwise as in preceding instar. Length increases from 5.2 to 6 mm.

From now on the duration of the instars varies considerably, according to the size of the individual fruit, which influences the vitality of the larva attacking it. The third and fourth instars usually last five days, but may continue for ten. In each a third berry is entered. This time, anywhere on the side, or in the old flower scar.

In the fourth instar (Fig 8) the head is of a lighter brown than in the preceding. The dorsum of the last two and part of the third abdominal segments are dotted lightly with black. The body is stouter. Otherwise as in the preceding instar. The length increases from 6.2 to 7.2 mm.

The fifth instar (Fig 8) has all of the dorsum of the last three abdominal segments dotted lightly with black. Otherwise as in the fourth instar. The length increases from 6.5 to 9 mm.

The third fruit is now eaten to a shell. The larvae crawl out through the entrance hole, drop to the ground and, depending on its hardness, burrow from one to three inches below the surface. Here they spin a brown cocoon of papery consistency and enter a resting state before pupating the following spring. The last larva had entered the ground by June 24 in 1925.

At all times and particularly during the last two instars the larvae are very active when removed from the fruit.

(c) The cocoon is made of a brown silk spun so that it has a papery consistence. To it particles of earth adhere. It is oval in outline and slightly greater in diameter at the cephalic end. It measures 4.5 to 5 mm. in length and 1.8 to 2 mm. in width.

(d) The pupa is of the type in which the appendages are free,

but held close to the body. Male and female pupae can be told apart by their size and external genitalia. The pupae are slightly smaller than the adults.

On May 5, 1925, a number of cocoons were dug up from under saskatoon bushes that had been heavily infested in 1924. Some of these were opened and were found to contain larvae with the head and thorax bent almost at right angles to the body in preparation for the pupal moult. From the remaining cocoons adults emerged on May 11. Hence the pupal period must be very short.

(e) The adult (Fig 1) is a small yellowish insect with a large black spot on the tergum, the size of which varies with the individual and the sex. In the male it covers all of the tergum except the apex as well as the thorax above. In the female its boundaries are not so great. The antennae and a small patch around the ocelli are also black. Length 3.9 to 4.1 mm.

Emergence of the Adults. The time of emergence of the adults depends on the weather conditions of the spring. Usually they appear in the latter half of May but the date may vary over three weeks or a month according to the progress of the season and always coincides with the opening of the first flowers of the host plant. In 1925 a few forerunners were taken on some early saskatoon flowers in a warm hollow by the Assiniboine river on May 11, but the main body of the sawflies did not appear until May 18, when the majority of the saskatoons were coming into flower. By May 29, the saskatoons had practically finished flowering and only a few sawfly stragglers were observed. In 1924 emergence was about three weeks later, due to a late spring.

len. After a short rest she oviposits again. Then another rest and a third egg is laid, after which she retires for a longer time, often flying to a different part of the plant and mating before resuming egg laying. The process of making the saw cut and laying the egg takes about a minute.

Eggs are laid in the flowers from the time the petals are about to unfold until the time they fall. As soon as the petals drop the sepals curl back and harden. In this condition the sawflies will not oviposit. Hence it is only for about two or three days that the saskatoons are subject to the egglaying of the sawfly.

Judging from observations, the length of life of the adult sawflies coincides approximately with the period of flowering of the host plant, which is from 15 to 20 days.

Enemies. No parasites have yet been reared, but the larvae of several ichneumons were found in the cocoons of the sawfly. All died before emerging.

Ants prey to a small extent on the adults and larvae, when migrating. They are frequently crawling up and down the saskatoon bushes and have been observed to catch the adults when they alight.

Birds undoubtedly feed to a limited extent on the adults.

The greatest means of natural control is brought about by meteorological conditions that prevent the maturation of the saskatoon fruit. A late frost being the most destructive.

Control. No experiments have yet been carried out on the control of this sawfly. Adults could probably be killed by contact spraying, with a nicotine oil solution, in the early morning when still sluggish, or a poisoned sugar solution in the warm part of

the day. Spraying with arsenic, when the larvae are migrating (9), would kill many. If the sawfly attacks cultivated fruits, thorough cultivation of the soil under the bushes in the fall (I) would kill many hibernating larvae.

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EXPLANATION OF PLATE I

Fig. I. Adult female Hoplocampa halcyon Nort. x IO.

Fig. 2. A section through a young saskatoon fruit showing a sawfly egg deposited under the inner epidermis of a sepal.

Fig. 3. A newly laid egg of H. halcyon x 37.

Fig. 4. A saskatoon fruit partly disected away to show a first instar larva eating its way into the center of the berry.

Fig. 5. A young saskatoon fruit in which a sawfly has deposited an egg under the inner epidermis of a sepal. The saw cut is covered by an exudation that has turned black.

Fig. 6. The position of the egg of H. halcyon under the outer epidermis of the sepal of a saskatoon flower. The saw cut is shown by a black line and the pocket hollowed out by the saw by dotted lines in which the oval egg may be seen at the upper end.

Fig. 7. An egg of H. halcyon 5 days after being laid showing its increase in size and the developing embryo inside. x 37.

Fig. 8. From right to left the five larval instars of H. halcyon. Below each is shown the characteristic pigmentation of the last abdominal segments, x9.

Plate. I.

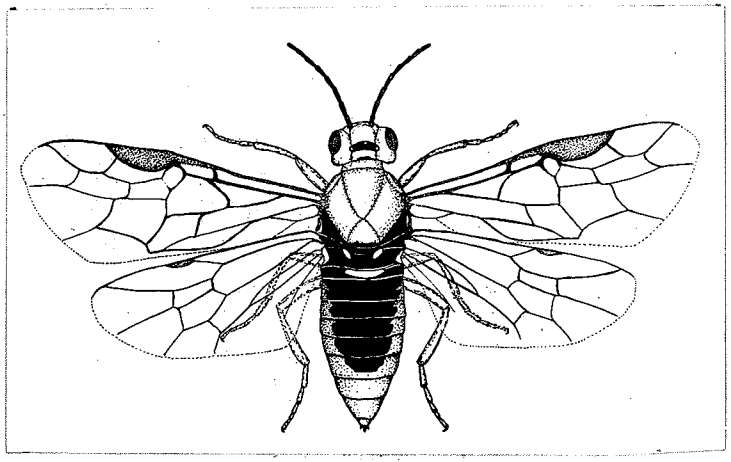

Fig. 1.

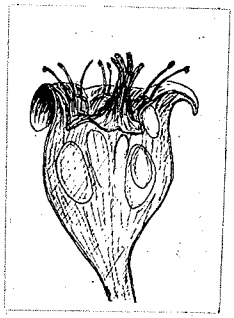

Fig. 2.

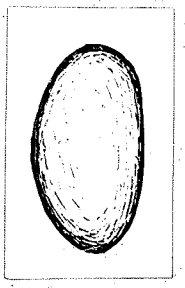

Fig. 3.

Fig. 4.

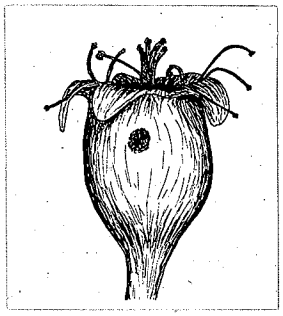

Fig. 5.

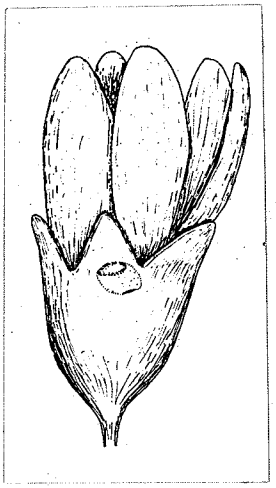

Fig. 6.

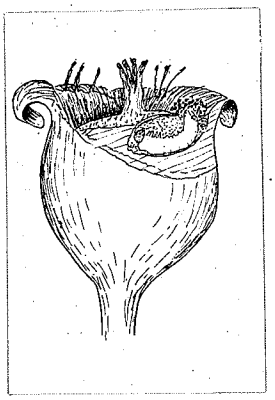

Fig. 7.

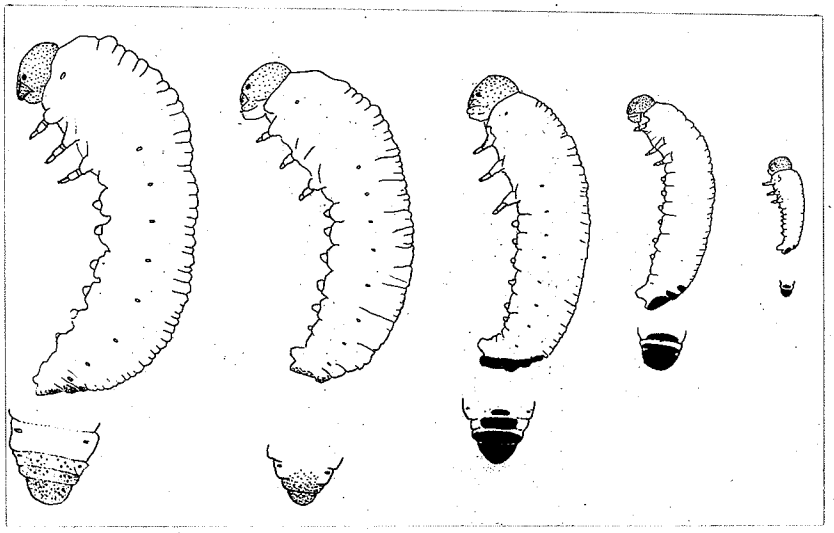

Fig. 8.

THE EXTERNAL ANATOMY OF THE ADULT OF Hoplocampa halcyon Nort.

(Hymenoptera, Tenthredinoidea).

by

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Although the sawflies are a large and important group of the Hymenoptera little anatomical work has been done on them. A study of the external anatomy of Hoplocampa halcyon Nort., a common sawfly borer in the fruit of the saskatoon, Amelanchier spicata, was undertaken with the hope of clearing up a few points of the morphology of the superfamily. This species belongs to the Hoplocampinae, a subfamily of the Tenthredinidae.

Literature

The literature on insect anatomy that has any bearing on the species studied is rather scanty. MacGillivary (1916), Marlatt (1896) and Smulyan (1923) give a brief discussion of the external structures of sawflies used in classification, while Rohwer (1911) gives those of the genus Hoplocampa. Martin (1916), discusses the sclerites of the thorax and cervical region, and Crampton (1921, 1925) those of the head and mouth parts of insects in general. MacGillivary (1912) describes the maxillae of Hymenoptera and (1906) gives a detailed study of the wings of Tenthredinoidea according to the Comstock-Needham system. Probably the best detailed anatomical study of a Hymenopteron is that of Snodgrass (1925) on the honeybee.

The genitalia on account of their systematic value have been the subject of several papers. The most extensive work on this subject is that of Boulange (1924) in which the male genitalia of many species of sawflies are described in detail. Shorter works on the male genital apparatus are those of Crampton (1919, 1923). Morice (1911) describes the saw of the female in several species and its mode of action. Newell (1918) studies the genitalia of insects from a comparative point of view and Parrett and Foulton (1915) figure and briefly describe the genital apparatus of both sexes of Profenusa collaris MacG.

I would like to express my indebtedness to Prof. C. H. O'Donoghue of the Dept. of Zoology, University of Manitoba, for many helpful suggestions in preparing the following notes and to Dr. C. G. Crampton of the Massachusetts Agricultural College, Amherst, Mass., for reprints of his papers and many suggestions in correctly naming the parts.

The larger parts of the specimens were studied under a binocular microscope. The appendages were removed, cleared in xylol, mounted in balsam and studied with the monocular. For the head capsule and thorax it was found necessary to remove the non-chitinous parts by boiling in a 5% solution of potassium hydroxide. The heavily pigmented parts of the thorax were bleached in chlorine water.

All drawings were made with the aid of the camera lucida and at the magnification stated. Pigmented areas are indicated in black or heavy stippling, membrane in light stippling and non-pigmented areas are left white.

The nomenclature proposed by Dr. Crampton has been followed as closely as possible. The cells and veins of the wings are named according to the Comstock-Needham system used by MacGillivary (1906).

THE HEAD

The head of the male is slightly smaller than that of the female corresponding to the smaller size of the body and has the pigmented areas darker and more extensive.

The outline of the head capsule seen from the front (fig. 2) is approximately a square, but with rounded corners and sides: from above (Fig. 1) that of a short, thick chevron: from the side (Fig. 3) an oval.

The walls of the head capsule of this sawfly, like those of the honeybee are not marked with sutures to any extent, but the cranial areas may easily be made out. The vertex or postocellar area (v) is marked off by distinct paracranial sutures or vertical furrows (v.f.). The front (f) is rounded on each side of the median line to the antennal furrows (a.f.). The remaining two thirds of the distance to the compound eyes (e) is flattened. The genae (g) and postgenae (pg) are short. The supraclypeal area is uniformly convex. Just anterior to the vertex are three ocelli (o) whose dorsal margins are almost touched by the ocellar furrow (o.f.). One is just below the median line and one just below each antero-lateral corner of the vertex. The area between them and the ocellar furrow is heavily pigmented. The median foven is wanting. The antennal socket (a) is much larger than the base of the antenna. It is oval in outline, save for a peg-like projection from the latero-ventral border, with which the antenna is articulated. The occiput (oc) is bent in a wide "V". The foramen magnum (f.m.) is elongated vertically and is bounded at a little dis-

tance from its edge by a pigmented chitinous ridge (c.r.), which is much higher near the ventral border, where the apophyses of the lateral cervical sclerites articulate with it. The neck muscles are attached to the more dorsal part of the ridge.

The antennae (Fig. 6 and Fig. 2, an.) are nine jointed, cylindrical and somewhat heavily pigmented. The first two joints are about one half the length of the third, which is the longest, the remainder being slightly shorter. The whole is covered with numerous very short hairs.

The compound eyes (e) are oval, black and prominent.

The clypeus (c) is marked off by a distinct clypeal suture (c.s.). It is four times as long transversely as vertically and has a median wide shallow curved indentation.

The labrum (L) is much smaller than the clypeus, to the distal end of which it is attached. The labrum and distal half of the clypeus are hairy.

The mandibles (m) end in a long curved point and bear a deep notch and tooth about half way along the cutting edge. A wide notch is situated proximally to the tooth and two small dentacles distally. The exact shape of the tooth and dentacles vary considerably in individuals and even in the same specimen, as may be seen in the figures. The distal end on the mandible is heavily chitinized and of a dark brown color. Proximally to the chitinized part there is a patch of hair on the outer side.

The maxillae (Fig. 7) bear a six jointed palp (p). The cardo (ca.) is a small, rectangular sclerite at the proximal end of the rhomboidal stipes (s). Only one segment of the galea (ga) is dis-

tinct, the other, like the palpifer, being completely fused with the stipes. The lacinia (la) is triangular in outline and passes without any sign of a suture into the stipes. The palps, galea, lacinia and part of the outer edge of the stipes are hairy.

The labium (Fig. 5) has three jointed palps and an elongated palpiger (pl), which appears like the first joint of the palps. The mentum (me) is a cylinder, almost as long as broad, but the submentum (sm) is reduced to a small, little chitinized plate. The glossae (gl) fused to form a single plate and the paraglossae (pa) are flattened, triangular structures, which, like the palps and palpigers, are hairy.

THE THORAX and CERVICAL SCLERITES (Pl. 2, Figs. 11,13,14).

The pronotum (pn) extends as a narrow, collar-like sclerite around the anterior end of the thorax from the front edge of one fore wing to that of the other and expands into a triangular expansion passing postero-ventrally along the anterior edge of the basalar plate. It is divided by an indistinct suture into an anterior, antepronotum (ap) and a posterior, postpronotum (pp). This division is purely secondary and has no reference to the division of the mesonotum and metanotum into scutum and scutellum as indicated by Crampton, Snodgrass and others.

The mesonotum is composed of five median sclerites, which, naming from the front, are respectively the prescutum (pr), scutum (sc), scutellum (ms), posttergite (po) and postscutellum (pos), and two pairs of paired sclerites, the paratergites (pt) and the parascutella (ps). On the antero-lateral margins of the scutum (sc) near the tegula (t) are the narrow paratergites (pt) and on its

postero-lateral margins are the triangular parascutella (ps), which end anteriorly in rounded projections for attachment to the fore wings. The mesoscutellum (ms) appears as a large triangular sclerite wedged in between the parascutella and into the scutum so as to almost reach the backward projection of the prescutum (pr). Just behind the mesoscutellum is the posttergite (pt) of the mesonotum, which is separated from the large postscutellum (pos) by a narrow membrane as in other insects. The postscutellum is continued internally under the succeeding segment of the thorax and the first tergum of the abdomen as the heavily pigmented phragma (Fig.12) which is indicated in the figures by dotted lines.

The metanotum is composed of four median sclerites, but the prescutum is hidden, so that the first visible sclerite is the large metascutum (met) on which are situated the oval, membranous cenchri (ce). Lateral to the metascutum are triangular sclerites that correspond to the parascutella of the metanotum and just behind it is the metascutellum (ml) which is separated from the metapostscutellum (mp) by a membrane as in lower insects. The metapostscutellum is closely associated with the first abdominal tergite and connects laterally with the epimeron (ep).

In the lateral and ventral views of the thorax may be seen the lateral cervical sclerite (n) which is fused at its proximal end with the prothoracic episternum (es) and terminates at its distal end in the apophysis (as), which articulates with the chitinous ridge on the side of the foramen magnum.

The prothoracic episternum (p. es) is separated by a narrow suture on its dorso-proximal edge from the procpimeron (pe) and

on its ventro-proximal edge from the prosternum (pm). Between these two latter sclerites the procoxa is articulated but is separated by a wide membrane (mm) from both, save ventrally, where it is closely approximated to the prosternum.

The very large mesothoracic episternum (m. es) is completely fused with the sternum (st) and the two lateral plates thus formed meet in the midventral line. At the dorsal end is a triangular basalar sclerite (b) and at the ventral end, the coxa (cx) and the furcasternite (fs). The mesothoracic epimeron (m. ep) is divided into an upper and lower region, the anepimeron (ae) and the katepimeron (k). The lateral region of the postscutellum is divided into an upper (u) and lower (l.p.) postalar plate. At the base of the wing is an indistinct subalar plate (s.a.).

In the metathorax the episternum is divided into an upper sclerite, the anepisternum (am) and a lower, the katepisternum (ke) which unites with the sternum, and at the ventral edge of this is the coxa and furcasternite. The epimeron is connected with the lateral margin of the postscutellum. As in the mesothorax there is an indistinct subalar plate (sa).

The spiracles (sp) occur as indicated.

THE LEGS (Figs.15,16,17).

The legs are long and slender and do not differ noticeably in the two sexes. The pro- and mesothoracic legs (Figs.15,16) are the same length, namely 3.5 mm. while the metathoracic legs (Fig.17) are 5 mm. long. The coxae (cx) are subconical and lie close together. The trochanters (tr) are somewhat larger at the distal than the proxi-

mal end. The femurs (fe) have a small proximal portion marked off by a distinct annulus. The tibia (ti) of each leg is slightly longer than the femur and is armed with two apical spines (ai). The tarsus (ta) is slightly longer than the femur and is five jointed. The first joint is twice the length of the second, the second almost twice that of the third, and the third of the fourth. The fifth joint is as long as the third and fourth together. Each of the first four joints of the tarsus bears an arolium (ar) at its apex. The fifth has two claws between which there is a pulvillus (pu). The tibiae and tarsi are sparsely covered with fine hairs.

The terminal structures of the foot may best be understood by reference to figures 18, 19, and 20.

The claws (cl) are strongly curved downward at the tip and bear a small rounded knob-like (to) on the ventral side about one quarter the distance from the distal end. On the inner side opposite the tooth each bears a long stiff hair and on the outer side behind the tooth two slightly shorter ones. The proximal half is covered with numerous small hairs. The claws articulated with a small sclerite on the dorsal side, the ungifer (un).

The adhesive organ or pulvillus is situated between the claws and consists of a terminal dome-shaped structure or arolium (ar) and a stalk around which there are several sclerites. On the dorsal surface is a large rectangular sclerite, the orbicula (or), which bears two long hairs on each side about one third of the distance from the distal end and a number of small ones all over its surface. At its base it is articulated with the ungifer. At the base on the

ventral surface is an elongated plate, the ungitractor (ut) to which muscles in the fifth tarsal joint are attached. Proximal to the ungitractor is a large sclerite covered with numerous small hairs, the planta (pla) (MacGillivary). Around the base of the arolium runs a narrow ring-like sclerite, the cemera (cm) (MacGillivary).

THE WINGS (Figs. 8, 9)

MacGillivary (1916) has outlined a classification of the Tenthredinoidea on the basis of the wing venation. He has divided the superfamily into two groups, (1) the generalized Tenthredinoidea to which belong the families Xyelidae and Lydidae and (2) the specialized Tenthredinoidea in which he places the remainder of the superfamily. The specialized forms he again subdivides into two groups (1) the cell R_4 group in which he places the Blasticotomidae and the Tenthredinidae and (2) the cell R_5 group to which belong the remainder of the specialized forms.

The Tenthrredinidae are further divided into the generalized and the specialized forms. The latter are grouped according as to whether the anal cell is conserved or lost. The forms which retain the anal cell may lose or conserve the second anal vein and the forms that lose the second anal vein may have the second anal cell reduced by atrophy or coalescense and if by atrophy conserve or lose the costal area. If the costal area is conserved the radial cross-vein may be conserved or lost. The forms in which the radial cross-vein is conserved are represented by the subfamilies Hoplocampinae and Dineurinae.

To sum up then, the Hoplocampinae belong to a specialized group of the Tenthredinoidea, which are specialized Tenthredinoidea, and are characterized by conserving the anal cell, losing the

second anal vein by atrophy and by conserving the costal area and radial cross-vein.

For the characteristics of the wings of the Heplocampinae we can do no better than quote MacGillivary:-

> "The Heplocampinae and the next subfamily (Dineurinae) represent a series in which the anal veins have been modified before the loss of the radial cross-vein. In this subfamily the costal area is broad with the free part of Sc_1 distinct. The area between R_1 and R_3 is very broad, the radial cross-vein is long, straight and slightly oblique. The area between the base of the stigma and the base of the radial sector has been chitinized so that it appears as a part of the stigma. The medio-cubital cross-vein is joined to R M distinctly before the origin of media, usually near the free part of Sc_1. The free part of M_4 Cu_1 is joined to the cell M_4 near its middle. The anal cells are contracted for a short distance in Heplocampa and for a considerable distance in Hemichroa. In the hind wings the anal lobe is larger, the venation is of the usual type."

As regards Heplocampa halcyon itself little can be added to the above quotation. The characters which specifically differentiate this species from the other members of the genus are the shapes of certain cells in the radial area and the anal cell of the fore wings. These can be seen in figure 8 and their diagnostic value appreciated by reference to Rohwer (1911). It might be added that at the base of the fore wing there are three axillaries (ax) and a median plate (m.p.). On the costal margin of the hind wings

are a row of 9 hamuli (h) which fasten into a fold on the inner margin of the fore wings. The membranous parts of the wings are sparsely covered with fine hairs.

THE ABDOMEN (Figs.21,25,26)

The abdomen, as in all sawflies, is not constricted at its junction to the thorax. In the female there are nine large terga and in the male eight large terga and a very small ninth, which is completely hidden by the eighth. In addition there is in both sexes a small sclerite (x), to which the club-like, unsegmented cerci (cc) are attached. This may represent the fused tenth and eleventh tergites found in lower insects (Crampton 1919). The first tergite, which has no corresponding sternum, is really the second. A pair of spiracles occur in each segment, one near the lateral margin of the tergum on each side. There are only six sterna in the female, the remainder being modified to form the ovipositing apparatus. In the male there are eight sterna, e.g. second to ninth. The eighth is very small, but the ninth is larger than any of the others. It covers the ventral side of the genitalia and is called the hypandrium. The claspers and penisvalvae may be seen projecting dorsally. In the female posterior to the sixth sternum (actually the seventh abdominal sternum) is the ovipositor sheath made up of three sclerites, a basal triangular one (os) which is divided into two halves by a suture and two pairs of long narrow ones that enclose the saws.

THE EXTERNAL GENITALIA

(a) Female. The external genitalia of the female consists of two saw blades, the dorsal edges of which work in the ventral edges of two blade-like guides in the manner of a sliding tongue and grouve joint. The saw and guides are enclosed in a sheath composed

of three parts. The apex of the sheath which is of specific importance is figured, (Fig. 23). The saws and their respective guides lie side by side the one being to the other as the right to the left. Each saw (Fig.24, sw) is one millimeter in length and 0.105 mm. in width at the proximal end, from which it gradually tapers to a point at the distal end. Each is slightly concave and smooth on the side nearest its mate, the opposite, i.e. outer, side being slightly convex and annulated. The whole is bent ventrally in the arc of a large circle, save the tip, which bends slightly dorsally. The teeth are arranged on the convex side and the ventral edge in a series of 14 sets and together with the ridges on which they are borne give the saw its ringed appearance. The sixth set from the proximal end is the most perfect. It consists of a row of dentacles along the side, attached so that they point toward the proximal end of the blade and an anvil-shaped tooth on the ventral edge. The dentacle nearest the ventral tooth is the largest and appears to be related to it so that the two form a pair. The remaining sets of teeth are imperfect modifications of the above. In sets 7 to 14 the lateral dentacles become less pronounced, the large ventral one continuing until the thirteenth but the others disappearing on the ninth. In sets five to one the lateral dentacles remain perfect, but the ventral tooth progressively loses its anvil-like appearance and is almost entirely absent from the first. From both the dorsal and ventral edges of the saw a chitinous band runs back to which the muscles are attached.

The guides (Fig.24, s.g.) are slightly concavo-convex, but bear no teeth and only twelve annulations, marked by chitinous

bands. At the proximal end they are 0.109 mm. in width. The edges run parallel until the distal fifth then the dorsal edge bends ventrally so that the blade ends in a point. They also bear chitinous projections for attachment to muscles, the dorsal one having a curious pointed projection at its junction to the blade.

(b) The male genital armature (Fig.22) is a chitinous organ, cylindrical in shape and somewhat flattened dorso-ventrally. It is drawn up into the distal end on the abdomen where it is covered ventrally by the large sternum of the ninth abdominal segment. The anterior edge is oblique; the dorsal part projects forward and is bounded by a chitinous ring, the gonocardo (gc), which is pointed at its anterior extremity. The main body of the organ consists of two large lateral valves, the gonostipes (gs), which meet ventrally, but dorsally are only connected by a membrane, the exact boundaries of which are not distinct as its edges become chitinous and grade into the valves. At the posterior end of each lateral valve is another chitinous plate, the claspers, genital forceps or gonopods (gp). The volsella (vo) bear a blunt point directed downwards and outwards. Anteriorly it grades into the dorsal membrane. On each side of the median line, just ventral to the volsellae, are two elongated structures, the penisvalvae (pv) that serve as a penis. The end of the ejaculatory duct is chitinized and forms the verga (ve) which projects from the dorsal surface of the penisvalvae near the distal end as a long spinous process. Their adjoining surfaces are concave so that when pressed together they form a tube. Proximally they are extended as rods under the dorsal membrane where they are attached to muscles.

Conclusion

As this article is the first complete account of the external anatomy of any one sawfly, this species (Hoplocampa halcyon) cannot be compared as a unit to any other. It might be of interest, however, to compare it with the generalized structures of insects.

All insects are made up of a head; a thorax of three parts, pro-, meso- and meta-thorax, and an abdomen.

The head consists of a capsule divided by grooves or sutures into a number of plates, the most important of which are the vertex, the front, the genae, the postgenae and the occiput. The sutures may be lost or may become complicated by grooves and pits or foveae. On each side of the head is a large compound eye and on the front three simple eyes or ocelli. A pair of jointed antennae are also situated on the front. The mouth parts of the primitive forms are mandibulate, i.e. they consist of a clypeus and labrum or upper lip, a pair of mandibles, a pair of maxillae and a labium or fused second maxillae sometimes called the lower lip. From this description it will be seen that the head of the sawfly differs little from the primitive type.

A typical thoracic segment consists of a dorsal plate, the tergum, of a ventral plate, the sternum, and of a lateral plate or pleuron on each side. In each segment a leg is attached between the pleuron and sternum on each side and in the last two a wing between the pleuron and tergum on each side. According to the development of the wings and legs the typical structure of the thorax is modified to accomodate the enlarged muscles, those of the wings requiring the greatest modifications. The structure of a typical wing-

bearing segment of the thorax is theoretical, for every insect has this structure modified in some form or other. The generally recognized ground plan of such a segment may be briefly described as follows:-

The tergum is divided by more or less distinct transverse sutures into prescutum, scutum, scutellum and the surface plate of phragmanotum or postscutellum. Two lateral lobes of the tergum extend down for attachment to the wing, the anterior notal wing process and the posterior notal wing process. An arm of the prescutum makes a pronotal bridge to the pleuron in front of the wing base, corresponding with a postalar bridge from the postscutellum behind the wing base. Just anterior to the base of the fore wing is a small sclerite, the tegula.

The pleuron is divided by a longitudinal suture into an anterior plate, the episternum, and a posterior plate, the epimeron. At the base of the wing there are one or more subalar plates. A spiracle is situated between the pleuron of the first and second and second and third thoracic segments.

The sternum is frequently divided into two lateral halves by a longitudinal suture and an anterior and posterior part by a transverse suture. In addition there is frequently a furca-bearing sclerite, the furcasternum.

If we now compare this typical segment with those of the thorax of the sawfly we shall see at a glance how greatly the latter has been modified.

The tergum of the prothorax is reduced to a single plate, the pronotum, divided by an indistinct suture into an anterior and posterior part. The episternum is fused on one side to the neck

plate and on the other to the presternum which is divided by a longitudinal suture. The epimeron is a small triangular plate.

The mesothorax occupies the largest part of the thorax of the sawfly. In addition to the regular divisions of the tergum there are the parategites, parascutella, and postterga. The episternum is very large and the epimeron is divided by a transverse suture into an upper and lower plate. There is one basalar plate. The postalar bridge is divided into an upper and lower postalar plate. The episternum is fused to the sternum which is divided by a longitudinal suture. Part of the furcasternite is visible between the coxae.

In the metathorax the tergum is typical save that the prescutum is hidden and the scutum has a lateral parascutellum. The episternum is not divided, but the epimeron is divided into an upper and lower plate. The sternum is as in the mesothorax.

The legs of the sawfly are of the generalized type as they consist of coxa, trochanter, femur, tibia and tarsus of five segments. They are not modified for any special purpose.

The wings are of the hymenopteran type.

The abdomen is a very distinct region of the body attached to the thorax by a broad or narrow base. It contains the larger part of the alimentary canal and the reproductive organs. It typically consists of 10 segments, each with a tergum and sternum, but in some orders it contains 11 and in the embryo 12. In the embryo each sternum bears a pair of protuberances that suggest that insects originally had legs the entire length of the body. The terminal segment always carries the anal and reproductive openings, in the male on the ninth and in the female on the eighth. In lower orders on the anal segment there is a pair of cerci and in all orders

the genitalia about the reproductive openings. The female ovipositor originates from six small outgrowths (gonapophyses), two on the sternum of the eighth abdominal segment and four on the ninth. The inner pair of gonapophyses of the ninth sternum forms the sheath, the pair on the eighth the lancets, and the outer pair of the ninth the guides. Parts of the genitalia of the male appear to be derived from the gonapophyses, others are clearly secondary lobes of the ninth and tenth segments.

It will thus be seen that the abdomen of the sawfly exhibits several primitive characters, the broad attachment to the thorax, the cerci and the formation of the ovipositor of the female from the gonapophyses of the eighth and ninth segments. In the female we find specialization in the development of the lancet into a saw.

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List of Abbreviations

....antennal socket
a....anepimeron
af...antennal furrow
ai...apical spine
an...anepisternum
an....antenna
ap....antepronotum
ar....arolium
as....apophysis
ax....axillary
....basalar sclerite

....clypeus
ca....cardo
ce....cercus
ch....cenchrus
cl....claw
co....camera
cr....chitinous ridge
cs....clypeal suture
cx....coxa

....compound eye
ep....epimeron
es....episternum

....frons
fs....furcasternite
fe....femur
fm....foramen magnum

....gena
ga....galea
go....gonocoxde
gl....glossa
gp....gonopod

....hamuli
ha....harpes

....katepimeron
ke....katepisternum

....labrum
la....lacinia
lp....lower postalar sclerite

....mandible
mep...mesothoracic epimeron
me....mentum
mt...metasternum

m.es...mesothoracic episternum
ml.....metascutellum
mm.....membrane
my.....metapostscutellum
m.p....median plate
ms.....mesoscutellum

n.....cervical sclerite

o.....ocellus
oc.....occiput
of.....ocellar foramen
or.....orbicular
os.....1st sternite ovipositor sheath

p.....palp
pa.....paraglossa
pe.....prepimeron
p.es...prothoracic episternum
pg.....postgena
pl.....palpiger
pla....planta
pm.....postepimeron
pn.....pronotum
po.....postfergite
pos....postscutellum
pp.....postpronotum
pr.....presutura
ps.....parapsutellum
pt.....paratergite
pv.....paniculvae
pu.....pulvillus

s.....sternites
s.....stipes
sa.....subalar plate
sc.....scutum
sg.....saw guide
su.....submentum
sp.....spiracle
st.....sternum
sw.....saw

T.....tergites
t.....tegula
ta.....tarsus
ti.....tibia
to.....tooth
tr.....trochanter

u.....upper postalar sclerite
un.....ungifer
ut.....ungitractor

v.....vertex
ve.....verga

vf....vertical furca
ve....volsella

x.....fused tergite of 10 & 11 abdominal segments

Wing Abbreviations

1stA...First anal vein
2ndA...Second " "
3rdA...Third " "
C.....Costa
Cu.....Stem of cubitus
Cu_1....First branch of cubitus
M.....Stem of media
m.....Median cross-vein
M_2.....Second branch of media
M_3.....Third branch of media
M_4.....Fourth branch of media
$M_{1\ 2}$...Stem of the first & second branches of media.
$M_{3\ 4}$...Stem of the third and fourth branches of media
$M_4\ Cu_1$.Combined fourth medial and first cubital branches
$M_1\ R_4\ 5$..Combined first medial and fourth & fifth radial branches
m-cu...Medio-cubital cross-vein
R.....Stem of radius
r.....Radial cross-vein
R_1.....First branch of radius
R_2.....Second branch of radius
R_3.....Third branch of radius
R_4.....Fourth branch of radius
R_5.....Fifth branch of radius
Rs.....Radial sector
R M....Combined stems of radius and media
r-m....Radio-medial cross-vein
Sc.....Stem of Subcosta

Wing Abbreviations (cont'd)

Sc_1....First branch of subcosta
Sc_2....Second branch of subcosta
Sc-R-M....Combined stems of subcosta, radius, and media

Explanation of Plates

Pigmented areas are indicated by black or heavy stippling, membrane by light stippling, and non-pigmented areas by white. All drawings were made with the aid of the camera lucida at the magnification indicated.

Plate I

Fig. 1. Head capsule of female seen from above. x 37.
Fig. 2. " " " " " " in front. x 37.
Fig. 3. " " " " " " the side "
Fig. 4. " " " " " " behind "
Fig. 5. Labium of female x 37.
Fig. 6. Left antenna of female x 37.
Fig. 7. " maxilla " " "
Fig. 8. " fore wing of female x 17.
Fig. 9. " hind " " " "
Fig.10. Hamuli on costal margin of hind wing x 70.

Plate II

Fig.11. Lateral view of thorax of female x 37.
Fig.12. " " " mesopostscutellum and phragma x 74.
Fig.13. Dorsal " " thorax of female x 37.
Fig.14. Ventral " " " " " "

Plate III

Fig.15. Prothoracic leg of female x 37.
Fig.16. Mesothoracic " " " "
Fig.17. Metathoracic " " " "

Fig.18. Dorsal view of terminal structures of the foot of female x 150.

Fig.19. Lateral " " " " " " " " " "

Fig.20. Ventral " " " " " " " " " "

Plate IV

Fig.21. Lateral view of abdomen of male x 37.

Fig.22. Dorsal view of male genitalia x 35.

Fig.23. Apical portion of distal sclerite of saw sheath x 75.

Fig.24. Saw and guide of female x 75.

Fig.25. Lateral view of abdomen of female x 37.

Fig.26. Ventral " " " " " "

Plate. I

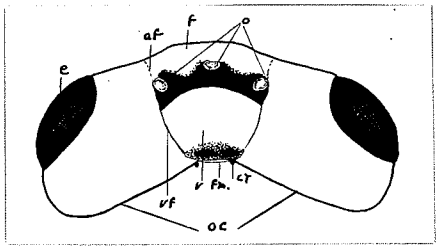


Fig. 1

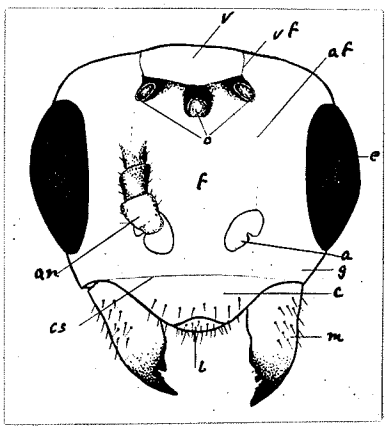


Fig. 2

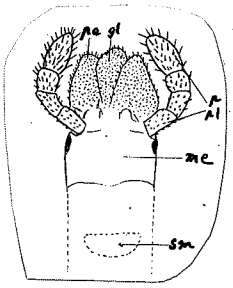


Fig. 5

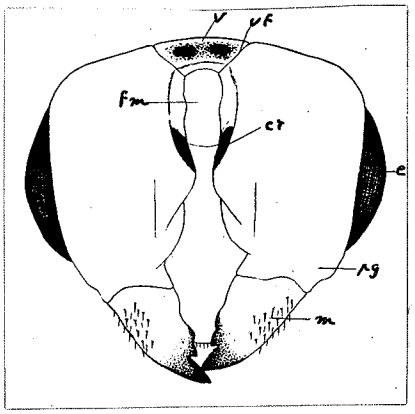


Fig. 4

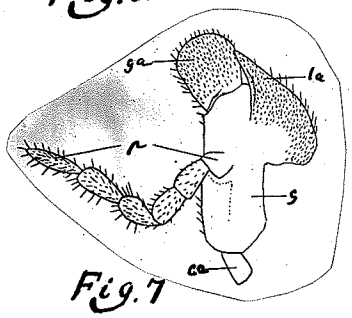


Fig. 7

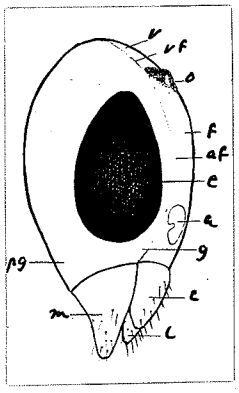
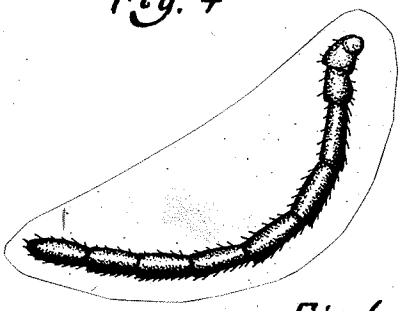


Fig. 3



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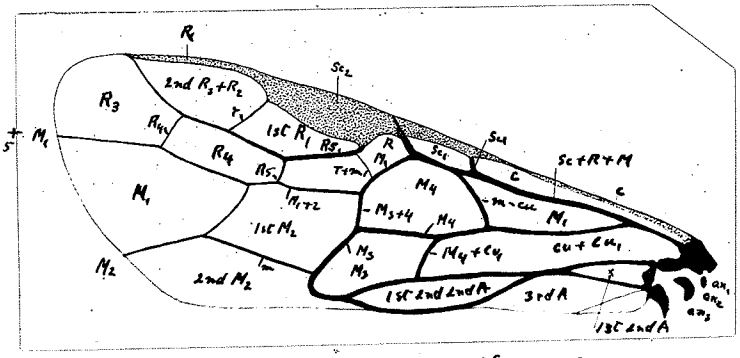

Fig. 8

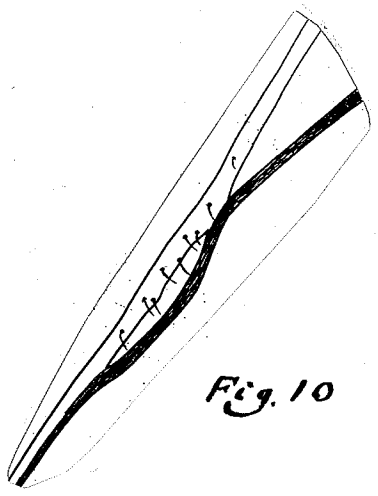

Fig. 10

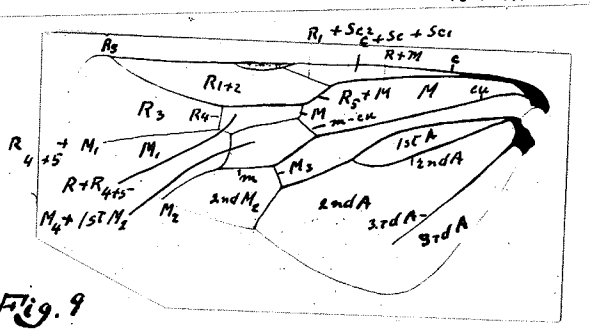

Fig. 9

Plate. II

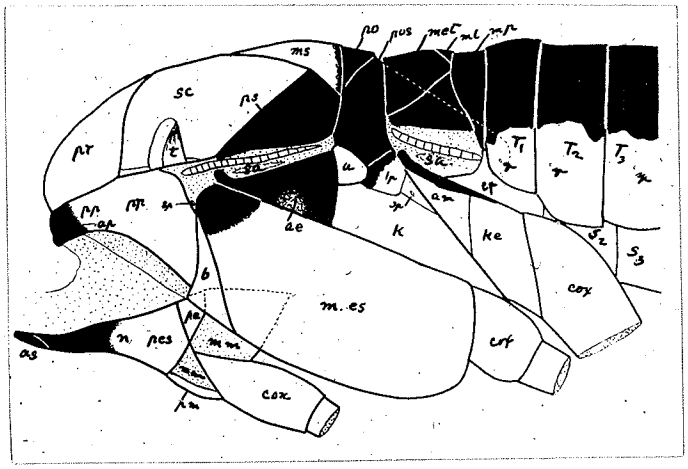

Fig. 11

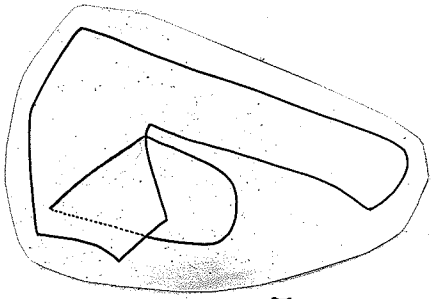

Fig. 12

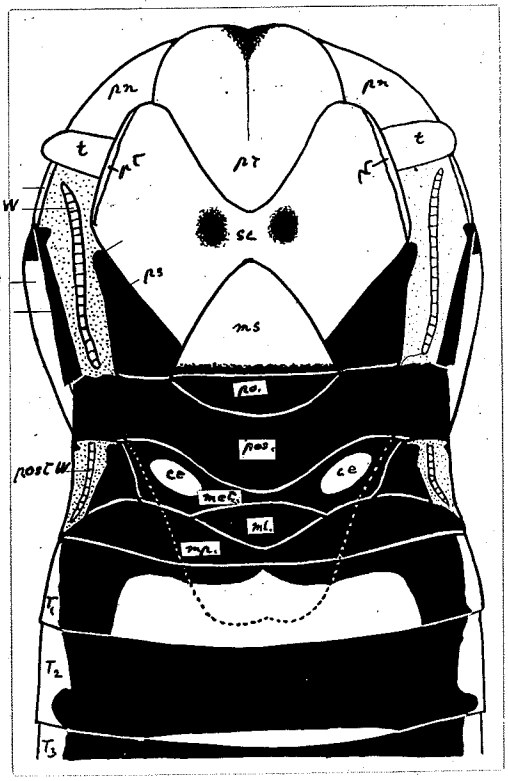

Fig. 13

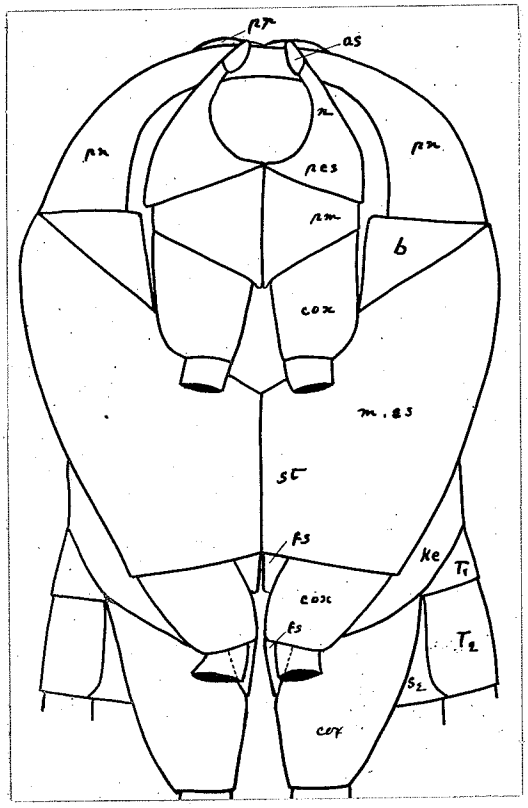

Fig. 14

Plate III

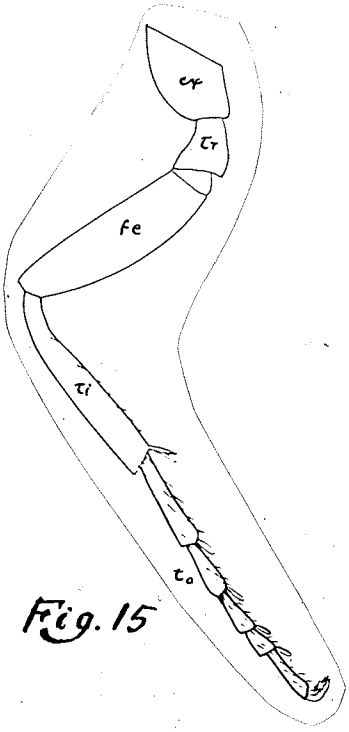

Fig. 15

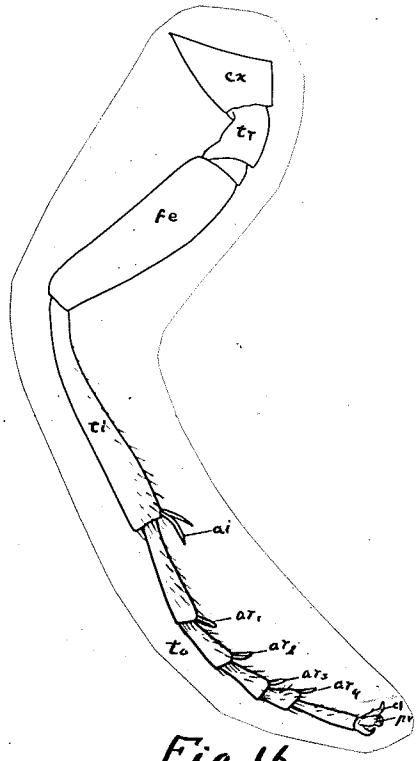

Fig. 16

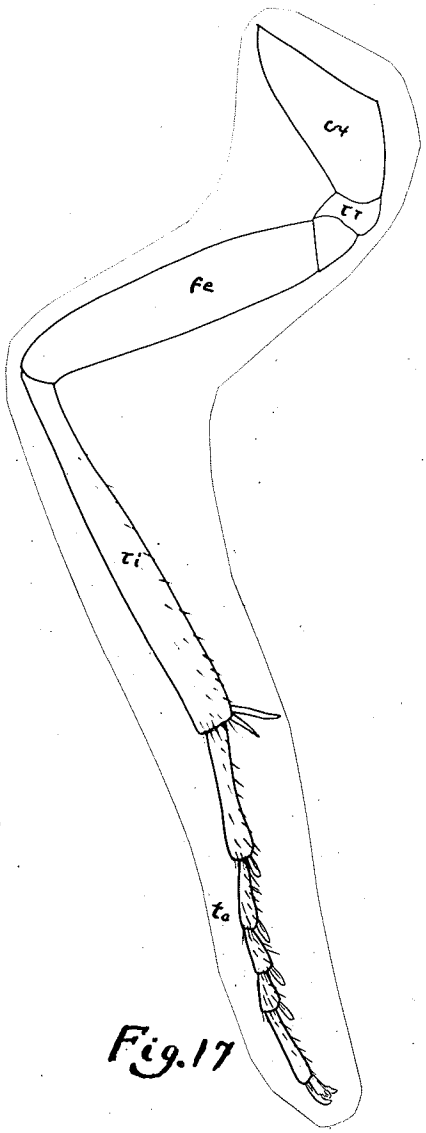

Fig. 17

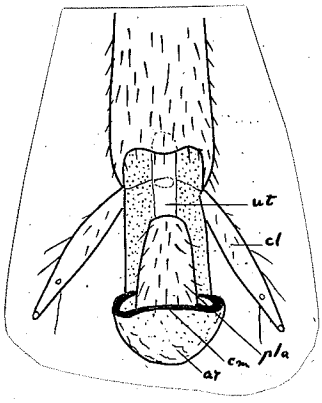

Fig. 18

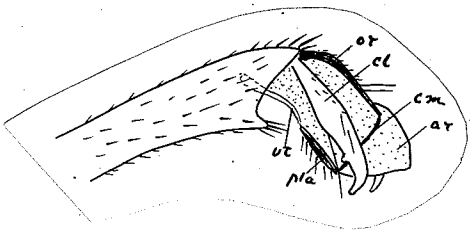

Fig. 19

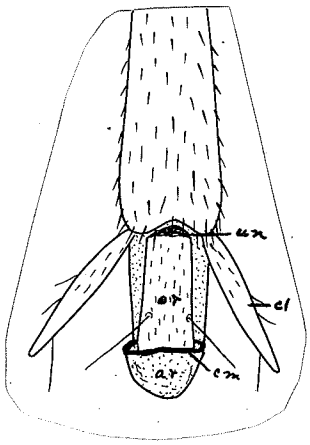

Fig. 20

Plate IV

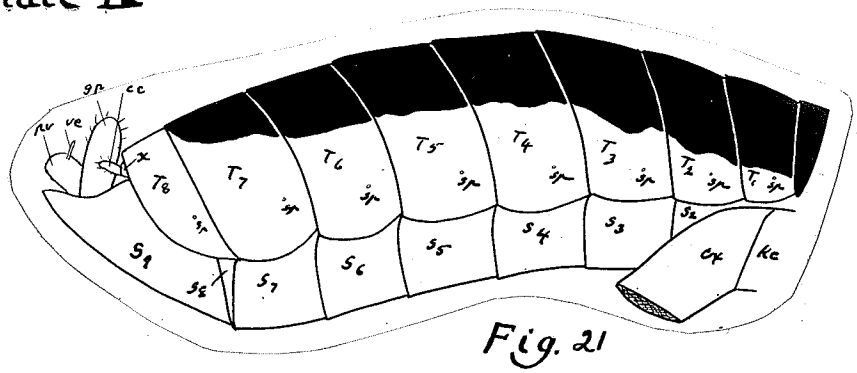

Fig. 21

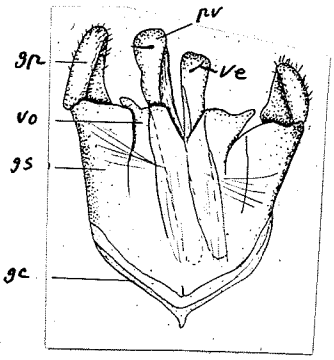

Fig. 22

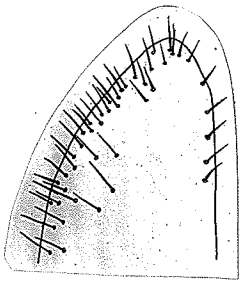

Fig. 23

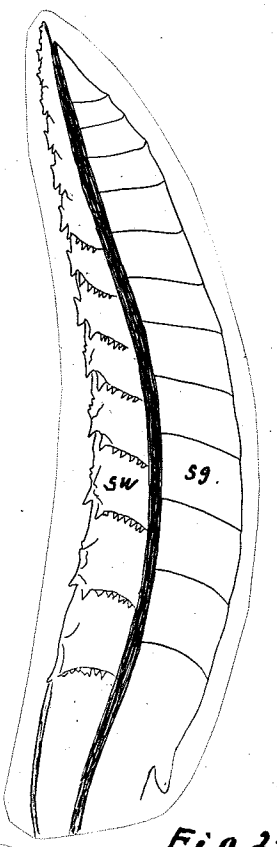

Fig. 24

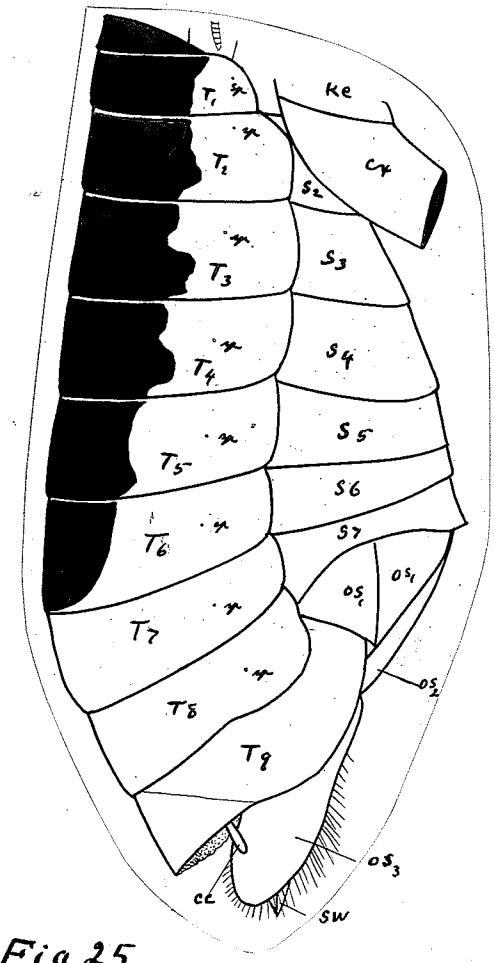

Fig. 25

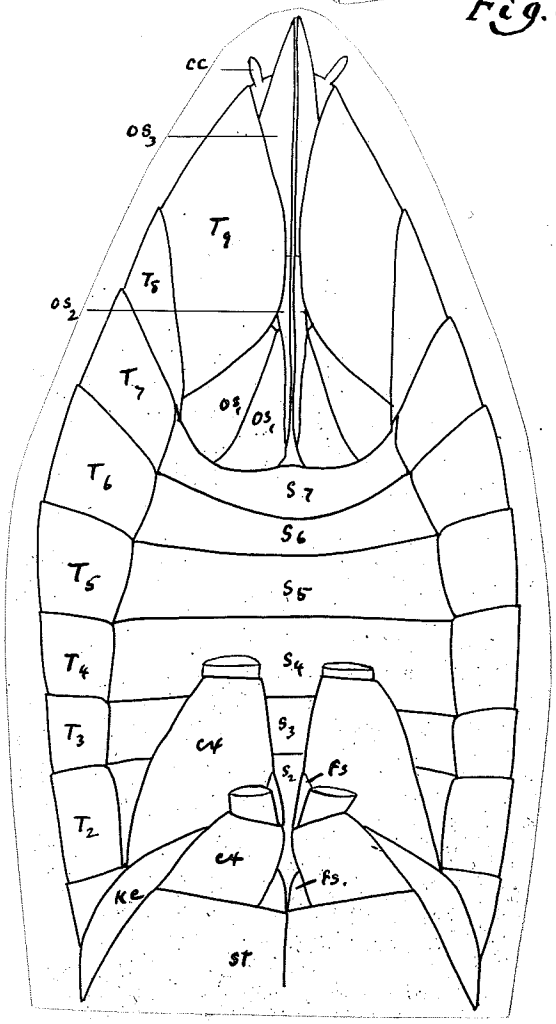

Fig. 26

A PRELIMINARY ECOLOGICAL SURVEY OF THE DISTRICT SURROUNDING THE ENTOMOLOGICAL STATION AT TREESBANK, MANITOBA.

by

R. D. BIRD,

Dominion Entomological Laboratory, Treesbank, Man.

While working at the Dominion Entomological Laboratory at Aweme, 5 miles north of Treesbank, Manitoba, Canada, during the summers of 1924 and 1925, the writer became interested in the ecology of the surrounding country, Lat. 49 42, Long. 99 35.

An area (see map) of about eighty-three square miles situated in part of townships 9 and 10, range 15; T. 8, 9 and part of 10, R. 16; part of T. 8, 9 and 10, R. 17, all west of the principal meridian, was selected for study as it includes the typical habitats of the district. It is of particular interest as about two thirds of it is of virgin territory, unmolested by man, and hence gives an unusual opportunity for the study of natural conditions. The laboratory is situated on the north-east quarter of section 32, T. 8, R. 16.

In order to bring to the mind of the reader a general understanding of the ecology of the district it was thought advisable to publish this preliminary account, which could be followed later by more intensive studies of the various habitats and associations.

Before proceeding farther I would like to express my gratitude to Mr. Norman Criddle, offer in charge of the laboratory, for

much invaluable assistance in all phases of the work, but particularly along botanical lines, for indentification and environmental notes. To Mr. Stuart Criddle I am indebted for a list of the mammals and their habitats and to Miss Maida Criddle for meterological records.

The following members of the University of Manitoba have given freely of their time. Miss Kirk Scott has identified the lichens, and together with Mr. C. W. Lowe some of the more difficult flowering plants. Mr. Alan Mozley has identified the molluscs.

The floral nomenclature is that of Gray's Manual 7th ed. and that of the mammals of G. S. Miller's List of North American Recent Mammals, 1923.

Geological History

The area lies in a great belt of sand that was deposited by the Assiniboine River as it flowed into the glacial Lake Agassiz near the present town of Brandon. A large amount of the sand has been reasserted into dunes, most of which have been overgrown by invading plants.

There are no exposures of bed rock, but a short distance north of the area some Pleistocene deposits appear near the surface.

Topography

Through the north-east corner of the area a belt of sand hills, some four miles in width, runs in a south-easterly direction. This is composed of individual hills and ridges 20 to 40 feet in height running in the same general direction. They are partly overgrown with white spruce, poplar, juniper grass and other plants, but present many scarps of pure sand on the south and west sides. In

one place two miles west of Onah station there is an area of about two miles long by one mile wide of drifting sand. This is encroaching on the low bog area of tamarack swamp, bordering its south-eastern edge, at the rate of one to two feet a year, due to the prevailing north-west winds.

The remainder of the area is a gently rolling plain of an elevation of twelve-hundred feet through which run the valleys of the Assiniboine and Souris rivers. These are from fifty to eighty-five feet deep and from one-quarter to one-half a mile in width. In some places they present steep cliffs rising to the level of the plain, in others with two or three terraces covered with a rich deposit of silt. The rivers themselves flow at about two and a half miles an hour during the summer and five miles an hour in the spring floods. They exhibit a number of rapids at low water.

Some of the terraces on the north side of the Assiniboine are boggy due to numerous cold springs. These are partly covered with tamarack.

The soil to the north of the Assiniboine, save for a shallow surface layer of black humus, is almost pure sand. If this land is much cultivated it at once blows and forms a series of blowouts. In 1876 to 1884, when there was a series of wet years the water level rose at least ten feet and the sandy land grew excellent crops of wheat. When the succeeding dry years came the land blew and the farms were deserted. Numerous ruins of log houses and blown out fields slowly going back to sod mark the remains of a once semi-prosperous settlement of hardy pioneers.

South of the Assiniboine the soil is a sandy-clay and now

supports excellent crops of wheat, while in the wet years of the last century much of it was too wet to farm.

Meterological Conditions

The average yearly precipitation for 38 years, from 1887 to 1924, was 18.45 inches. The greatest for any one year was 25.82 inches in 1924 and the least, 12.6 inches in 1917. In the year 1920, which had a total precipitation of 18.5 inches, the sum of the normal mean daily temperatures above 43 F (6 C) was 10,951 F. During the six hottest weeks the temperature fell below 64.4 F nine times.

From the above meterological conditions weesee that the area besides being near the center of the transition belt is midway between the eastern and western humid zones. Hence the biota is a queer mixture of the four types, eastern, western, northern and southern.

In the years 1878 to 1882, before meterological records were taken, but within the memory of the early settlers, the precipitation must have been much greater as the water level was a least ten feet higher than today. All the hollows in the prairie and sand hills were full of water and alive with thousands of wildfowl. In several places stumps and fallen trees of a poplar forest that had been drowned out were to be seen, showing that at an earlier date the seasons must have been considerably dryer, more like those of the last forty years.

As wet and dry periods usually go in cycles it is highly probable that the wet conditions will return with disastrous results to the farmers on the lowlands.

The Vegetation

The vegetation of the area is that of a transition between prairie and deciduous forest types, with an isolated area of spruce and several of tamarack.

North of the Assiniboine River we find an area of deciduous forest climax, composed mainly of white poplar and a prairie climax. Between the two there is a transitional area where the forest is encroaching on the prairie. This is marked by fingers and isolated areas of each. In the sand hills there is a transitional area of prairie with spruce and poplar and in one place (see map) an area of drifting sand. In the cold bogs along Epinette creek and the Assiniboine River the dominant flora is tamarack and dwarf-birch, Betula glandulosa. Along the rivers there are poplar, elm, ash and maple associations.

South of the Assiniboine there is a mixture of prairie and polar forest, but the vegetation is of more luxuriant growth due to the clayey nature of the soil which holds the moisture.

In discussing the biota of the area we will consider briefly the following associations (see map):-

1.. San plain.

2. Prairie.

3. Deciduous forest.

   (a) Poplar.

   (b) Poplar, elm, ash, maple, willow.

   (c) Cottonwood, elm, ash.

   (d) Oak, Saskatoon transition belt.

   (e) Birch.

   (f) Willow, saskatoon, cherry, etc.

4. Mixed white spruce and deciduous forest.

5. Tamarack swamp.

1. The sand plain association

An interesting discussion of this habitat is given by N. Criddle, Some Inhabitants of a Sand Plain in June, Can. Ent., pp.24-30, June 1915.

On the sand, with only odd clumps of grass for shelter, we find a grasshopper, Tremerotropis agrestis, and a tiger beetle, Cicindella lepida, that show a remarkable color adaptation to their environment.

In many places we find isolated individuals and clumps of plants that have obtained a footing and are binding the sand with their spreading roots. The chief of these are:- The grasses, Crisopsis cuspidata, Andropogon furcatum and Calamovilfa longifolia; the willow, Salix longifolia; the skeleton weed, Lygodesmia juncea, and the veined dock, Rumex venosus. Here we find the tiger beetles, C. manitoba and C. nymphea; the burrowing spider, Lycosa wrightii and its deadly enemy, the solitary wasp, Pompilus scelestus. There are many bembecine wasps of which Bembex pruinosa is the common species. On the willow we find many beetles, Disonycha quinquivittata, which forms a large part of the food of the tiger beetles.

Among the grasses are numerous grasshoppers, Hippiscus neglectus, Cordilacris cinerea, Amphitornus bicolor and several species of Melanoplus:- angustipennis, pachardi and scudderi.

In the hollows, where the sand has blown almost down to the water level, the vegetation is much more abundant. Here the commonest plants are:- Petalostemum candidum, P. villosum, Eleagnus argentea, Equisetum hymenale, Senecio manitobensis, Arctostaphylos uva-ursi, several species of sunflowers, Salix longifolia and Populus deltoides.

Most of the insects mentioned in the last paragraph are found together with Cincindella lengi-versuta, Lycosa missouriensis, Omorphron americana (a burrowing carabid) and a few mammals, the chief of which are the pocket gopher, Thomomys talpoides talpoides and the white-footed mouse, Peromyscus maniculatus baidrii, which is more yellowish than the prairie form.

The sand plains, being small in area and bounded on one side by a tamarack swamp and on the other by sand hills overgrown with spruce and poplar, is frequently overrun by the larger mammals from these habitats. Coyote, moose, deer and bear tracks are frequently seen on the sand.

The birds, as a rule, are scarce, but the Prairie Chicken and Vesper Sparrow are sometimes seen in the less bare spots.

On the sand we find several cases of invading plants from the surrounding country. A few are composed solely of choke cherry, Prunus virginiana, others of a mixture of larch, white spruce, Acer negundo, Populus tremuloides, P. deltoides and Betula pendula.

2. The Prairie Association.

Almost half of the area is composed of a prairie climax typical of the plains of south-western Manitoba and south-eastern Saskatchewan, although somewhat more arid, due to the sandy nature of the soil.

The dominant vegetation is grass, of which the commonest species are;- Andropogon furcatum, Panicum capillare, P. wilcoxianum, Stipa viridula, S. comata, S. spartea, Sporobolis brevifolius, S. heterolepis, Agrostis alba, Calamovalfa longifolia, Koeleria

aristata, Bouteloua oligostachya, Poa compressa, P. pratensis, Hordeum jubatum and Avena americanum. The sedges, Carex siccata and C. pennsylvanica are also common.

The flowering plants are plentiful and at times form quite a blaze of color. The common forms, all flowering at definite seasons, are;- Lilium philadelphicum, Ranunculus rhomboides, Thalictrum sp., Anemone patens var. wolfgangiana, A. canadensis, Draba nemorosa, Erysimum asperum, Lesquerella sp., Arabis holboelli, Heuchera hispida, Potentilla consimus, P. pennsylvanica, Geum triflorum, Rosa pratincola, Psoralea esculenta, Petalostemum purpureum, P. candidum, Astralgus caryocarpus, A. canadensis, Oxytropis lamberti, Linum lewisii, Houstonia longifolia, Allium cernum, Penstemon gracilis, P. albidus, Viola pedata, Oenothera pallida, O. biennis, Androsace occidentalis, Orthocarpus luteus, Lithospermum canescens, L. angustifolium, Monarda mollis, Physalis grandifolia, Chrysopsis villosa, Castilleja sessiliflora, Campanula rotundifolia, Solidago missouriensis, Liatris punctata, Aster commutus, Antennaria campestris, Helianthus scaberrimus, Artemisa frigida, A. ludoviciana, A. dracunculoides, Senecio plattensis, Brauneria angustifolia, Gillardia aristata, Achellea millefolium and Prunus pumila.

In the more sandy places the lichens, Celaria islandica, Parmelia molliuscula and Cladonia sp. are found growing plentifully among the scanty grass.

Many of the sandy knolls are covered to a large extent with Juniperus horizontalis. In the hollows we find Elaegnus argentea and the snowberry, Symphoricarpus occidentalis.

In this habitat there are many indigenous insects, birds and mammals.

Of the insects the grasshoppers are the most numerous. Ones frequently met with are:- Several species of Melanoplus - dawsoni, gladsoni, angustipennis, minor, atlanis, luridus, infantilis, and bivittatus; Spharagnemon collare, Neatobrecma kiowa, Tremerotropis monticola, Arenetettix decrum, Arphia pseudonietana, Gomphocerus elevatus, Camnula pellucida; several species of the grouse locust, Agrydium and the field cricket, Gryllus assimilis luctuosus. The above all winter as the egg and do not mature until July. Other common forms such as Hipiscus tuberculatus, Arphia frigida, Chortophaga viridifasciata and Stenopleura deleculata winter as nymphs of the last instar and appear as adults in the spring. The numbers of the grasshoppers are largely kept in check by the larvae of the bee-fly, Systoechus vulgaris, adults of which are often seen on the prairie flowers, and the blister beetle, Cantharis sphaericollis whose larvae feed on grasshopper eggs. The adult beetle is a leaf feeder on the prairie snowberry.

The prairie birds are few in species, but there are a large number of individuals. However, after the breeding season few are seen for then they are moulting and hide closely in the grass. A little later they flock in preparation for the fall migration. Common forms that remain to breed are:- The Saskatchewan and Prairie Horned Larks (Criddle 1917), the first a bird of the open prairie, the second a species more partial to prairie not far from the woods; Western Meadow Lark, Chestnut-Collared Longspur, Western Vesper Sparrow and Upland Plover. The Swainson's and Rough-Legged Hawks nest in the woods on the edge of the prairie, but use the latter as their chief hunting grounds. The Red-tailed Hawk is a bird of the open woods, but hunts to a certain extent on the prairie.

In the summer the Pinnated and Pin-tailed Grouse are to be seen on the prairie where there are odd clumps of bush for shelter. In the winter they retire farther into the wooded area.

These prairies were at one time the haunts of vast herds of buffalo, the bones, paths and wallowing holes of which were seen in every direction by the early settlers. The elk, Cervus canadensis, was found on the border of the open woods as is told by the shed antlers. The Prong-horned Antelope probably extended its range into these regions.

The smaller mammals are still common. The shrew, Sorex personatus haydeni, the white-footed mouse, Peromyscus maniculatus bairdii, and the vole, Microtus drummondi, are common everywhere. The banded pocket mouse, Perognathus fasciatus fasciatus is found in the more sandy places, particularily where the sand has blown. The pocket gopher, Thomomys talpoides talpoides is a common burrowing mammal. Two species of 'gophers' are found, namely, Citellus richardsonii and C. tridecemlineatus tridecemlineatus. The jack rabbit, Lepus townsendii campestris forms one of the main foods of the coyote, Canis latrans. The badger, Taxoidea taxus taxus is an important enemy of the gophers and mice.

On sunny hill sides, usually not far from the river or other moist shady places, are found four species of snakes. The garter snake, Thamnopis sirtalis parietalis is the commonest. The next in abundance are the Plains Garter Snake, Thamnopis radix and the Green-snake, Liopeltis vernalis. A rarer species is the Red-bellied Snake, Storeria occipito-maculata. All the above are perfectly harmless. In fact, they are decidedly beneficial as their food is of small mammals, frogs and insects.

3. The deciduous forest association.

(a) The deciduous forest of the uplands is composed almost entirely of white poplar, Populus tremuloides, with a few trees of Populus balsamifera on the damp spots and Quercus macrocarpa where the soil becomes clayey.

The forest climax is encroaching on the prairie, but there are a number of factors that keep it in check. Until recently fires continually swept across the prairie in to the forest, killing many saplings, but in the last few years they have been kept in check by settlers. A second great factor is composed of several species of wood-boring beetles, which attack the young trees that are advancing on the prairie. The most important species are Saperda calcarata and Dicerca sp. Other factors are drought, frost, hail and rabbits. The importance of drought was demonstrated in the spring and summer of 1902 when poplar and willow seedlings came up over the prairie, often miles from the nearest trees. Snow, too, is an important factor for it drifts heavily on the young poplars invading the prairie, often breaking or bending them severely. The next summer the tips grow upright, only to be bent over the following winter. In this manner many stunted trees of fantastic shapes are produced, which are much weakened and subject to the attack of insects and fungi.

Growing along the forest border and in many places throughout the forest are found:- Juniper horizontalis, Amelanchier spicata, Prunus virginiana, P. pennsylvanica, Salix rostrata, S. discolor, Symphoricarpos racemosus, Rubus aculeatissimus, Rosa blanda, R. acicularis, Cypripedium var. pubescens, Rhus toxicodendron, Sterionema ciliata, Arctostaphylos uva-ursi, Corylus americana, Lathyrus ochroleucus, L. venosus, Viola americana, Fragaria

(virginiana) glauca, Arenaria lateriflora, Anemone canadensis, Apocynum androsaemifolium, Geum microphyleum, Spirea salicifolia, Heliopsis scabra, Prenanthes alba, Helianthus scabrimus and H. maximiliani.

Other plants do not grow far into the woods. The chief of these are;- Solidago rugosa, S. canadensis, S. rigida, Aster lindleyanus, A. laevis, Anemone multifida, Cornus canadensis and Lonicera glaucescens.

The poplar woods, particularly along the border, are rich in all forms of life. There are many associations, strata, consocies and mores, but the more important ones only can be discussed in a very general way in this paper.

Among the insects there are many leaf-feeders and borers, each on its respective food plant, e.g. Caenegia rosaceana, which eats the leaves of the saskatoon and Saperda bipunctata, which bores in the stems.

This is the favorite haunt of many birds both as breeding and nesting grounds. The crow, Red-tailed Hawk, Tree Sparrow, Robin, Brewer's Blackbird, Northern Flicker, Song Sparrow, Bluebird (both eastern and western), Mourning Dove, Tree Swallow, Cowbird, Brown Thrasher, Western House Wren, Yellow Warbler, Clay-coloured Sparrow, Chipping Sparrow, Kingbird, American Goldfinch, Catbird, Red-eyed Vireo, Crested Flycatcher, Ruby-throated Hummingbird, and Cedar Waxwing are all common.

The mammals are also plentiful;- The bats, Lasionycteris noctivagans, Eptesicus fuscus fuscus, Nycteris borealis borealis, the coyote, Canis latrans, the fox, Vulpes fulvus, the weasels,

Mustela cicognanii richardsonii, M. rixosa rixosa, M. longicauda longicauda, the skunk, Mephitis hudsonica, the red squirrel, Eoirus hudsonicus hudsonicus, the chipmunk, Eutamias minimum neglectus, the ground squirrel, Citellus franklinii, the grasshopper mouse, Onychomys leucogaster leucogaster, the white-footed mouse, Peromyscus maniculatus bairdi, the red-backed mouse, Evotomys gapperi loringi, the voles, Microtus drummondi and M. miner, and the jumping mouse, Zapus princeps miner, are all found. Up to 1900 the mule deer, Odocoileus hemionus hemionus was fairly common, but after that date the white-tailed deer, Odocoileus virginianus borealis invaded its range. The mule deer is now extremely rare and the white-tail common.

The common toad, Bufo hemiophrys is quite abundant.

The poplar woods may be divided into a number of strata, e.g.,

The tree top stratum composed of:- the forest tent caterpillar, Malacosoma disstira, the Warbling Vireo and the Baltimore Oriole.

The tree trunk stratum composed mainly of:- the flying squirrel, Sciuropterus sabinus sabinus, the Downy Woodpecker, the Hairy Woodpecker, the Yellow-bellied Sapsucker, the Cooper and Sharpshinned Hawks, the Black and White Warbler, the Longeared Owl and the Least Flycatcher. On the tree trunks themselves grow abundantly two species of lichens, Physcia stellaris and Placodium cernum.

The underbush stratum composed mainly of:- Mourning Dove, Towhee, Rosebreasted Grosbeak, Willow Thrush, Western Wood Pewee, Black-Billed Cuckoo, Blue Jay, Catbird, Brown Thrasher, Chipping and Clay-Coloured Sparrow, and Yellow Warbler.

The forest floor stratum composed of:- The snowshoe Rabbit, Lepus americanus phaeonotus, several mice, shrews and voles found on the forest border; the Ruffed Grouse and the Oven Bird.

The leaf mould stratum composed mainly of:- Wire worms, a few carabid beetles and numerous snails of the following species:- Cochlicopa lubrica Mull., Vallonia costata Mull., Euconulus sp., Vertigo ovata Say, and Pyramidula cronkhitei anthonyi Pils.

(b) The valleys of the Assiniboine and Souris Rivers present an interesting series of habitats. On the sand bars and flood plains is a very dense growth of the willow, Salix longifolia, mixed with Salix amygdaloides and the dogwood, Cornus stolonifera. These are bound together with the hop, Humulus lupulus, and the bindweed, Convolvulus sepium and form an almost impregnable barrier for one trying to force his way through. On the next highest level is a thick stand of elm, Ulmus americana, ash, Fraxinus pennsylvanica var lanceolata, alder, Alnus incana, manitoba maple, Acer negundo, black poplar, Populus balsamifera, and the white poplar, Populus tremuloides, under which the fern, Pteris aquilina, is found. From this belt to the top of the valley is a very luxuriant white poplar forest composed of trees up to 16 ins. in diameter at the base and 60 feet in height. In many places under the above the high bushcranberry, Viburnum opulus var americanum occurs and in the leaf mould numerous gastropod molluscs of the following species:- Succinea ovalis Say., Cochlicopa lubrica Mull., Vallonia costata Mull., and Vitrina limpida Gld.

In places the forest does not reach the low water mark of the river. Here are found the mint, Mentha canadensis, Joe Pye

weed, Eupatorium purpureum, Aster novae-angliae, A. umbellatus, Solidago graminifolia, the sneeze weed, Helenium autumnale, Physostegia virginiana and Potentilla anserina.

The birds and mammals of this habitat are not strikingly different from those of the poplar bluff, but a few are peculiar to it, e.g., Phoebe, Whip-Poor-Will, Northern Yellow-Throat, Grinell's Water Thrush, the vole, Blarina brevicauda brevicauda, the lynx, Lynx canadensis canadensis, and the jumping mouse Zapus hudsonicus campestris. The wood frog, Rana sanbrigensis sanbrigensis, is frequently seen hopping about on the forest floor.

The mink, Mustela vison lacustris, and the muskrat, Ondatra zebethica cinnamomina, make their dens in burrows excavated in the river banks at water level, but obtain most of their food from the river and seldom wander far from it.

The common leopard frog, Rana pipiens, breeds in the stagnant back waters and oxbows of the river and is often seen in great numbers upon the banks where it feeds on any unlucky insects that wander near it. Two species of turtles also breed here; the painted turtle, Chrysemys marginata bellii, is quite common, but the snapping turtle, Chelydra serpentina, which sometimes reaches a great size is of rarer occurrence. Both species resort to bare places on grassy banks where they excavate shallow holes in which they lay a clutch of a dozen or so eggs.

(c) The lower reaches of the Souris River valley, from the railway bridge to the mouth is gravelly and presents broad beaches of this material. These are sparingly covered with the cottonwood, Populus deltoides, and are frequented by the Killdeer

and Spotted Sandpiper.

Back of the beaches on the next highest level there is a rich deposit of river silt on which there is a dense growth of elm, ash, cottonwood, Salix amygdaloides, S. discolor, S. rostratum, Quercus macrocarpa, Betula pendula, et.

(d) Between the prairie and the poplar wood of the river valley is a narrow transitional zone composed of oak, Quercus macrocarpa, choke cherry, Prunus pennsylvanica, saskatoon, Amelanchier spicata, hazel, Corylus americana, and C. rostrata, and other plants typical of the forest border.

The birds and mammals are typical of the forest border. The only one peculiar to this region being the eastern chipmunk, Tamias striatus griseus.

(e) On certain sections of the river valleys, where the drainage is good, are found small stands of birch, Betula pendula. This tree is also found on the slopes draining into tamarack bogs.

In the area studied the stands of birch are too small to ascribe to them any indigenous birds or mammals. A few insects, however, are partial to them, e.g., Dicerca caudata, a flat-headed beetle that bores in the trunk.

(f) A few of the higher river terraces facing in a westerly direction instead of being covered with a rich poplar forest maintain a growth of shrubs. Here the dominant plants are:- willows, Salix discolor, and S. rostrata, saskatoon, Amelanchier spicata, choke cherry, Prunus pennsylvanica, snowberry, Symphoricarpos racemosus, dogwood, Cornus stolonifera,

Potentilla fruticosa and Spirea salicifolia.

4. Mixed white spruce and deciduous forest association.

The sand hill region is overgrown with intermingled areas of prairie and forest, composed mainly of white poplar, but in which there is a shrub formation of the oak, Quercus macrocarpa, and willow as well as clumps and isolated trees of white spruce, Picea canadensis. At one time the valleys and north sides of the hills were fairly heavily forested, but frequent fires killed many of the trees. Since the area has been proclaimed a forest reserve most of the fires have been kept out and the forest is rapidly growing up again.

The smaller plants are typical of the prairie and forest as described before. On the prairie, however, on account of the sandy nature of the soil there are a greater number of lichens of the same species that are found on the dry sandy prairie, and Juniper horizontalis. In addition there are found Juniper communis, Opuntia fragilis, and Mammalaria vivipara.

There are no birds or mammals that are peculiar to the hills, but certain species reach their greatest abundance in them. They are the favourite haunts of the larger hawks, particularly the Swainson and roughleg. Pocket gophers are very plentiful.

The hills were the chief range of the mule deer; the white-tail deer, however, use them mainly as a winter range. An odd bear, Ursus americanus americanus, is occasionally seen. They are the stronghold of the coyote, Canis latrans, and were until the last century roamed by the grey wolf, Canis occidentalis, and the red fox, Vulpes fulvus.

The hog snake, Heterodon contortrix, is sometimes seen.

5. The tamarack swamp association.

The tamarack swamp has rather an interesting fauna and flora. The commonest plants are;- Tamarack, Larix americana, the black spruce, Picea mariana, the dwarf birch, Betula glandulosa, the pitcher plant, Sarracenia purpurea, the leaves of which form the only breeding place for the mosquito, Wyeomya smithii, a species that does not bite man; Aster junceus, Viola renifolia, Bidens laevis, Pedicularis lanceolata, Gentiana affinis, Heracleum lanatum, Hedysarum boreale, Salix candida, Habenaria hyperborea, Cypripedium hirsutum, Orchis rotundifolia and Sphagnum sp.

On the trunks and twigs of the tamarack and other bushes are found growing in great abundance three species of lichens, Usnea plicata, Evernia thamnoides and Remalina caliceris.

Breeding in the swamp are several mammals:- the moose, Alces americana, the jumping mouse, Zapus hudsonicus hudsonicus, the otter, Lutra canadensis canadensis (only along Spinette creek), the shrews, Sorex richardsonii and Blarina brevicauda brevicauda.

The Canada Jay and Black-capped Chickadee may always be found.

Living in the sphagnum are several species of snails;- Succinea avara Say., Strobilops sp., Pyramidula cronkhitei anthonyi Pils., Cochlicopa lubrica Mull., and Vallonia costata Mull.

Summary

An area of eighty three square miles has been selected in south-western Manitoba for ecological study. It is of particular interest because it includes a variety of the habitats typical of that pary of the province.

Topographically, the area is a plain of an elevation of twelve hundred feet traversed by two river valleys. In the north-east corner of the area there is a belt of sand hills, relics of dunes formed by the reassortment of sands deposited in glacial Lake Agassiz.

Meterological conditions place the area in the transition belt and midway between the eastern and western humid zones.

The vegetation is that of a transition between prairie and deciduous forest types, with an isolated area of spruce and several of tamarack.

In discussing the biota, the area is divided into five main associations:- (1) Sand plain, (2) Prairie, (3) Deciduous Forest, (4) Mixed spruce and deciduous forest, (5) Tamarack swamp. In each the dominant plants, mammals, birds, reptiles, amphibians, molluscs and a few of the insects are mentioned.

The biota is interesting because it includes northern, southern, eastern and western species on account of the meterological conditions.

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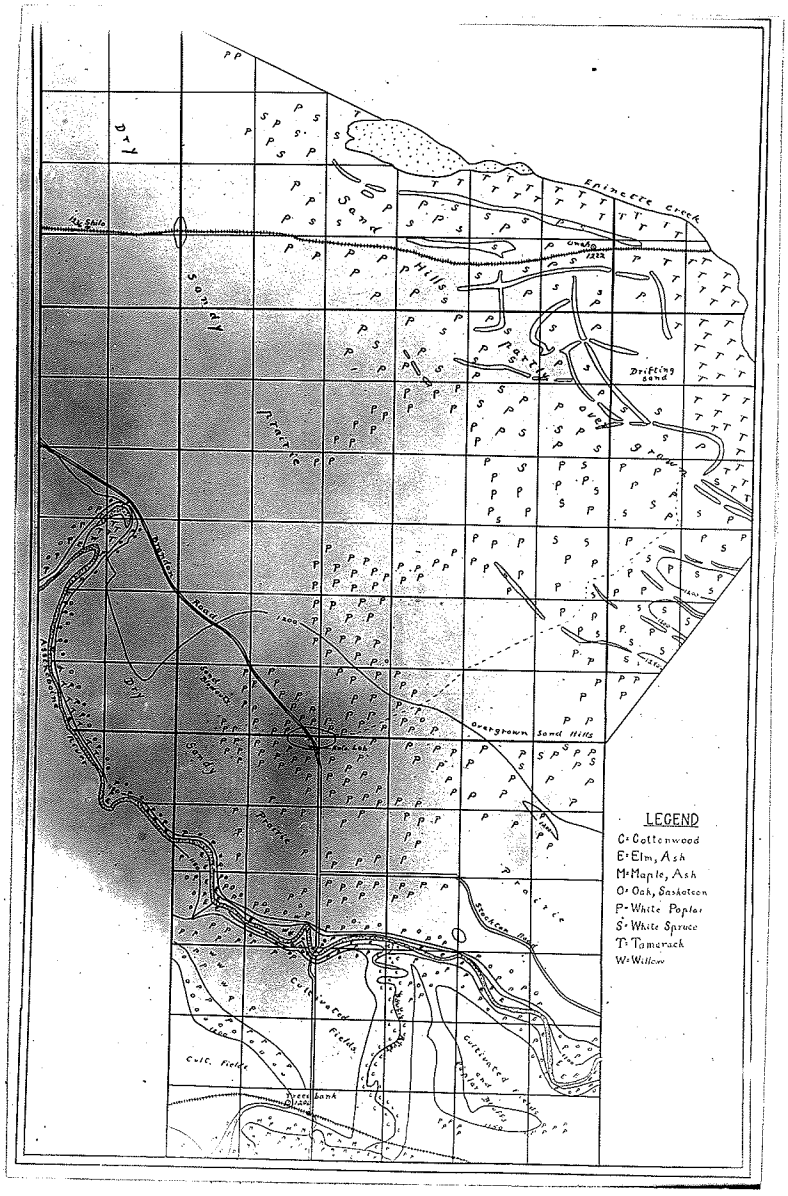

Fif. I. Vegetation map of the area studied, modified from the sectional map of Manitoba, sheets 72 and 22.