BIOLOGY OF *PLEUROTROPIS UTAHENSIS* CRAWFORD (EULOPHIDAE, HYMENOPTERA), A PARASITE OF *CEPHUS CINCTUS* NORTON

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BIOLOGY OF *PLEUROTROPIS UTAHENSIS* CRAWFORD (EULOPHIDAE, HYMENOPTERA), A PARASITE OF *CEPHUS CINCTUS* NORTON

INTRODUCTION. *Pleurotropis utahensis* Crawford is one of several parasites of the Wheat Stem Sawfly, *Cephus cinctus* Norton, known to occur in Western Canada (15)[x] (23). That is is parasitic on wheat stem sawfly has been known for a number of years as Crawford (4) reported it as having been taken from *Cephus cinctus* prior to 1913.

The data in this paper is that gathered during the years 1937-1939, and during the summer of 1946. During these periods this study was only a minor phase of the wheat stem sawfly research investigations conducted by the Dominion Entomological Laboratory, Lethbridge, Alberta. The author realizes that this study is not as complete as it might be, but it is believed that the data at hand is of sufficient value to be published at this time.

HISTORY OF GENUS *PLEUROTROPIS*. The genus *Pleurotropis* was erected by Förster (1) in 1856. The type species of the genus is listed by Gahan and Fagan (13) as *Pleurotropis isomera* Förster; and monobasic through subsequent reference. Förster listed the genus under the family Chalcidae, but it has since been listed by Ashmead (2), Crawford (3), and

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[x] Figures refer to references in the accompanying bibliography.

Waterston (6) under the family Eulophidae, subfamily Entedoninae. Viereck (8) and Essig (21) place it in the family Entedontidae. However, Clausen (20) in 1940 again reverts to the family Eulophidae, subfamily Entedoninae which is the present classification used by the Dominion of Canada, Division of Entomology, Systematic Branch, and by the Division of Insect Identification of the United States Bureau of Entomology and Plant Quarantine.

GENERAL ACCOUNT: SYSTEMATIC. There has been, according to Waterston (6), considerable confusion as to the meaning and essential character of the Genus Pleurotropis. In his article, "Notes on African Chalcidoidea" (6), he gives a resume of the genus as follows:

> "The essential character of the genus is the presence on the smooth propodeum of two central keels which diverge apically to meet the raised posterior edge of the segment. There are also present two lateral keels, as a rule strongly developed, running (inside the oval raised spiracle) along the edge from which the descent to the pleura begins. The lateral keel joins the posterior edge above a generally slightly protruding angle inside the insertion of the meta coxae. The general shape of the propodeum is transversely quadrate, not truncately triangular as in Entedon. The petiole which joins the propodeum by a distinct, though often very short, process, is pitted, quadrate, or even sub-pentagonal in section. The proportion of the first abdominal tergal surface to the whole visible surface varies sexually and specifically, from less than one-third to three-quarters.
>
> "The scutellum shows the usual Entedonine bristles. The parapsidal furrows vary in distinctness in different species but can always be traced. They seem invariable to bend rather abruptly at about the middle of the mid-lobe which

bears apically at the sides a distinctive setae. The area around the setae may be depressed or smooth or different in sculpture from the rest of the mid-lobe.

"The head is generally broad and the eyes are bare, pubescent or completely hairy. The antennae in both sexes have nearly always eight joints; scape, pedicel, ring joint, three in the funicle and two in the club, with the terminal spear not articulated. In the female the funicle and first club joints are generally more cylindrical and increasingly stouter; in the male they are more beard-like and of equal breadth. The ring joint is very small, but highly magnified (600-1000) shows a complex laminate structure. Proximally there is the usual short stalk of insertion with the pedicel, and the dorsal edge is solid and chitinized. When the antennae bends upwards the ring joint is seen to consist of two or three laminae, which are distinctly separated only ventrally.

"The fore-wing of the genus is remarkable for the great development of the marginal vein which is sometimes over twice as long as the submarginal.

"The scutellum and propodeum also afford most important characters. In the former, differences of sculpture and pattern can easily be expressed. On the notum of the propodeum the chief points to be attended to are the curvature of the median keels, their distance apart and the nature of the hollows before the stalk, e.g. whether single or multiple, shining or dull; and in the latter case, whether smooth or pitted. On the pleura the position and size of the stigma are of value.

"The chief variation of the propodeum in any species seems to occur inside the central keels, where false or incomplete keels are frequently thrown up. The distal hollows are much more constant."

Crawford (3) lists the characters of the genus Pleurotropis and states, "The species found in the United States which answer the above characters have been described in so many genera that a table of synonomy is included." In 1912 Crawford (3) lists in his key to species from the United States only nine species. Since that time several others have been described.

In 1914 Waterston (6) published his Key to Species of Pleurotropis; described from Africa and Persia.

In 1932 Gahan (17) states that Girault's description of the genus Pseudacria offers no characters which will separate it from Pleurotropis and he considers it to be a synonym.

GEOGRAPHICAL DISTRIBUTION. The original descriptions are based on specimens taken by Ainslie (4) from Kimball, and Salt Lake City, Utah. He subsequently records them from North Dakota (9) and Gahan (11) reports them as being taken at Missoula, Montana. In Canada they have been recorded from as far west as Sylvan Lake, Alberta, also in Saskatchewan, and Criddle (7) (10), in his original notes, records it from as far east as Boissevan, Manitoba.

The points of distribution records in Canada are shown on the map in Fig.(1). This map is an adaptation of that given by Farstad and Platt (22) for the distribution of wheat stem sawfly in Canada. While the distribution of the parasite has not been checked in detail for every area, sufficient locations are recorded that one might assume that it occurs throughout the area where wheat stem sawfly is found.

MORPHOLOGY. The original description of Pleurotropis utahensis Crawford is published in Proceedings of the United States National Museum 45: 316-317, 1913 as follows:

PLEUROTROPIS UTAHENSIS, new species.

Female. Length about 2.5 mm. Green, with brassy tints, more apparent on head, the abdomen, except basally, bronzy; head both above and below V-shaped furrow with thimble-like punctures; funicle 2-jointed; first joint of funicle longer than pedicel, the second shorter than pedicel; meso-scutum and scutellum rugosely reticulated, the scarlike continuations of the parapsidal furrows smooth; propodeum normal--that is, with two median carinae which posteriorly diverge; lateral carinae present, posteriorly these join oblique carinae, which join at the side, the carina surrounding the superior half of the short propodeal neck; the median carinae join these oblique carinae slightly posterior of a point midway between the lateral carinae and the point where the oblique carinae join the apical carina; propodeum, except for carinae, smooth, polished; wings hyaline; legs, except tarsi, greenish; abdomen, except basal segment, finely reticulated.

Male. Length about 2 mm. Similar to the female; funicle 3-jointed.

Type-Locality. Salt Lake City, Utah.

Holotype female reared from Agromyza parvicornis in corn leaves, and recorded under Bureau of Entomology, United States Department of Agriculture, note number, Webster No. 8819; allototype male and four males and one female paratopotypes from *Cephus* sp.; also 2 females and 1 male paratypes from Kimball, Utah, reared from *Cephus* sp. (Webster No. 6681); all specimens collected by C.N. Ainslie.

Type. Cat. No. 15555, U.S.N.M.

Gahan (11) observes that the number of antennal joints of the species are not constant. His plates are reproduced in Fig.(2) A.B.C.D.E. He states, "The antennae of the male allotype of *P. utahensis* is 10-jointed. The scape is only slightly more dilated than in typical species of the genus. The flagellum tapers from base to apex and the club is hardly differentiated from the funicle although joints 9 and 10 are more or less anchylosed and probably represent the club. If so, the funicle is 3-jointed as in typical *Pleurotropis*. There are three distinct, though minute, ring joints."

Other morphological structures are shown as follows:

Fig. 2. E.F. Front and Rear Wings

Fig. 3. Female *P. utahensis*

Fig. 4. A. Male *P. utahensis*

B. Scutellum, metasternum and propodeum of male *P. utahensis*

Fig. 5. A. Abdomen of female *P. utahensis*

B. Plates of female ovipositor

C. Abdomen of male _P. utahensis_

D. Male genitalia of _P. utahensis_

HOSTS. _Pleurotropis utahensis_ has two known hosts. Crawford (4) states the holotype female was reared from _Agromyza parvicornis_ (Loew); the allotype male and four males and one female paratopotype from _Cephus_ sp. Gahan says (10) that the latter was subsequently determined as _Cephus cinctus_ Nort. The data presented in this report are on _Pleurotropis utahensis_ Cwfd. from its host _Cephus cinctus_ Nort. It has been reared from this host from the following plants: _Bromus inermis_ Leyss, _Agropyron smithii_ Rydb., _Agropyron pauciflorum_ (Schwein), _Phleum pratense_ (L), _Stipa viridula_ Trin., _Secale cereale_ L. and fall rye. Criddle (6) says that _P. utahensis_ was common in grasses in the province of Manitoba, but not in wheat. He does not name these grasses but a review of his original notes during the summer of 1946 showed these grasses to be _Bromus inermis_ Leyss, _Agropyron tenerun_ Vassey, _Agropyron richardsoni_ Schrad., and _Elymus canadensis_ L. It has also been reared from sawfly in _Triticum vulgare_ varieties of Garnet, Thatcher, Red Bobs, Marquis and a new sawfly resistant wheat "Rescue".

Many of the parasites from the wheat varieties were reared from sawfly cut wheat stubs (see Fig. 6) collected at Scott, Saskatchewan from the uniform wheat sawfly nurseries of the Dominion Experimental Farm, Swift Current, Saskatchewan and the Dominion Entomological Laboratory at Lethbridge, Alberta.

ECONOMIC IMPORTANCE. P. utahensis is important in the control of sawfly in grasses, but its ability to reduce the numbers of sawfly in wheat is very limited. Ainslie (9) reported it attacking sawfly in Bromus and timothy in Bottineau county, North Dakota to the extent of destroying more than 50% of the larvae. Criddle (6), in Manitoba, found it common in grasses, but again not in wheat. At Pearce, Nobleford and Orton, Alberta in 1939, parasitism was from 50%-70% in roadside stands of the grasses Bromus inermis, Agropyron smithii, and Agropyron pauciflorum, but in adjoining wheat fields, which were from 75%-90% infested with sawfly, there was not more than 1%-2% parasitism.

In 1946 at Pearce, Alberta an 80% sawfly infestation in the Agropyron smithii was parasitized slightly over 50%, while a similar sawfly infestation in wheat which was from 1-10 feet away, was parasitized less than 2%.

At Champion, Alberta in 1946 in Bromus inermis and Agropyron smithii which was approximately 95% infested with sawfly, the parasitism was 75%. Again in adjoining wheat with a similar sawfly infestation, parasitism was less than 2%. Other similar observations have been made at numerous locations throughout Alberta and Saskatchewan, all of which support the evidence of higher parasitism in grasses than in wheat.

In areas where the sawfly population is very low and largely confined to the native grasses P. utahensis may play an important part in keeping the sawfly under control. This is particularly true of the areas where native grasses grow well, but in many of the sawfly infested areas of Western Canada the grasses in headlands and road allowances do not reach a growth sufficient to support an infestation of sawfly, and consequently there are few, if any, parasites present in these areas. Possible reasons for this preference of host plant by P. utahensis are discussed later. In view of this host preference by the parasite it is doubtful if it has much economic value at the present time. With the introduction of the sawfly resistant wheat "Rescue" in 1946, it is hoped that sawfly will eventually be largely eliminated from the wheat fields. If this occurs, then the control of the remaining sawfly by P. utahensis and other parasites in grasses will be much more significant than it now appears under present conditions of severe sawfly infestation.

OVIPOSITION. The female P. utahensis in selecting the place on the plant to oviposit, first travels rapidly up and down the stem, then finally returns to one of the internodes. Having selected the internode, she again travels back and forth within a length of 1/4 - 1/2 inch with her antennae held rigidly against the stem. Upon satisfying herself of the proper place for oviposition she inserts her ovipositor with apparent ease and deposits the egg or eggs. The exact number of eggs deposited at a single oviposition is not known.

During the act of oviposition, which may occur with the parasite resting either with the head up or down, the female raises herself on her pro-legs and lowers herself on her meso and metathoracic legs. She holds herself in place by grasping the veins of the stem and thus established, the abdomen is tipped under, the ovipositor inserted and the egg deposited. The length of time for oviposition is usually less than one minute; the ovipositor is then withdrawn and she moves to another stem where the act may either be repeated within a few seconds or not until considerably later.

EGGS. The egg, Fig.(7) A, is elongate, kidney-shaped and tapered at one end. The length varies between .12 mm. and .18 mm., with a mean length of .16 mm. The width varies between .03 mm. and .06 mm. The difference between the blunt and tapered end of the egg is not over .01 mm.

Eggs of P. utahensis are laid not only in first, second and third instar larvae but also in sawfly eggs. The fact that the parasite eggs are sometimes deposited in the host eggs is believed to be more of an accident than a regular occurrence, for out of several hundred dissected sawfly eggs only one was ever found to contain P. utahensis eggs. In this case only one egg was present. The sawfly egg appeared normal in every respect, with the embryo well developed. It cannot be stated whether or not such a parasite would develop to maturity.

In the host larvae the eggs are deposited in the fatty tissue, and always with their long axis parallel to the long axis of the sawfly larvae. The first and second instar sawfly larvae are more heavily parasitized than are those of third instar. The time required for hatching of the Pleurotropis eggs is not greater than 4-5 days as P. utahensis larvae have been dissected from first instar sawfly larvae. Sawfly larvae remain in the first instar only 2 to 5 days.

The reproductive potential of a single female P. utahensis is not known. As many as 30 eggs were dissected from a female, reared from stubs, collected in the field 25 June, 1946 at Cayley, Alberta. This female was taken from a cage 11 July, 1946 and dissected, but at this date the flight had been under way for approximately 7 to 10 days in the cage, so it is very probable that some eggs had already been laid.

An experiment designed to ascertain the length of the preoviposition period was conducted in 1946. Pupae of P. utahensis were collected in the field, brought into the laboratory and reared individually in glass shell vials.

As these pupae turned to adults the females were kept in these vials without food, and then preserved in Hood's solution at 2, 4, 6, 8, 10 and 12 day intervals after emergence. At a later date these females were dissected and carefully examined for any egg development. No egg development had occurred in any of the above females. Females, after having been kept at various temperatures for 21 days--also without food--(Table 1) showed no egg development.

This lack of egg development may be linked with feeding habits or environmental conditions such as suggested by Flanders (12) and which causes an absorption of ovarian follicles and egg disintegration. The developing oocytes can be readily dissected from females recovered in the field. Unfortunately the above experiment was not duplicated with females that had been caged over grasses for known periods, as it can now be seen that this would probably provide the answer to the pre-oviposition period and the role of food in egg development.

Whether or not polyembryony occurs is not known. Eggs have been dissected from host eggs, first, second and third instar larvae. In the hundreds of host eggs examined only in one instance was the host egg parasitized, and only one egg of *P. utahensis* was present, so whether or not the parasite is able to mature in such cases is still not known. On the other hand in first, second and third instar parasitized larvae, there has always been more than one parasite egg. However, there is often only one parasite pupa present in a cut stub. Ref. Table (2). Under caged conditions of extremely large numbers of parasites in relation to the number of sawfly larvae present as many as fifteen eggs have been dissected from two first instar sawfly larvae. The usual number of eggs present varies between five and nine. This number closely corresponds to the number of pupae Table (2) found in "stubs", but this in itself is no indication that twinning and monembryonic development does not occur. Leiby and Hill (13).

LARVAE. The larva, Fig. (7) B, of P. utahensis develops within the host sawfly larva and upon killing it the parasite larva emerges into the host hibernaculum where it spends the winter. Fig. (8) C. From Fig. (11) can be seen the relationship between host and parasite development. Under magnification the mature larva may be seen to have well developed and chitinized mandibles. Fig. (7) C, shows a frontal view of the head of a mature larva, with the mandibles readily discernible and Fig. (7) D, is an enlargement of a mandible from a mature larva.

First instar parasite larvae are found in first, second and third instar host larvae. On 1 July, 1946 parasite eggs were dissected from first instar sawfly larvae. On 1 Aug. 1946, and the parasite flight lasted for another 5 to 6 days, Pleurotropis eggs were dissected from first, second and third instar sawfly larvae. Thus it may readily be seen that first instar parasite larvae may be present in the various instars of host larvae between 3-4 July and as late as 15 Aug. All of the parasite larvae complete their development within the host and migrate through its skin by means of tiny punctures into the lumen of the stem. This sometimes occurs before the sawfly larva has cut the plant and has been observed to have taken place as early as 9 September. The majority of the larvae do not usually complete their development this soon. As a rule they kill the host and migrate through the skin into the stem lumen after the sawfly larva has cut the stem, lined and plugged the "stub". In either case the developing parasites feed on the host tissue, completely devouring everything except the larval skin, head capsule and mouth parts. Having escaped from the host larva the P. utahensis larva overwinters within the "stub" in the cocoon which was made by the sawfly larva. The parasite is afforded protection below the ground surface level throughout the winter.

PUPAE. Pre-pupal and pupal development occurs in the "stub", Fig. (8) C, and Fig. (10) A and B. This begins with rising spring temperatures. Pupation usually starts during the last two weeks of April, but some individuals may be found pupating as late as the last week of June,

(Fig. 11). Just prior to pupation the gut is emptied and the faeces appear as a series of round, brown pellets, which are often joined together.

When pupation first occurs the pupae are entirely creamy in color and appear as in Fig. (8) B. Pigmentation usually begins the same day that pupation takes place, color first appearing in the eyes, then the petiole, coxal areas, and later extending to the remainder of the body until the entire pupa is an opaque, blackish brown. They remain this color for from 2-8 days, then turn a shiny, metallic black. Fig. (8) A, is a drawing of this stage. Fig. (10) A and B are photographs of the pupae within cut stubs of <u>Agropyron smithii</u>. A is normal size and B an enlargement. Fig. (9) A and B are both photographic enlargements of the same stage of pupal development. Once this shiny metallic stage is reached they transform into adults in 3-10 days. (See Table 5).

All pupae within a single stub do not mature simultaneously. Those which are nearest the soil surface, do not necessarily mature first as one might expect. For example, in a stub of <u>Agropyron smithii</u> from top to bottom the following were found; 2 adults, 1 pupa, 1 adult, 1 pupa. In other stubs both colored and uncolored pupae are found, and there seems to be no relation between their stage of development and their location one to another within the stub.

As the pupal development is completed and the adult is ready for emergence, the pupal skin is split ventrally and slips dorsally over the head and thorax. These pupal skins often retain their shape for several days and may be found in a stub from which the parasites have emerged.

ADULTS.

Method of Escape from stub

The adult *P. utahensis* escapes from the stub usually by chewing a circular tunnel through the "frass" plug, Fig. (6), which seals the end of the stub. Occasionally it escapes by chewing a new circular hole in the side of the stub. The same two methods of emergence are used by sawfly adults and another of its parasites, *Microbracon cephi* (Gahan). The size of this emergence hole is usually indicative of which of the three insects has emerged. The hole made by *P. utahensis* is the smallest of the three and that made by *Cephus cinctus* the largest of the emergence holes.

The adult *P. utahensis* are apparently mature for a time before they emerge from the stub, for if a portion of the stub wall is cut away they can readily be seen with their wings folded in a resting position. They may also be observed moving back and forth within the lumen of the stub. If the stub is completely opened the apparently mature adults immediately hop or fly away.

COURTSHIP AND MATING. In caged *Bromus* in the laboratory, female and male *Pleurotropis* which had been reared individually were liberated simultaneously. Shortly after their release there began a period of "courtship". During this period the male approaches the female which may be either walking or stationary and who has her wings folded flat on her back in the normal position. He seizes her dorsally with his prothoracic legs on her thorax, and his meso and metathoracic legs rest on the stem or leaf. He is at right angles to the female. His wings are held almost vertical to his thorax and are in constant motion or "flutter" during this procedure. Often two males may approach the same female on opposite sides, and each begin the procedure, but one of the two leaves within one or two seconds. The female sometimes remains quiet during this "courtship" but more often she moves her abdomen in a horizontal or vertical plane and appears to be cleaning herself with her meso and meta-thoracic legs. This courtship may or may not end with the mating act. If it does not the male releases the female and they both move away, and either one or both may go through the same procedure with another individual. If the courtship terminates with the mating act, the male, still maintaining his grip on the female thorax with his prolegs, turns until he is almost parallel with the female, then twists the tip of his abdomen under the female and mating occurs. Usually this whole procedure is completed in from one to four seconds and upon completion the female is released and moves as she pleases.

PARTHENOGENESIS. During the summer of 1946 an experiment was started to determine whether or not *P. utahensis* was parthenogenic. Clumps of brome grass, *Bromus inermis*, were brought from the field to the laboratory and potted in 8" clay flower pots. Simultaneously *P. utahensis* pupae were brought from the field and reared in individual vials.

When the brome grass came into bloom it was covered with circular cotton cages, 8 inches in diameter and 16 inches high, with a glass front 4 inches wide and the height of the cage.

On 27 June, 1946 male and female *C. cinctus* were brought from the field and released in all four of the cages in sufficient numbers to insure infestation of all suitable stems of brome grass in each cage. At the same time, *P. utahensis*, both male and female, from the individually reared pupae, were also placed in two of the cages. In the other two cages only female *P. utahensis* were released with the sawfly.

On 18 July 1946 the brome stems from the cages which had contained both male and female *P. utahensis* were split and the sawfly larvae examined. Upon dissection these sawfly larvae were found to contain larvae of the parasite.

On 31 July 1946 the four sawfly larvae, now third instar, from the two cages into which had been placed the sawfly and the female parasites, were dissected. None of these sawfly larvae were parasitized.

From the above it is concluded that it is very unlikely that parthenogenesis occurs in P. utahensis.

REACTION TO TEMPERATURE AND MOISTURE. Under field conditions periods of rainfall and accompanying lower temperatures reduced the activity of P. utahensis. On 23 June 1946 at Champion, Alberta the day was hot and bright and adult P. utahensis could readily be seen moving amongst the stems of the Bromus and Agropyron. Late that afternoon and night .95 inches of rain fell over the area. The following afternoon the sun was again out and the grasses had dried considerably, but between the hours of 2 to 5 p.m. no adults could be seen moving in the grass and it was only after considerable sweeping with a 14 inch net that any were recovered. On 25 June the location was again visited during the afternoon. The sun had been out all day and there was little moisture on the grass. Adults were again active and as numerous as they had been before the rain.

In order to determine the probable effect of prolonged cold or prolonged periods of high temperature and humidity that might occur on adults in the field, the following experiment was designed. In the laboratory pupae were reared individually in shell vials to adults and then the adults placed in a cabinet with a constant temperature of 10°C. and left there from 27 June, 1946 until 11 July, 1946. They were then divided into groups of twenty-one and placed in constant temperatures of 5°C., 10°C., 25°C. and 80% Relative Humidity, and 25°C., 90% Relative Humidity. Results are listed below in Table (1).

Table 1. Effects of Constant Temperatures on adult <u>P. utahensis</u>

Date of	5°C.		10°C.		25°C.-80%R.H.		25°C-90%R.H.	
Examining	alive	dead	alive	dead	alive	dead	alive	dead
27June46	all adults were placed in 10°C. cabinet 1-2 days after becoming adults.							
11July46	21	0	21	0	21	0	21	0
18July46	11	10	16	5	17	4	0	21
18July46	2dissected		2dissected		2dissected			
31July46	6	13	11	8	0	19		
14Aug.46	0	19	2	17				
6Sept46			1	18				
8Sept46			0	19				

The above results indicate that a constant temperature of 10°C. the length of adult life may be considerably longer than at lower or higher constant temperatures. For the majority of the adults, however, there was little difference in mortality rates between those at 5°C. and at

10°C. on 14 August or after a period of 48 days. At 25°C. and 80% Relative Humidity there was only a 19% mortality after 21 days as compared to 100% mortality at 25°C. and 90% Relative Humidity at the end of 21 days. While such constant temperatures are not present under field conditions, the results suggest that the length of the adult life of P. utahensis may vary considerably from year to year and from one locality to another in the same year, depending on the climatic conditions of the particular area.

The results of the dissections shown in the above table have already been discussed under Eggs.

FREEZING STUDIES. Larvae which were collected at Pearce, Alberta 11 April, 1946 from Agropyron smithii were subjected to low temperatures by Dr. R.W. Salt (23) at the author's request. As the larvae were too small to cause a rebound on a single thermocouple, the indirect method was used. The larvae were exposed to a series of low temperatures and were found to freeze at temperatures of -22.5°C., -23°C., -24°C., -25°C., -28.5°C. and -30°C. Larvae exposed to -21°C., and -22°C. remained unfrozen. The undercooling points, therefore, lie close to -22.5°C. and this can be considered the approximate lower lethal limit for these larvae collected at this time of the year. As it is possible that some development or change had

had taken place before this late collection date, April 11, further work must be done to ascertain whether or not this is the case. The above tends to confirm that freezing is not a big factor in mortality, even in those areas of chinook winds, where sudden warmth, then freezing, often occur in spring.

HOST PLANT STUDIES. Between the years 1935-1946 inclusive, various collections of sawfly-cut stubs of spring wheat and the grasses, *Bromus inermis*, *Agropyron smithii* and *Agropyron pauciflorum* have been made to determine the number of *P. utahensis* which mature from a single sawfly larvae in one stub. It might be well to again point out that regardless of the number of sawfly eggs that are deposited in any one stem, only one sawfly larva will mature in that stem. The remainder of the eggs or young larvae either die naturally or are destroyed by cannibalism, within the stem. Hence any *Pleurotropis* that occur in a "stub" mature from one sawfly larva. The majority of these collections have been made in Alberta from as far north as Huxley, east to Provost and south to Orton (8 miles south of Macleod). In Saskatchewan the bulk of the collections have been from material grown at the Dominion Experimental Farms at Scott and Swift Current. All collections have included both larvae and pupae. Results of this study are listed in Table (2).

Table 2. Comparison of Numbers of <u>P. utahensis</u> Developing in sawfly From Different Host Plants.

Host Plant	Stubs Examined	Minimum of P. utahensis per stub	Maximum of P. utahensis per stub	Mean Number of P. utahensis per stub
A. smithii	51	1	12	5.54
A. pauci-florum	49	1	9	4.32
B. inermis	65	1	7	3.98
Spring Wheat	16	1	7	3.00

While the numbers of stubs examined from the various host plants are not large it is felt that they are sufficient to be representative of the host plants concerned. (The one exception to this is the wheat sample and this is because of the scarcity of parasites in sawfly in wheat.) In addition to those stubs examined and recorded in the above table for the three grasses, several hundred others have been examined during other phases of the study and the numbers of <u>Pleurotropis</u> present closely follow the figures as given in Table (2).

The one very noticeable fact from examination of Table (2) is the presence of the higher mean number of <u>Pleurotropis</u> in the native <u>Agropyron</u> grasses and particularly <u>Agropyron smithii</u>, which is the more common variety in the sawfly infested areas.

Ainslie (9) records a maximum number of 12 _P. utahensis_ per stub in grasses in Utah near Salt Lake City, but he says that 5-6 is the more common number.

FLIGHT. Both male and female _Pleurotropis utahensis_ are positively phototropic. They are rather weak fliers, and flight never seems to be prolonged, but is usually from one stem to another of very close proximity. They move by flight, short flea-like hops, and by crawling or walking.

When male and female _Pleurotropis_ are caged over _Bromus_ with male and female sawfly there is no antagonism between the two species. Both seem to pursue their normal activity and habits without apparent notice of the other. If a sawfly, in the course of traversing the length of a stem should encounter a _Pleurotropis_, the parasite either crawls further along the stem or moves to another stem. If the parasite retains its position, then the sawfly invariably turns about or moves to another stem.

The period of flight of _P. utahensis_ in southern Alberta usually begins during the first week of June and lasts until about the first week of August. See Fig.11. This period of flight represents the maximum observed in this area. Undoubtedly there will be some variation in the flight period as a result of varying soil types and climatic factors.

The peak of the flight usually occurs between 10-25 July. The peak of the sawfly flight from wheat according to Manson (8) at Drumheller, Alberta, and corroborated by Farstad (23) is usually the last days of June and the first few days of July. It is the author's observation that the parasite flight is only 7-12 days later than the peak of the sawfly flight from native grasses, but at least two weeks later than the peak of the sawfly flight from wheat. Thus the peak of the flight of P. utahensis would be at a time when the larvae of C. cinctus in wheat are chiefly in the second, third and fourth instar, and in the native grasses chiefly first and second instar.

REARING STUDIES. During 1938 seasonal history studies were undertaken to determine the length of the developmental stages. As the larvae are entirely enclosed within a "stub" similar to that shown in Fig. 6, which may be entirely below ground or slightly above the soil surface, it was impossible to check the development of individuals under field conditions. Consequently it was necessary to rear the P. utahensis under artificial laboratory conditions.

Just prior to the ground freezing in the fall of 1938 a collection of "stubs" of Bromus was made at Orton, Alberta and brought into the laboratory where they were stored at 6°C. This was done to simulate field conditions during the winter. On January 12, 1939 these stubs were split and the larvae of P. utahensis obtained. The larvae were isolated and reared individually in shell vials 1/8 inch in diameter and 1 inch long. The vials were stoppered with a loose cellulose plug and placed in a constant temperature cabinet at 25°C. and 80% Relative Humidity. This temperature was selected because of the temperature range available, it more nearly approached field temperatures during the late larval and pupal period. It was believed that this might serve as a lead for future rearing work. Results are shown in Table 3.

On March 22, 1939 another collection of Bromus stubs was made at Orton, Alberta, and the P. utahensis larvae isolated and reared in similar vials to those used previously. This series was reared at a constant temperature of 55.4° Fahrenheit. By so changing the rearing temperature it was hoped that the reaction to different temperatures would be noted, as it was felt that development periods would not be the same under the varying soil types and temperatures as found throughout the area of distribution. The mean temperature the day of the collection of the stubs as recorded at Lethbridge (20 miles from the collection point) was 54.7° Fahrenheit. The mean maximum temperatures for March, April and May, 1939 were 41.5° Fahrenheit, 57.8° Fahrenheit, and 67.2° Fahrenheit. The mean minimum temperatures for the same months were 16.2° Fahrenheit, 30.4° Fahrenheit and 42° Fahrenheit, respectfully. These results are also shown in Table 3.

Table 3. Period of Development of *P. utahensis* taken from *Bromus inermis* when reared at Constant Temperatures.

	55.4°F.		77°F. &80% Rel.Humidity	
#larvae used	60		20	
#larvae that pupated	47		15	
	Mean	Range	Mean	Range
# days as larva	17.5	16-32	18.5	15-35
# days as pupa	20.2	16-23	13.1	12-15

Two similar laboratory experiments were carried out during the spring of 1946, one with *P. utahensis* larvae from *Agropyron smithii*, and the other with the larvae from *Agropyron pauciflorum*. Those from *Agropyron pauciflorum* were collected at Cayley, Alberta on 26 March, 1946 and placed in the 77° Fahrenheit and 80% Relative Humidity cabinet on 28 March, 1946. Those from *Agropyron smithii* were collected at Pearce, Alberta on 14 March, 1946 and placed in the 77° Fahrenheit and 80% Relative Humidity cabinet the following day. In both cases they were reared individually in shell vials as previously described. Results of these rearings are shown in Table 4.

Table 4. Period of Development of P. utahensis from Different Host Plants at a Constant Temperature of 77° Fahrenheit and 80% Relative Humidity, 1946.

Host Plant	Agropyron smithii		Agropyron pauciflorum	
#individuals in experiment	36		46	
	Mean	Range	Mean	Range
Number per stem	3.9	1-7	3.4	1-9
Days in larval stage	12.6	11-19	12.8	11-13
Pigmentation period	3.0	-	2.9	-
♀ days in black pupal stage	9.1	4-16	5.4	3-10
♂ days in black pupal stage	8.0	4-14	6.3	3-15

From Table 4 it seems that there is little difference in the length of time required to complete larval development, or the pigmentation period. However, the number of days required to complete development in the black pupal stage, by both male and female, averages 2-3 days less in the Agropyron pauciflorum. The reason for this difference in developmental time is not understood.

SEX RATIO. The sex of the adult P. utahensis from the rearing experiments was recorded and is shown in Table 5. It is realized that the data is inadequate due to small numbers of individuals recorded, but as there were differences in the sex ratio from different host plants the data is presented.

Table 5. Sex Ratio of P. utahensis from Different Host Plants when reared at Constant Temperatures.

Host Plant of C. cinctus from which P. utahensis was reared.	Females	Males	Ratio ♀/♂
Bromus inermis	32	14	2.28
Bromus inermis*	9	5	1.8
Agropyron smithii	29	7	4.14
Agropyron pauciflorum	36	10	3.10

* Reared at a constant temperature of 55.4°Fahrenheit. All others were reared at 77°Fahrenheit and 80% Relative Humidity.

In any single stub which contained more than one P. utahensis, the sex of the reared adults were (a) all female (b) both male and female. In no instance were only males recorded from a single stub.

DISCUSSION OF POSSIBLE REASONS FOR LOW PARASITISM OF SAWFLY IN WHEAT. There is, as previously mentioned, a decided preference by Pleurotropis utahensis Cwfd. to parasitize sawfly in grasses rather than in wheat varieties commonly grown in western Canada. The exact nature of this host preference is not known. In the light of many observations made during this study the theories formed regarding this host preference are as follows. The growth habit of the wheat plant should not prevent the parasite from readily attacking the sawfly larvae in the wheat. The stem of the wheat plant is usually as soft as that of the grasses, so it could be easily penetrated by the ovipositor. The ovipositor is also of sufficient length to penetrate the wall of the wheat stem and as the parasite has access to all sides of the stem it should be able to parasitize the sawfly larva. From Fig. 11 it will be noticed that there is sufficient overlap of egg and larva instars of sawfly from wheat that host availability at any given stage of development in wheat is not a likely factor. This then eliminates lack of a suitable host, inability by the parasite to penetrate the wheat plant with the ovipositor to deposit eggs.

It is the author's opinion that the cause is very closely linked with a combination of method of movement, temperature and humidity requirements of adult parasites and food requirements. The primary method of movement is by hops rather than sustained flight and parasites emerging from grasses are more apt to stay in these grasses rather than move to adjacent wheat fields. *Pleurotropis utahensis* occurs in greatest abundance in heavy or thick stands of native grasses, especially when these stands are in barrow pits or depressions where water accumulates occasionally. Such stands provide a very humid atmosphere and stems in close proximity, both of which favor increased parasitism. From the results obtained during the pre-oviposition studies as discussed under Eggs, it is possible that feeding on the grasses is essential to complete egg development. If this is the case then the combination of feeding habits and method of flight or movement play the most important role in determining host selection.

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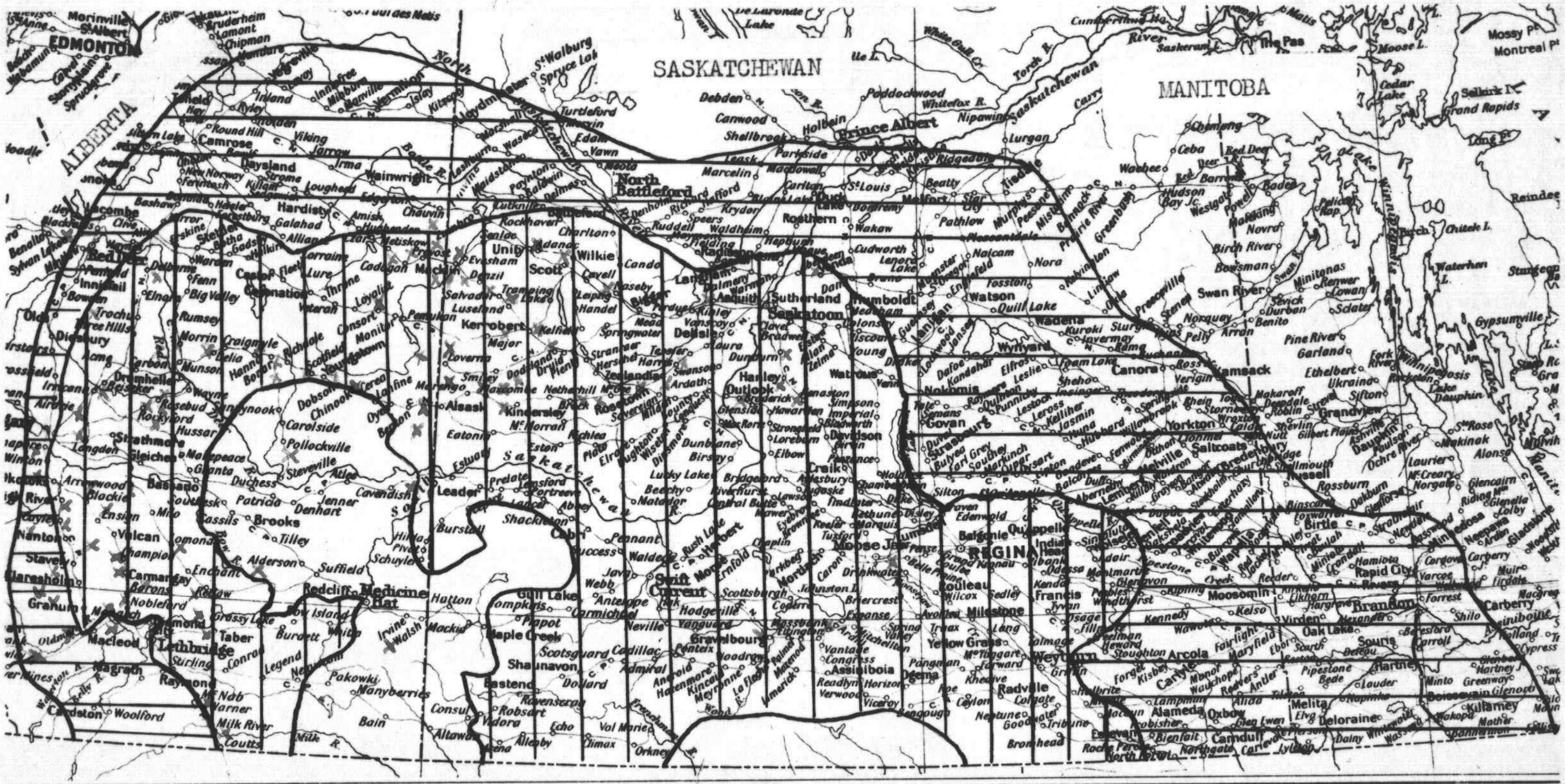


Fig. 1 Map showing distribution of P. utahensis in relation to C. cinctus

(vertical hatching)	Severe infestation. Generally severe during past ten years
(horizontal hatching)	Moderate infestation. May build up to severe during a series of dry years but cropping practice and parasitism contribute to keeping pest under control.
(blank)	Light Infestation. Sub-marginal land, rolling topography, range land, with relatively small wheat acreage.
X.	Districts of known P. utahensis distribution

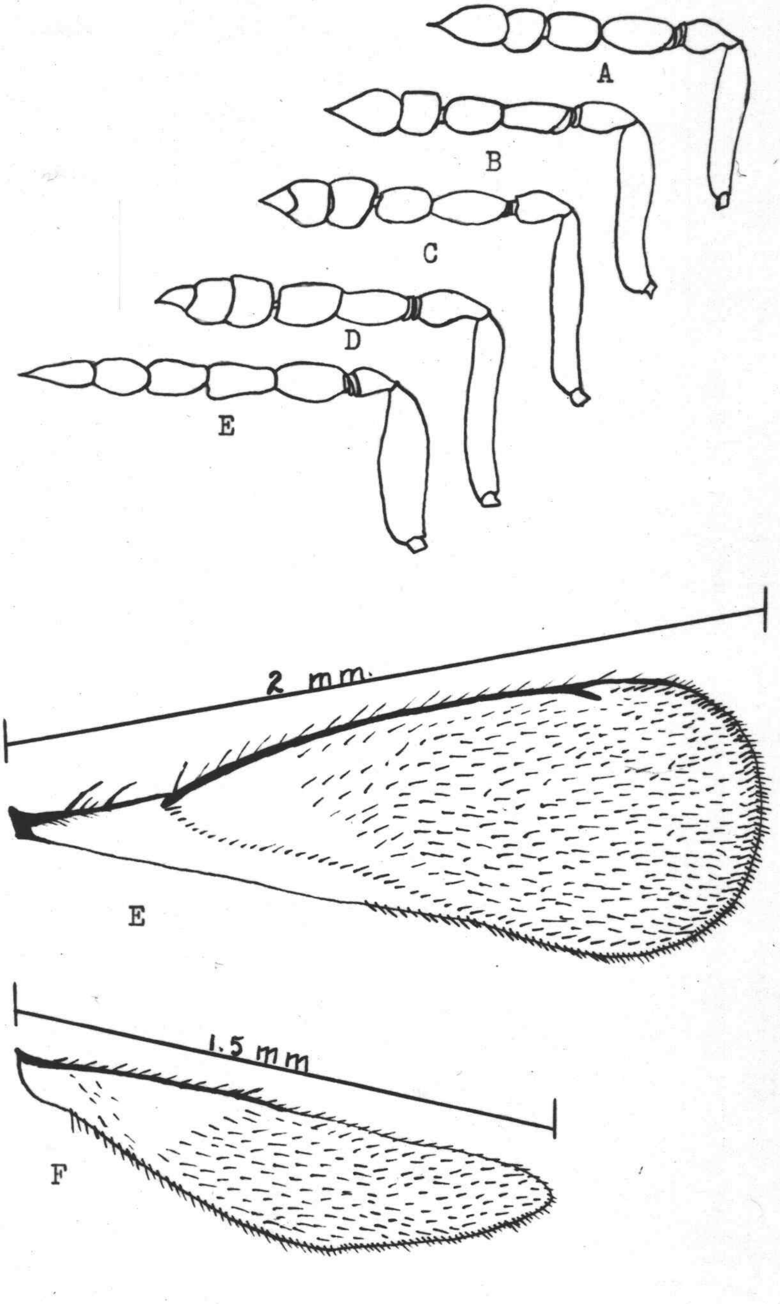


Fig. 2 Pleurotropis utahensis Cwfd. A,B,C,D, female antennae illustrating variations. (after Gahan).
E,F, - front and rear wings.

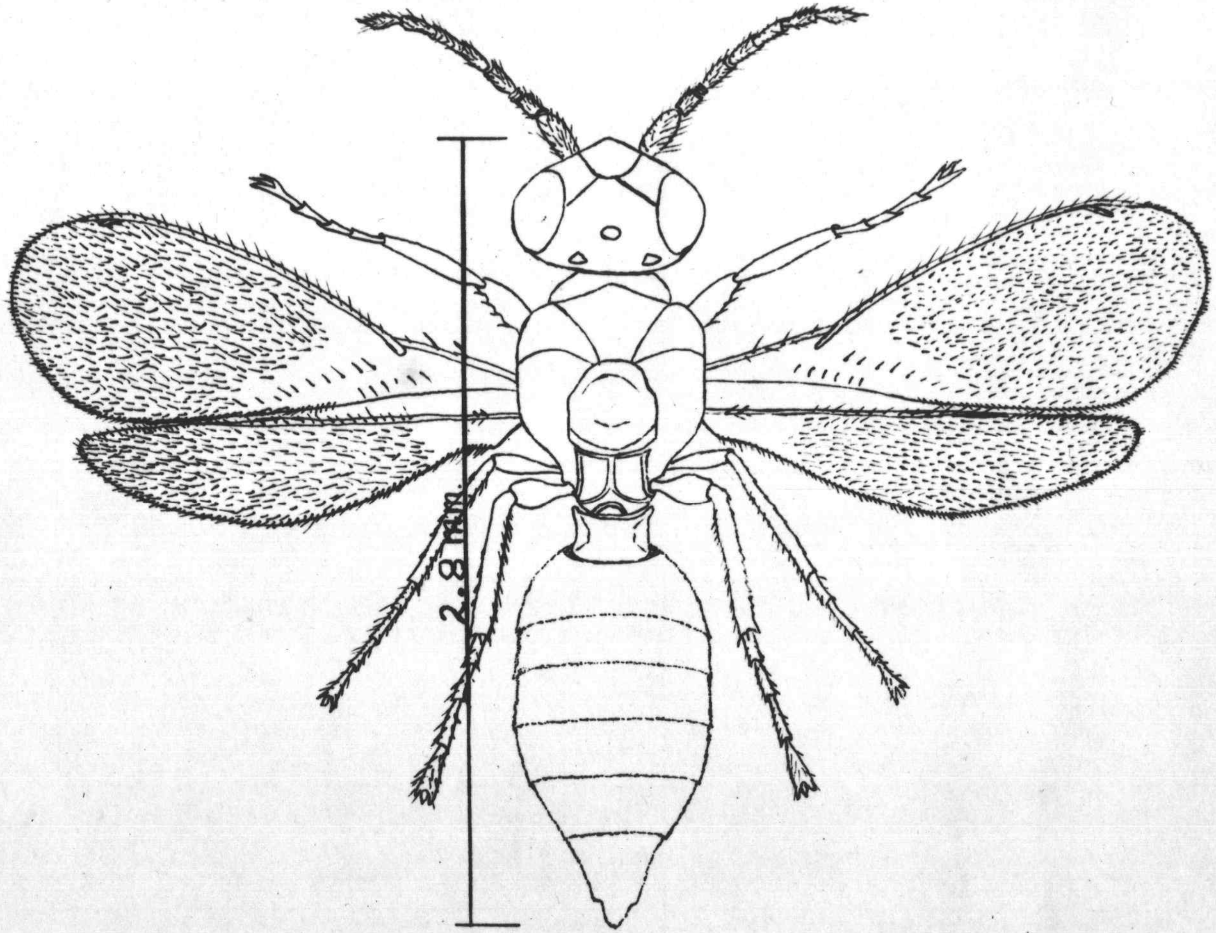


Fig.3 Pleurotropis utahensis Cwfd. Female

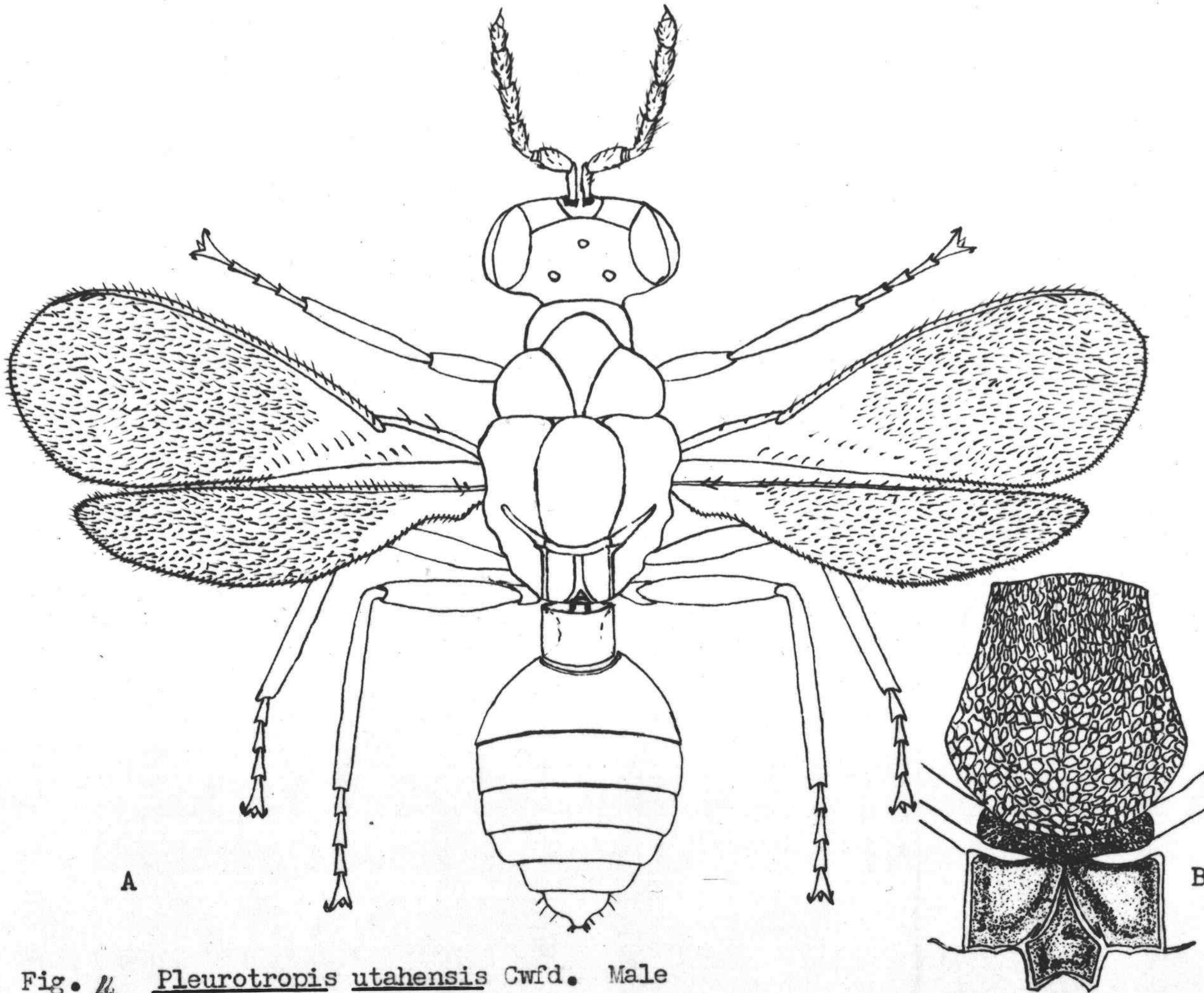


Fig. 4 *Pleurotropis utahensis* Cwfd. Male
B- scutellum, metasternum and propodaeum

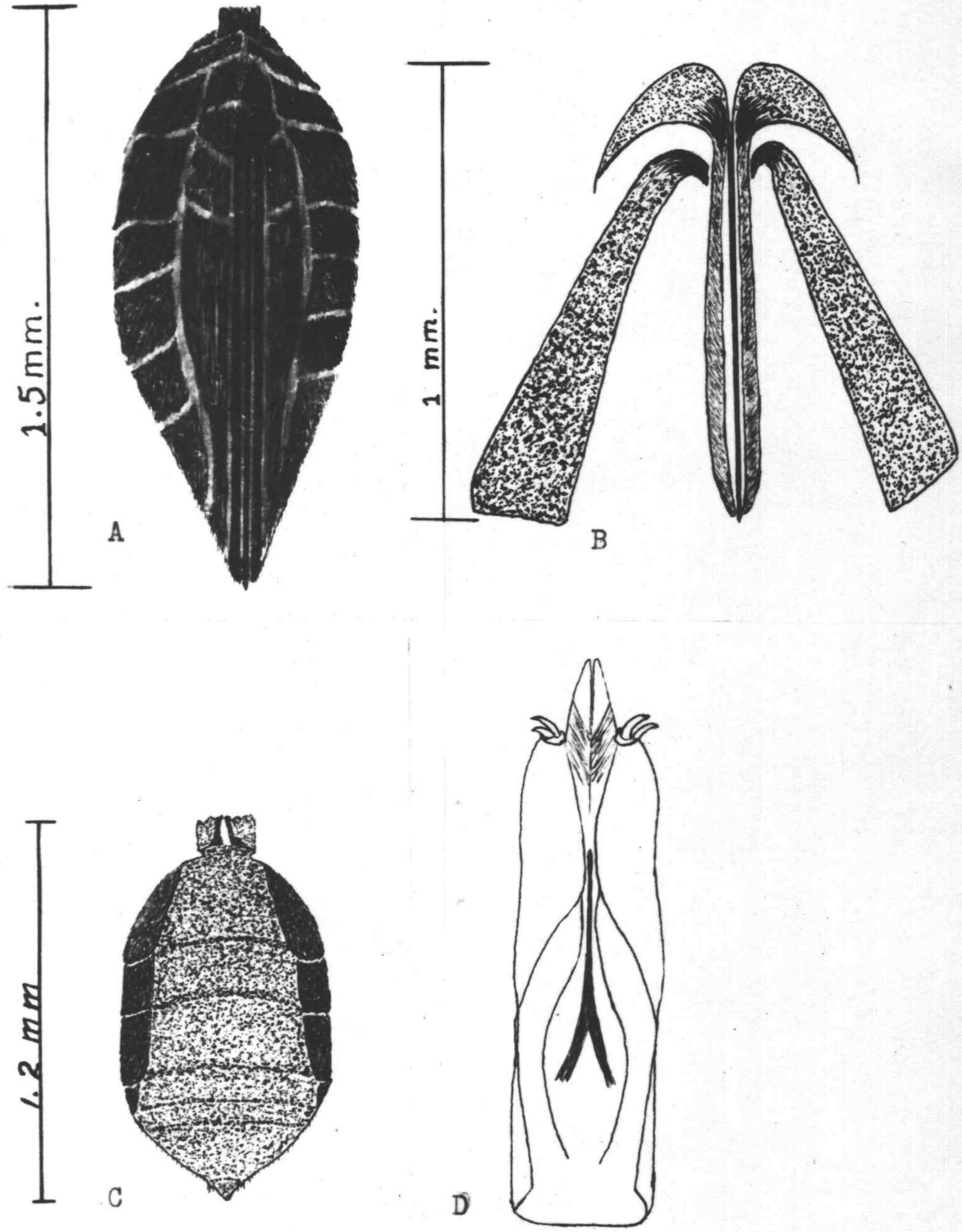


Fig. 5 Pleurotropis utahensis Cwfd. A- female abdomen, B- Plates of ovipositor, C- Male abdomen, D- Male genetalia.

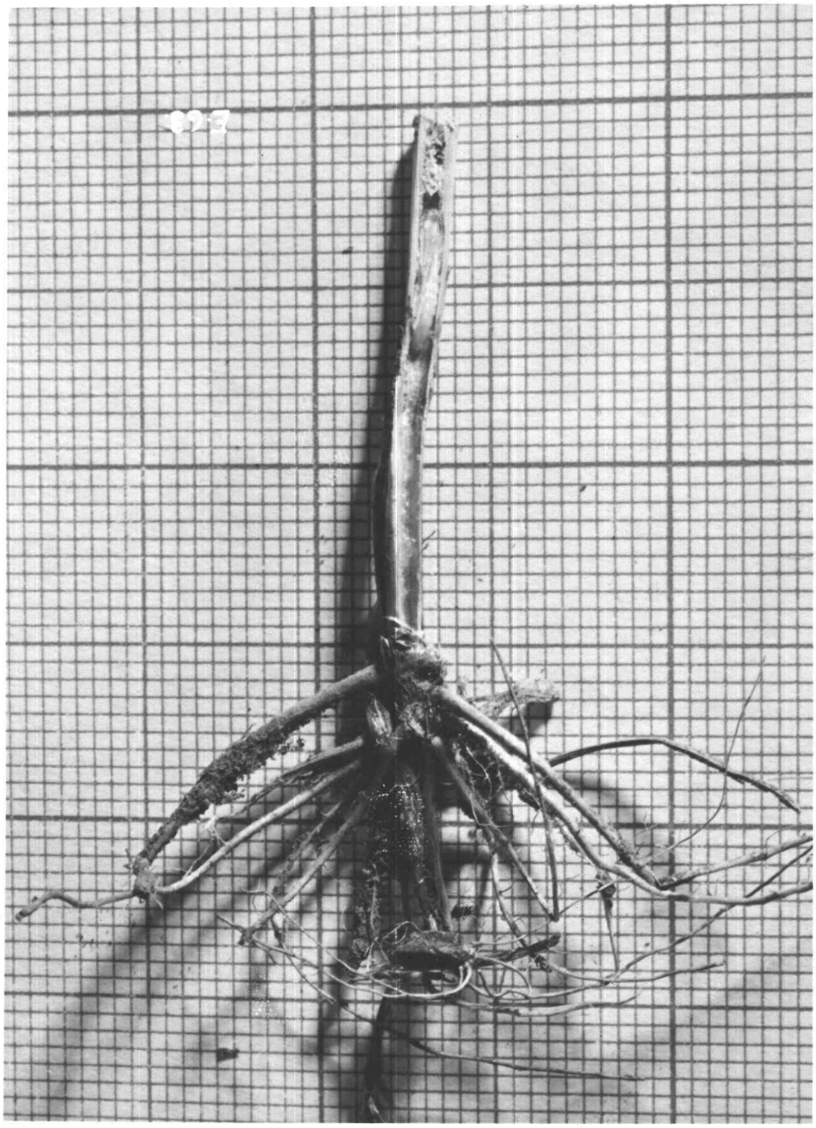


Fig. 6 C. cinctus Nort. pupa in a wheat "stub" . Note "frass" plug at top of stub.

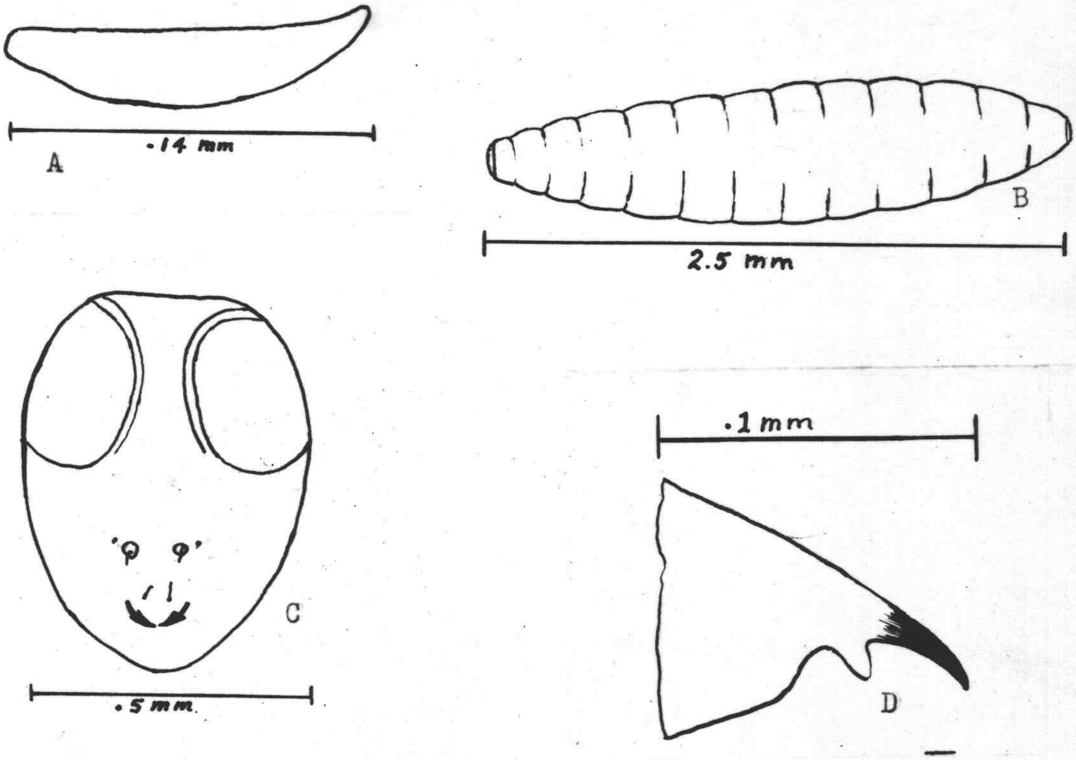


Fig. 7 Pleurotropis utahensis Cwfd. A- egg, B- mature larva, C-frontal view of larva head, D- larva mandible.

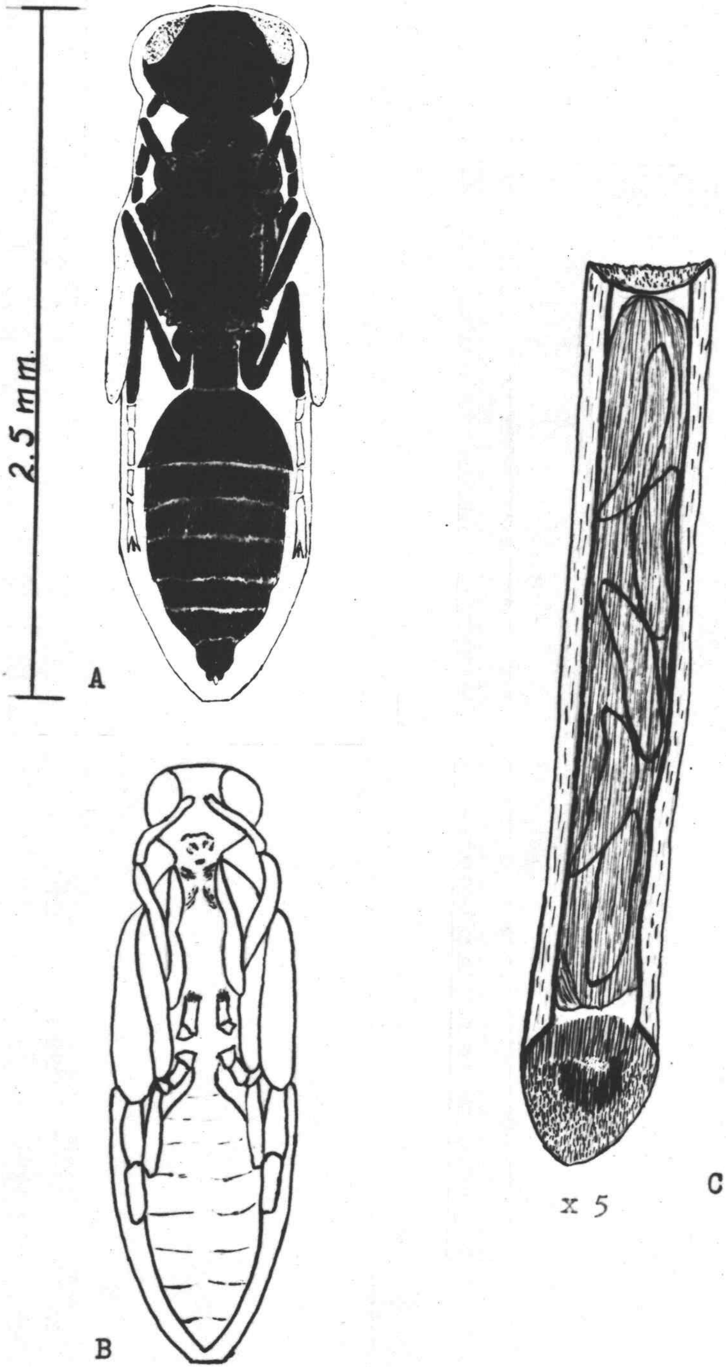
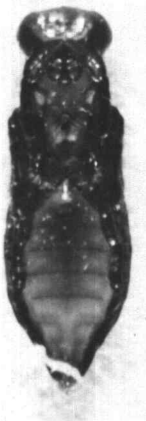


Fig. 8 Pleurotropis utahensis Cwfd. A- dorsal view of pupa. B- ventral view of pupa. C- larvae in cocoon of C. cinctus. Norton in stub of brome grass, Bromus inermus



A

B

Fig. 9 P. utahensis Cwfd. pupae
Enlarged ventral view.

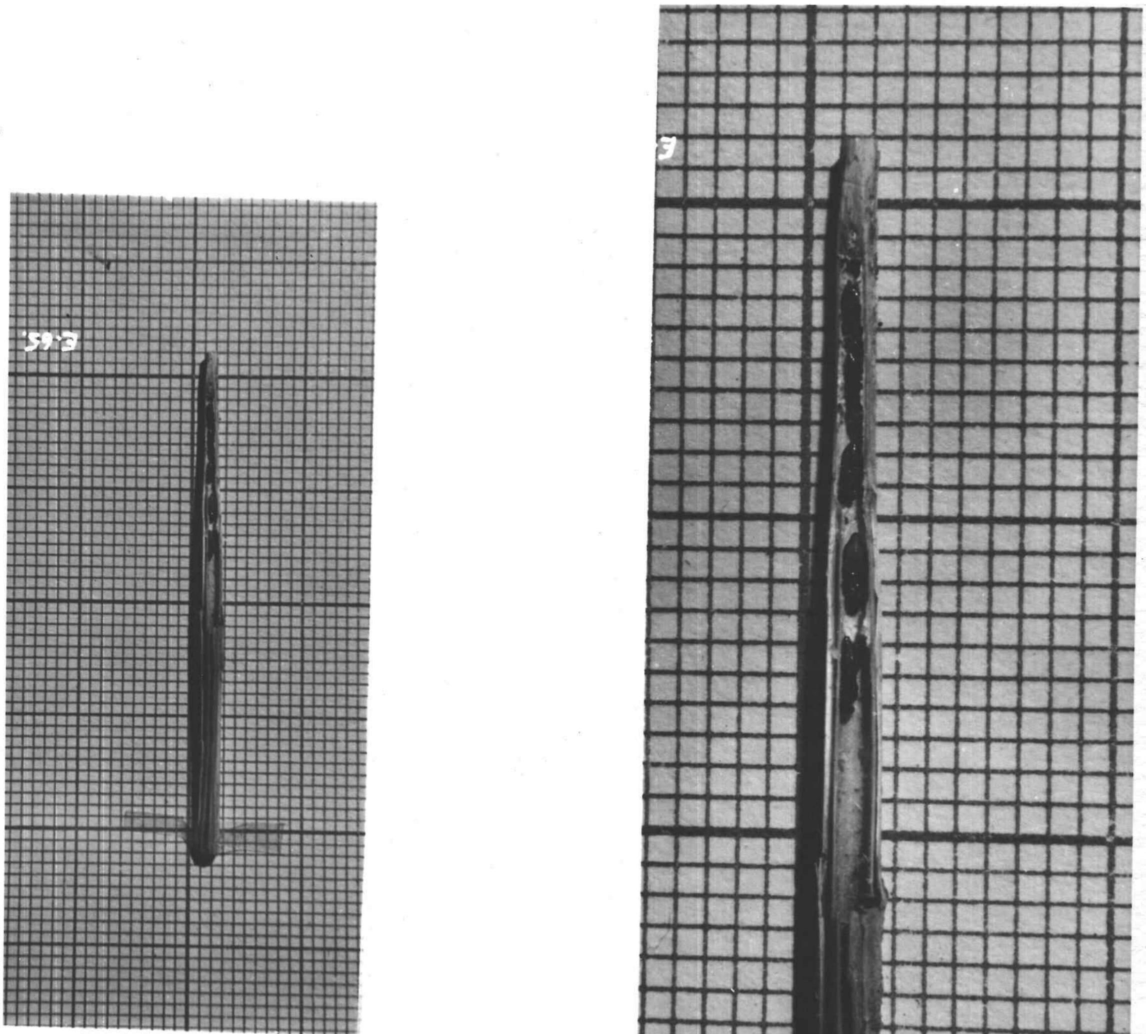


Fig. 10 P. *utahensis* Cwfd. pupae in a stub of A. *smithii*.

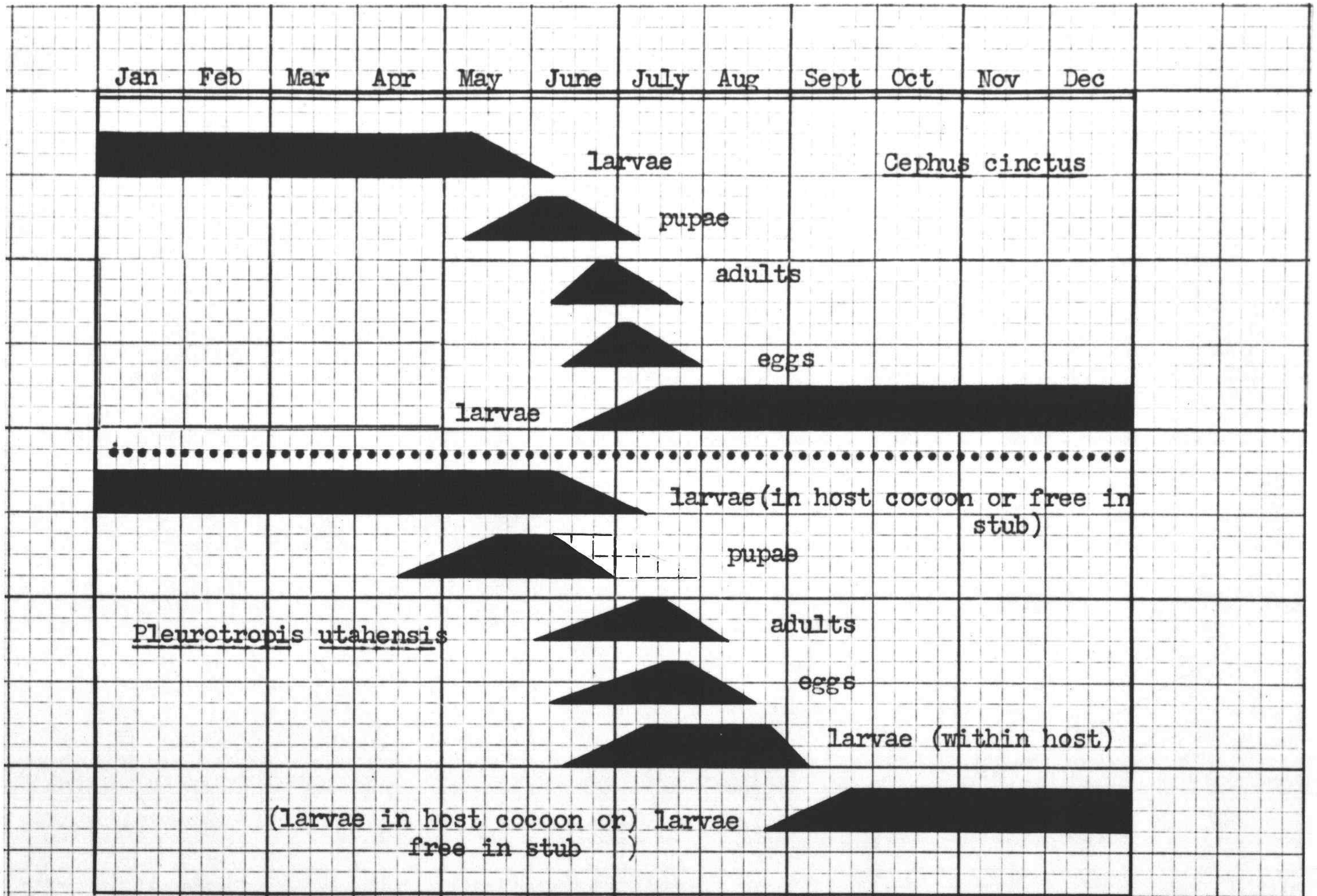


Fig. 11 Correlation of Life History of Pleurotropis utahensis Cwfd. with its Host *Cephus cinctus* Norton.