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Cover photo: Teasing apart the species complex of the nightmare taxon *Lasioglossum gemmatum* [Photo credit: Joel Gardner]

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OVIPOSITION BIAS BY *CULEX RESTUANS* THEOBALD IN MANITOBA, CANADA TOWARDS WATER USED BY HORSES (*EQUUS CABALLUS* L.) FOR DRINKING

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ABSTRACT

Culex mosquitoes in North America play important roles in the maintenance/enzootic transmission of arboviruses among animal hosts, as well as in epidemic transmission of these pathogens to humans. Arboviral disease outbreaks in human populations can be serious public health events that require response, often involving vector control. These responses are improved by early-warning information about the enzootic amplification of virus prior to human epidemics. *Culex restuans* is an ornithophilic species known to be commonly infected by avian alphaviruses and flaviviruses in much of North America and plays a significant part in increasing the infected-bird reservoir prior to spill over via bridge vectors such as *Culex tarsalis*, *Culex salinarius* and *Culex pipiens*. Thus, monitoring *Culex restuans* oviposition activity as a proxy for blood feeding and virus transmission may serve as an important form of early-season surveillance. Spring-time observations in Manitoba, Canada in 2014 of *Culex restuans* egg rafts in high numbers from horse troughs relative to other nearby mosquito larval sites (with *Ochlerotatus* spp. and *Culiseta inornata* present) led to experiments that demonstrate a bias in oviposition activity by *Culex restuans* to water in which horses frequently drink. The behavior is somewhat enigmatic given the blood-feeding preference of this mosquito species for bird hosts. Potential mechanisms underlying this bias are discussed.

INTRODUCTION

West Nile virus (WNV) has the potential to cause explosive epidemics of clinical disease in North America. It was first recognized in New York in 1999 and spread within a few years across the continent (Komar 2003; Anderson *et al.* 2015). Rapidly escalating epidemics, within a season, are especially common in western North America (Kramer *et al.* 2008; Anderson *et al.* 2015). *Culex pipiens* L. (Diptera: Culicidae) (eastern and central North America) and *Cx. tarsalis* Coquillett (central and western North America) are considered major epidemic vectors of WNV during the middle to late summer and early fall, whereas, *Cx. restuans* Theobald is thought to play an important role in early season amplification of the virus in areas of North America where these other species are common. The pre-condition for widespread infection of epidemic vector *Culex* spp. is significant infection of birds early in the season, likely caused by *Cx. restuans*, a widely-distributed, virus-amplifying vector species not caught in large numbers in adult mosquito traps (Johnson *et al.* 2015). The population and virus amplifying dynamics of *Cx. restuans* relative to late season population phenology of *Cx. pipiens* and *Cx. tarsalis* are

described by Kunkel *et al.* (2006) and Lampman *et al.* (2006) where the crossover date (the seasonal point at epidemic vector *Cx.* activity starts to exceed that of *Cx. restuans*) is demonstrated to be important in epidemic occurrence. These insights support the hypothesis that the biology of *Cx. restuans* as an enzootic, amplifying vector is a crucial component of seasonal risk for arboviruses in addition to the dynamics of epidemic vectors.

It is important to gain as much lead time as possible for planning and implementing vector control efforts directed at *Cx. tarsalis*, which is often not within the regular remit of many mosquito control programs in Canada and elsewhere because it is not a significant nuisance. Thus, it is useful to estimate early-season population trends and feeding activity of *Cx. restuans* as an amplifying vector, and thus, later risk of human disease, even if this species is not directly causal of human epidemics.

Small numbers of host-seeking *Cx. restuans* are collected in adult mosquito traps (Manitoba Health: Scott Derham, personal communication, 2018), but there is some question if this index is reliably indicative of the actual population dynamics of the species. *Culex restuans* do lay egg rafts in artificial containers, including tires (McMahon *et al.* 2008) and others, if there is some organic enrichment (Brust 1990). Considerable evidence suggests that organic enrichment alters the olfactory information available to gravid mosquitoes to discriminate between sites within their behavioural sphere of evaluation (Day 2016). Orientation toward aquatic sites for egg-laying is mediated by attractants, although actual egg deposition may or may not happen after contact evaluation has been made by the female mosquito (Day 2016). There is also an emerging body of evidence that mosquitoes, including *Culex*, have relatively specific olfactory sensilla that play a role in assessment of oviposition sites. There are a number of different, published approaches to organic enrichment (Brust 1990; Lampman and Novak 1996). Published accounts of sampling efforts yield significantly variable results, although geographic differences in study area, seasonal timing, and local ecology may contribute to this variation. Brust (1990) used sod-enriched oviposition pools to monitor egg-laying activity of *Culex* species in Manitoba, but that approach is cumbersome and inconsistent. A simple, more consistent oviposition attractant/stimulant for *Cx. restuans* would improve surveillance of this important, virus-amplifying species, especially if a standardized lure could be combined with available ovitraps on the market for other species of *Culex* (Day 2016).

In southern Manitoba in the spring of 2014, large numbers of *Cx. restuans* egg rafts were observed in pools of water where horses were known to drink relative to other available egg-laying spots (grassy pools near a tree line) in close proximity. There were also abundant egg rafts in containers that had been used by horses the previous summer for drinking and which had frozen, then thawed in the spring. This seemed to indicate considerable attractiveness despite no recent contact by the horses and/or addition of fresh organic material. This observation, and preliminary trials with water from horse troughs and control egg-laying sites (fresh well water and untreated water from a nearby wetland) led to more detailed experiments to test the hypothesis that drinking activity of horses at otherwise fresh water made those aquatic habitats more attractive than alternative sites to gravid *Cx. restuans*.

MATERIALS & METHODS

Study Sites

The primary site of experimental work for this project is near Tyndall, Manitoba, Canada (50.084 N, -96.661 W) on a rural property of approximately 16.5 hectares. The property is extensively treed with natural stands of ash, willow, birch, poplar, aspen, tamarack and many species of native shrubs as under story; a vegetation mix typical of transitional zones between short-grass prairie/aspen parkland and boreal forest. There is one human residence on the property with two dogs and two horses. Abundant wild mammals (white-tailed deer, black bear, skunk, raccoon, coyote, fox, porcupine, rabbits, and small rodents) and many species of birds are present in close proximity. The house site and small paddocks for the horses in the natural forest account for approximately 1 hectare. The horses graze/browse (June and July) in the forest but are primarily fed mixed grass hay with no alfalfa the rest of the year. They have access to fresh well water (troughs are rinsed weekly with well water) and standard trace mineral blocks. Five other collection sites assessed for comparison and additional data were rural properties (with some natural ponding suitable for *Culex* mosquitoes) within 30 km of the primary experimental site where horses were present and where it could be verified that no other livestock had access to troughs. Horse numbers varied between properties from two to more than 20.

General Methods

A field experiment was conducted to test whether *Culex* egg rafts are distributed by ovipositing females in a biased pattern with respect to the status of water in potential egg-laying sites. Egg rafts were collected from various oviposition sites with a fine-tipped, hog's-hair, artist's paint brush and placed in individual wells of tissue culture plates until hatched. Larvae from each egg raft were transferred to and reared in individual, plastic, disposable food trays for identification to species at fourth instar using keys in Wood *et al.* (1979).

In 2014, following from initial observations of an apparent concentration of oviposition activity where horses had been drinking, egg rafts were collected at the primary site from May to August from a horse trough (~0.7 m²) and adjacent aquatic habitat with no horse access for comparison (~8.5 m²). During the summers of 2016 and 2017, this work was continued at the primary site and extended to one other horse property (with the same trough system and known presence of *Culex* mosquitoes) in more open farmland approximately 25 km away. Records were kept of when the horse troughs were cleaned and replenished with fresh water. Aquatic habitats (~2.5 m²) used as controls in 2016 and 2017 were replenished with water from the same source as the troughs if they diminished due to lack of rainfall. Collections were made from 21 May to 31 August in 2016 and from 19 May to 15 September in 2017.

On three dates in 2014 (July 29, August 7, August 14), nine passenger car-sized tires representing three treatments (three tires per treatment) were used as containers to further evaluate *Cx. restuans* oviposition behaviour with respect to choice of water from different sources. All tires had been thoroughly scrubbed and rinsed multiple times with clean, cold water from the well. Water from a natural, wetland site (control) with documented presence of *Culex*

egg rafts was placed in three tires. “Horse” water (from a horse trough filled three days earlier because egg rafts usually appeared starting three to four days after a rinse and refill cycle) filtered through 1 mm mesh cloth was placed in three other tires. Water collected previously from a horse trough that also had *Culex* successfully emerge from it was placed in three other tires. From left to right, the first tire contained control water, the next tire contained water from a horse trough, and the last tire contained horse water that previously had mosquitoes reared in it. That sequence was repeated twice more from left to right. Water surface area in each tire = $\sim 0.03 \text{ m}^2$. The experiment was replicated three times although the start of each replicate differed by a few days. Tires were monitored daily for 1 week and total egg rafts accumulated in each tire was recorded. These data were subjected to ANOVA as sampling could be corrected per unit surface area of each type of habitat. Data from tires with “horse only” water and tires with “horse water that also had *Culex* successfully emerge” were pooled for statistical analysis as each of these types of water yielded similar numbers of egg rafts (no significant difference).

In addition to the observational and experimental efforts described, a survey was conducted of five, separate horse facilities in the surrounding area during summer of 2015. Horse troughs and other watering sources, including valve-controlled, continuous waterers, and adjacent habitat at each of these properties were checked for egg rafts. Owners were shown the egg rafts and mosquito larvae, and recommendations were made to empty and clean horse troughs once per week. This was followed up in 2016 at three of the same sites with a second survey of the same habitats (containers and adjacent areas). The total surface area of water sampled at each location, and classified as “with horse-contact” versus “no horse contact” was not measured accurately although “no horse contact” habitat was always in excess.

RESULTS

During preliminary observations from 2014, >75% of all (27/37) rafts were from habitats where horses had drunk in the last week, despite comparison sites representing the greater surface area ($12.1\times$) of habitat (8.5 m^2 vs 0.7 m^2). All were reared to fourth instar and all were identified as *Cx. restuans*. Most egg rafts observed to accumulate in the tire experiment (94%; 155/165) (mean = $14.05/\text{m}^2$, ± 2.08 (SE)) were laid in water that horses had contacted (either without or with the previous presence of *Culex* larvae). In contrast, few egg rafts ((6%; 10/165) (mean = $3.91/\text{m}^2$, ± 2.08 (SE))) accumulated in control tires (most after five days incubation when some organic debris had accumulated). All egg rafts yielded *Cx. restuans*. *Culex restuans* females laid significantly more ($T = 3.34$; $DF = 25$; $p=0.0026$) egg rafts in tires with horse water than tires with control water.

In 2016, 230 egg rafts were collected from troughs and control sites at the primary site and secondary site with horses. Thirty-four egg rafts were not viable (not hatched), whereas, 196 were reared to fourth instar, all of which were identified as *Cx. restuans*. Seventy two percent (166/230) of these rafts were from habitats where horses had drunk in the last week. In 2017, a total of 125 egg rafts were collected from the same sites as in 2016. Thirty-one rafts were not viable (not hatched), 95 were reared to fourth instar, all of which were identified as *Cx. restuans*. Eighty-two percent (103/125) of these rafts were collected from habitats where horses had drunk in the last week. An aggregate Chi^2 analysis of both years data combined shows significant bias

in presence of egg rafts toward water where horses have been drinking ($X^2 = 355$, $DF = 1$; $p < 0.001$).

In 2015, during a one-time survey of five horse properties, more than 90% (75/83) of egg rafts were collected from horse-watering sites versus immediately adjacent (< 10 m away) areas. Chi² analysis ($X^2 = 83$, $DF = 1$; $p < 0.001$) shows significant bias in presence of egg rafts toward water where horses have been drinking. In 2016, the follow up survey found no egg rafts in troughs that had been regularly cleaned based on recommendations from the previous year.

DISCUSSION

I found a significant, behavioural tendency of gravid *Cx. restuans* to lay eggs in wet sites where horses have been drinking for at least two to three days relative to other sites nearby that were presumed to have biological potential for larval development. It is not possible to definitively conclude that the “horse-influenced” sites were more attractive versus less repellent than alternative sites as no direct observations of mosquito orientation and contact-based acceptance/rejection behaviors were made (Day 2016), and thus the underlying mechanism for the bias was not ascertained. Though consistent in general pattern over several experimental and observational approaches, the observations detailed here are somewhat enigmatic, given that most of the published literature characterizes *Cx. restuans* as a primarily ornithophilic or bird-preferring species, at least with respect to blood hosts (Molaei *et al.* 2006). One might reasonably hypothesize that semi-permanent and permanent aquatic habitats with which birds are associated (by proximity or because birds drink there) would be highly attractive because they might signal to female mosquitoes the presence of suitable blood hosts on which to feed following oviposition. Also, many mosquitoes drink from potential oviposition sites immediately prior to egg-laying (Day 2016). It is likely that the selection of oviposition sites is uncoupled, in an olfactory sense, from host seeking, for reasons that have to do with organic enrichment of larval sites suitable for larval survival and emergence to the adult stage. It is well-established that immature mosquitoes in the genus *Culex*, particularly vector species within the sub-genus *Culex* do well in organically enriched water, although the chemical profile of these sites may vary significantly between species within the genus (and certainly among subgenera within *Culex*) (Lampman and Novak 1996; Reiskind and Wilson 2004). Furthermore, studies of other species of mosquitoes indicate that female mosquitoes often seem to choose egg-laying sites favourable for offspring success, though the degree to which that is signaled by the presence of eggs and/or larvae previously deposited seems to vary (Reiskind and Wilson 2004; Day 2016).

Setting aside the question of why *Cx. restuans* may preferentially lay eggs where horses have contacted the water, we may perhaps understand the behaviour mechanistically with respect to the sensory physiology of this and related species as follows. Nonanal is one organic molecule demonstrated to have a stimulatory effect on sensory cells of gravid *Culex* mosquitoes (Syed and Leal 2009). Nonanal is a nine-carbon ester commonly present in the saliva of many mammals, thus, horses may transfer it to drinking water, which may account for the apparent behavioural bias documented for *Culex* mosquitoes in this study. Other volatile organic compounds resulting from chewed forage (and microflora) transferred to fresh drinking water may also change the degree of olfactory stimulation underpinning oviposition site evaluation. Further research is

necessary to determine if there is a reproductive advantage to *Cx. restuans* of laying eggs in such places, or if a biochemical change precipitated by horse contact via salivary secretions or microflora introduced during drinking coincidentally produces olfactory stimulation of oviposition.

In Manitoba and by extension, other contiguous parts of the central/western North American prairies, there may be early indicators of the potential for outbreaks of human disease caused by arboviruses such as WNV that are primarily transmitted to humans by *Cx. tarsalis*. In 2003, an epidemic of human disease in Manitoba caused by WNV was correlated with population buildup of *Cx. tarsalis* in July and August (Manitoba Health 2018), but there was likely WNV circulating among birds prior to the presence of *Cx. tarsalis* and human cases, as elsewhere in North America (Komar 2003; Kramer *et al.* 2008). In Manitoba, the seasonal egg-laying activity (Buth *et al.* 1990) (earlier than *Cx. tarsalis*) and known host preferences of *Cx. restuans* for birds (Wood *et al.* 1979; Anderson and Brust 1995) implicate it as an important amplification vector for WNV. Although not collected in large numbers in the same adult traps that collect *Cx. tarsalis*, *Cx. restuans* are often infected with WNV (Manitoba Health 2018) on the southern Canadian prairies. Thus, the ability to detect and accurately monitor the population dynamics of this species before *Cx. tarsalis* become common may provide important lead time to plan for an epidemic and control measures that may become necessary. To this point, it is a potentially viable, but under-used source of early season risk information for potential, later outbreaks of arboviral activity.

Egg laying activity (the deposition of egg rafts into attractive oviposition sites) of *Cx. restuans*, as well as collection of the egressing females after egg laying for virus assay would provide important information about the population build up and the infection status of this amplifying vector before onset of a human epidemic. The extra two to three week lead time available for vector control planning and decision-making versus the usual practice of waiting for a sharp rise in the presence of infected, bridge-vector mosquitoes or human cases may, in most years, improve public health response.

The significant attractiveness of water which has been used by horses for drinking relative to other potential oviposition sites may lead to a sensitive and reliable egg-laying attractant for *Cx. restuans*, and thus a repeatable sampling approach to use *Cx. restuans* egg rafts as one of several tools for forecasting potential outbreaks of human disease caused by avian arboviruses amplified by this mosquito species (Day 2016). This may also yield another attractant that can be incorporated in novel or existing control approaches that involve inducing mosquitoes to lay eggs in artificial containers with insecticides incorporated in their design to prevent the development of new cohorts of immature mosquitoes.

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STUDIES IN THE BIOLOGY OF NORTH AMERICAN ACRIDIDAE: THE EGG-SAC AND EGG

By Norman Criddle

PREAMBLE TO PUBLICATION OF THE ORIGINAL MANUSCRIPT

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Norman Criddle was appointed as the officer in charge of the Dominion Entomological Laboratory, Treesbank, Manitoba in 1913, and remained in that position until his death in May 1933 (Gibson and Crawford 1933; Holliday 2006). At the time of his death, Criddle was planning three major publications on grasshoppers, one on eggs and egg-sacs, one on nymphs, and one on the natural history of grasshoppers, but none of these had been submitted for publication. According to Criddle's personal friend, J.B. Wallis, who bemoaned the loss of all three papers (Wallis 1954), submission was delayed because Criddle wanted to include all stages of all species in Manitoba, and a few remained to be obtained.

The archives of the Entomological Society of Manitoba have harboured the original handwritten manuscript and a typescript of the papers on natural history and on egg-sacs and eggs; these must be regarded as incomplete in Criddle's view, but nevertheless are major contributions to knowledge of grasshopper biology. A modified form of the natural history paper was posthumously presented at a conference and published as part of the conference proceedings (Criddle 1933). Volume 75 of the Proceedings of the Entomological Society of Manitoba contains a republication of the natural history paper (Criddle 2020), restored to be as close as possible to Criddle's original wording and organization, and with the removal of errors apparently introduced by the editors of Criddle (1933). Criddle (2020) is available online so is much more accessible than Criddle (1933).

No trace has been found of the work on nymphs. Earlier, Criddle had published descriptions of the eggs and nymphs of nine species (Criddle 1924) and descriptions of the nymphs of 31 species of grasshoppers in Manitoba (Criddle 1926). However, neither of these is the paper referred to as the third part of the trilogy in the introductions to Criddle (1933, 2020) and to the egg paper presented here.

Criddle (1918) contains some information about grasshopper eggs and egg-sacs, as does Criddle (1924). However, it was not until 1925 that Criddle began to rear grasshoppers systematically with the aim of describing egg-sacs, eggs, and nymphs. The paper on egg-sacs and eggs of grasshoppers that we present here is a result of those rearing studies, and has not previously been published in any form. It contains descriptions of the eggs and egg-sacs of 72 species of grasshoppers, with keys to allow many genera to be distinguished. As is evident from the acknowledgment in the introduction, the text was to be accompanied by photomicrographs,

probably one representing the egg chorion structure of each species. Unfortunately, there is no trace of these photographs, and so references to them have been removed from the text. Microscope slides of chorions of eggs were prepared by Criddle and his colleagues, some even after Norman Criddle's death. Slide preparations are not available for the eggs of all species included in the manuscript below. Furthermore, the specimens on the slides are not necessarily those used by Criddle in preparing the species descriptions and keys in his paper. These slides became part of the collections of the J.B. Wallis/R.E. Roughley Museum of Entomology at the University of Manitoba, and so are available for study. A list of these holdings, compiled by T.D. Galloway, is provided as an appendix to this publication.

There are two papers subsequent to Criddle's works in which grasshopper eggs were prepared and described in similar ways to those used by Criddle. Bushland (1934) described, and provided photomicrographs of, the chorion of 18 species of grasshoppers in South Dakota; as 14 of these are taxa described in the Criddle's work, Bushland's photomicrographs may be used as a substitute for some of the missing photographs. Tuck and Smith (1939) described the eggs of 48 species of grasshoppers in Kansas; their publication includes photographs of whole eggs at low magnification for 24 taxa described in Criddle's work, and high magnification drawings of chorion sculpture of seven of these taxa. In neither of these papers do the authors indicate awareness of Criddle's studies in Manitoba and, unlike Criddle's work, no species-specific descriptions of egg-sacs are provided.

Criddle was writing at a time before the current practice of citing sources with a corresponding reference list; indeed, most publications in *The Canadian Entomologist* in the early 1930s had no indication of the sources of previously-published information. For the current paper, Criddle provided a list of some relevant information sources but there are no citations in the text.

We have retained Criddle's scientific nomenclature for insects. Criddle's use of parentheses around authorities for scientific names was variable, and we have corrected errors of this type without notation of the correction. Where scientific nomenclature or authority designation now differs from that used by Criddle, we have included the current nomenclature in square brackets in addition to the original rendition. Current nomenclature of Orthoptera is from Cigliano *et al.* (2022), but with some interpretations derived from Vickery and Kevan (1985). Square brackets are also used to signify other insertions by the writers of this preamble. Mainly, these are to provide explanations of the treatment of deviations of current acridid classification from those used by Criddle, to clarify the meaning of Criddle's wording, to provide the current subfamily designation for each species description, or to indicate where Bushland (1934) or Tuck and Smith (1939) contain illustrations relevant to Criddle's species descriptions. With these exceptions, except when there were clearly errors in spelling or typography, we have reproduced Criddle's original wording, and his often idiosyncratic punctuation and key structure.

The authors of the preamble acknowledge the valuable comments of the anonymous reviewers. These comments helped in the presentation of a historic scientific document, the author of which could not be consulted for clarification of intent or meaning. The document has scientific significance in addition to its historical importance: it contains descriptions of eggs and egg sacs

that, for many species, to our knowledge, are not to be found anywhere in the published literature.

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STUDIES IN THE BIOLOGY OF NORTH AMERICAN ACRIDIDAE: THE EGG-SAC AND EGG

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INTRODUCTION

Hitherto the classification of the Orthoptera in North America has been based wholly upon the structures and colour of adults. This, in view of our ignorance concerning the immature stages of development, was necessary. The final arbiter, however in any classification must have a full knowledge of all phases of the insect's life. Such information is usually acquired slowly and it is generally necessary to add a few details at a time. To date, however, the contributions in respect to Orthoptera have been extremely meagre and with the exception of a few life-histories worked out by C.V. Riley and his associates G. Thomas and A.S. Packard, little has been done to enlarge upon our knowledge of this important order of insects.

My own studies of the immature stages of the Orthoptera began, in a fragmentary way, some 30 years' ago but it was not until 1925 that actual rearing of the various species was begun. Unfortunately the acquisition of material has been far from easy. For reasons which it is unnecessary to enter into, most entomologists have an aversion to collecting Orthoptera; moreover there is a certain amount of technique required in rearing, or keeping the insects alive a knowledge of which is seldom possessed. Under these circumstances I have been obliged to rely very largely upon my own efforts to obtain the required material and as a result many desirable species remain unstudied. It is felt, however, that enough is known to warrant the preparation of a preliminary paper, but since it has not been possible to find a medium for publication of the entire study, this has been divided into sections the first of which will deal with the egg-sacs and eggs. This it is hoped will be followed by one on the nymphal instars and another on general habits.

While this study relates chiefly to the Manitoban species a number of others from different parts of Canada and the United States are included and in this connection I am pleased to acknowledge assistance from a number of persons including Mr. E.R. Buckell of the Dominion Entomological Laboratory, Vernon, B.C. to whom I owe all the material from British Columbia. Mr. H.L. Seamans of the Entomological Laboratory, Lethbridge, Alberta, has aided me in securing living specimens from that province and Montana, while Messrs. K.H. King, George Manson, and P.C. Brown, all of the Dominion Entomological Branch, have performed a similar service in Saskatchewan. In Manitoba I have had the aid of Messrs. R.M. White, R.H. Handford and R.H. Painter of the Treesbank Laboratory, Mr Shirley Brooks of Transcona, and Mr. J.B. Wallis of Winnipeg; while my brothers, Evelyn and Stuart, and my sister Miss M. Criddle, have aided me in rearing work. To Messrs. George Stirrett and George Hammond of the Entomological Branch I am indebted for individual species from Ontario and Quebec. Finally my appreciation is extended to Dr. J.R. Parker and Mr. Robert Shotwell of the United States Bureau of Entomology,

Bozeman, Montana, for eggs of *Melanoplus differentialis* and [*Melanoplus*] *bivittatus* from Utah and South Dakota and to Mr. Morgan Hebard of the Academy of Natural Sciences, Philadelphia for the determination of several doubtful species. The micro-photographs were taken by the Branch Artist, Mr. Frank Hennessey.

On making a study of the egg-sac of the Acrididae it has become manifest that there is considerable variation in the size and shape of the sac even in the same species. This is, in part, due to the resistance encountered by the grasshopper in drilling the egg-sac cavity but also to a variation in the number of eggs deposited at one time, or to the age of the insect. These variations from normal are most frequently met with towards the end of the egg-laying period when the capacity of the female for reproduction is almost exhausted. At such time some individuals may deposit very few eggs or occasionally a sac without any. Another feature encountered at such times is a lack of a neck, or upper empty portion of the sac in species which normally provide one. It is important, too, to bear in mind that the sacs assume entirely different proportions with the development of the eggs within them. Thus when first deposited the sac may be quite narrow and the eggs tightly packed, but towards the time of hatching the sacs become so greatly distended that they burst asunder and consequently lose much of their original shape. There are, however, a number of exceptions to this rule mostly encountered in the "Acridinae" [See the section "Guide to 'Acridinae'" for explanation of Criddle's use of this epithet] when the sacs are sometimes very strong. In all such cases the eggs are less closely packed, thus allowing for an expansion of the eggs without breaking the sacs.

Apart from the variations mentioned above the sacs are fairly uniform, the texture is quite constant and arrangement of the eggs only varies within certain limits, such, for example, as the number of rows. In many instances the shape of the sac is quite characteristic and while it does not usually differentiate between species, many genera are easily recognised. In all cases, however, it is wisest to make determinations from a series of egg-sacs, thus escaping the pitfalls to which an abnormal sac might lead.

Those attempting to classify the eggs will also be confronted by a number of obstacles, the most important of which is a stretching of the chorion due to the development of the embryo and the consequent enlargement of the pattern. In some instances, the reticulation, after the development of the embryo, is practically twice the size it was before development. This enlargement of the meshes is chiefly in a transverse direction, the swelling being much greater in width than length. On account of this variation the size of the egg-pattern is a character to be used with reservation and with a knowledge of the variation within the species.

Another fact that should be noted is that in some groups of species the egg-pattern is very easily displaced and in consequence perfectly preserved eggs are rare. This is particularly true of the central tubercle found in the reticulation of certain Oedipodinae. An ideal comparative study would provide all eggs at exactly the same age. It is a lack of much uniformity in the present work which proves one of its most serious defects.

In the notes which follow the arrangement of the genera and species is based on the zonal studies of Morgan Hebard, with such modifications as are suggested by the characters under review. The

idea has been to indicate relationships rather than provide a linear arrangement from high to low or vice versa. Thus several species may be grouped together due to apparent affinities but whether they should be placed before, or after, other groups is a problem which we have not attempted to solve. Also it should be remembered that the study of other species, or genera, and of the nymphal instars may greatly alter the arrangement here presented in which undue weight may have been placed upon the characters of the egg-sac and egg.

The subfamily Acrydiinae [now family Tetrigidae] has been purposely omitted, the immature stages having been reviewed by J.L. Hancock (1902).

We should add that, unless otherwise indicated, all species studied came from Manitoba.

GUIDE TO THE “ACRIDINAE”

[Acridinae remains a valid subfamily; however, with the exception of *Stethophyma* which is now within the subfamily Oedipodinae, all taxa Criddle treated in this section are now in the subfamily Gomphocerinae. To maintain the integrity of his key, we have retained Criddle's use of “Acridinae”, but identify it as no longer valid by placing it in quotation marks. The current subfamily of each species is given in the headings of individual species treatments below].

Egg-sac, when present, short rarely more than three times as long as wide and, with the exception of *Stethophyma*, having thick, tough walls and frequently an oblique opening. Or more elongate slender with thin tough walls which, in most cases, are closely wrapped round the eggs. Eggs in the shorter sacs, most frequently smooth without definite markings, those in the slender sacs reticulated or not, dividing lines of reticulation never tuberculate and the meshes without a median tubercle. Of the two genera without sacs *Acrolophitus* has reticulated eggs, *Psoloessa* smooth ones. In several genera the egg-sacs are capped by a detachable stopper and in some the eggs have a button-like projection at the posterior extremity.

“Acridinae” Affinities

A study of the egg-sac and egg indicates that some of these fall into well defined groups while others are more difficult to place. Among the genera to which no definite place can be assigned are *Acrolophitus* and *Stethophyma*. In the arrangement of the eggs and in the egg-pattern they seem to show affinities, in other characters they are totally unlike.

There seems no doubt that *Acrolophitus* is a member of the “Acridinae”; this is suggested in the habits, egg-stage and nymphal instars. Doubtless the rearing of other genera will assist in placing it correctly.

There is little doubt but that *Opeia* and *Amphitornus* form a natural group, this is especially suggested by the egg-sacs with their detachable stoppers and other peculiarities. To this group we suspect *Cordillacris* should be added. The close relationship is indicated by the egg-sac, eggs and nymphal instars.

The placing of the groups which follow is open to greater criticism. If we based our classification on the egg-sacs, and to a lesser extent upon the eggs, then a natural arrangement would seem to be to place all those species with thick sacs together and follow with the thinner more elongate ones. The shape of the sacs and arrangement of the eggs within them also favours this classification.

Adopting these suggestions we would follow the group headed by *Opeia* with the obviously closely related genera *Gomphocerus* [*Aeropedellus*] and *Ageneotettix* and continue with their apparent allies *Bruneria* and *Aulocara*. *Chorthippus* [*Pseudochorthippus*] seems to have a place near here and it shows some affinities to the thin sac groups such as *Orphulella* and *Chloealtis* [refers to *C. conspersa*] which, however, is more evident in the nymphal instars. We are at a loss to place *Phlibostroma*: its elongate, abnormal shaped sacs are so very unlike any others. The eggs and their arrangement suggest those of *Psoloessa* and despite the lack of a sac in the latter species we are tempted to put the two together. The similarity of the nymphs also indicate that this is their correct position. We have by the above classification run gradually into the thin coated, elongate sacs and *Orphulella* seems to follow rather naturally, the sacs resemble those of *Chloealtis* [*conspersa*] and *Chrysochraon* [refers to *Chrysochraon abdominalis*, which is now *Chloealtis abdominalis*] but lack a detachable stopper. The two species under review, namely [*Orphulella*] *speciosa* and [*O.*] *pelidna* are rather dissimilar both in the egg and nymphal stages and may represent different genera.

The genus *Chloealtis* [*C. conspersa*] seems to come next with *Chrysochraon* [*Chloealtis abdominalis*] following. They have a number of features in common, to which might be added the habit of both in depositing their eggs in wood or dung. The egg-pattern of the latter, however, seems to definitely segregate them.

In *Stethophyma* with its short polished egg-sacs and strikingly marked eggs, we encounter a deviation from all others. The eggs recall those of *Acrolophitus*, while the nymphs are not unlike similar stages in *Chloealtis* [*conspersa*] and *Phlibostroma*.

Key to the Genera of “Acridinae”

[**Note:** the generic epithets in this key are those used by Criddle; the reader should consult the species treatments that follow to find the current names of taxa.]

	Sacs absent, the eggs unprotected	1	
	Sacs well defined	2	
1	Eggs upright, resting on the same level, dark in colour, usually six in number, length 7 mm		<i>Acrolophitus</i>
	Eggs in elongate rows, 12 to 16, colour creamy-white; length 5.5 mm.		<i>Psoloessa</i>
2	Walls of sac thick	3	
	Walls of sac thin	9	
3	Entrance to sac with a detachable stopper	4	
	Entrance to sac without a detachable stopper	5	
4	Top of sack horizontal, number of eggs 10 or 11		<i>Opeia</i>

	Top a little at an angle, number of eggs 4	<i>Amphitornus</i>
5	Top of sac at a distinct angle	6
	Top of sac horizontal, number of eggs 2 to 5	<i>Cordillacris</i>
6	Sacs elongate-cylindrical of about equal width throughout	8
	Sacs pyriform, oval or sub-cylindrical rarely more than twice as long as wide	7
7	Sacs elongate-pyriform, the upper part tapering to an obtuse point, number of eggs 5 to 14	<i>Chorthippus</i>
	Sacs oval or more broadly pyriform the upper part not gradually tapering, more definitely angulate, number of eggs usually 6	<i>Gomphocerus</i>
	Sacs smaller, eggs 3 to 5	<i>Ageneotettix</i>
8	Opening to sac widely angulate, length of sac 10 to 16 mm; eggs 5 to 6	<i>Bruneria</i>
	Opening to sac obscurely angulate, opening small; length of sac 12 to 20 mm, eggs 4 to 7	<i>Aulocara</i>
9	Sacs elongate-cylindrical	10
	Sacs sub-equal in width and length	13
10	Sacs in the form of loose sacking through which the outline of the eggs is plainly visible	11
	Sacs closely woven in appearance, through which the eggs are not visible; length 24 mm. number of eggs 16	<i>Phlibostroma</i>
11	Sacs always in wood or dung, the top with a detachable stopper	12
	Sacs only in soil, without a detachable stopper	<i>Orphulella</i>
12	Eggs hispid or tuberculate the pattern well defined	<i>Chrysochraon</i>
	Eggs smooth, or nearly so, the reticulation, if present, hidden by a coating of opaque matter	<i>Chloealtis</i>
13	Sacs leather-like, shiny without particles of earth attached; chorion closely wrapped round the eggs, the outline of which is everywhere visible. Number of eggs 4 to 24 . .	<i>Stethophyma</i>

***Acrolophitus hirtipes* (Say) [Gomphocerinae]**

Egg-sac.— There is no egg-sac, the eggs merely placed side by side in the earth.

Egg.— The eggs rest together in an upright position and may be partly attached to each other by a sticky material exuded by the female grasshopper. The usual number of eggs deposited at one time is six although they may number as high as eight. The eggs are large, the posterior cap constricted and distinctly produced; ring a little concave with a median dark line of close-set, elongate punctures. Chorion thick; reticulation coarse, the meshes round or indefinitely angulate, dividing walls wide, rugose or minutely hispid. Colour clay-yellow becoming reddish-brown with age; length 7 mm.

***Opeia obscura* (Thom.) [Gomphocerinae]**

Egg-sac.— Cylindrical or sub-cylindrical not unlike that of *Cordillacris*, a little wider below and with an egg-free neck of about half the total length. The top is capped by a close-fitting, concave stopper made of chitinous-like material. The walls are moderately thick but brittle. Length 8 to 12 mm, greatest width 5 mm.

Egg.— The eggs rest a little oblique, there being usually five on almost the same level and a few others, less closely packed, lower down. They usually number 11 to a sac. The eggs smooth, opaque, but with age the surface develops innumerable elongate cracks. The posterior cap is produced into an obtuse, button-like, protuberance and the posterior ring is indicated by a row of elongate punctures. Colour creamy-white; length 5 mm.

The specimens were obtained from Estevan, Sask.

***Amphitornus bicolor* (Thom.) [*Amphitornus coloradus coloradus* (Thomas)] [Gomphocerinae]**

Egg-sac.— Sub-cylindrical, usually curved, about twice as long as wide; walls thick and very tough; top closed by a shallow bowl-like stopper which is readily detached. Length 6 to 8 mm, width 3.5 to 4 mm.

Egg.— Four in number arranged in pairs so that the lower ones are about a sixth of their length below those above. Posterior cap with a button-like extremity, the ring indicated by a series of fine, short transverse punctures; surface shiny without marks; colour pale cream, the posterior end darker; length 5 mm.

***Cordillacris occipitalis cineria* (Thom.) [*Cordillacris occipitalis* (Thomas)] [Gomphocerinae]**

Egg-sac.— Short cylindrical, in some instances sub-oval, averaging nearly three times as long as wide, there is a short egg-free neck which is deeply concave on top although no definitely detachable stopper is discernible. The walls are moderately thick and spongy. Length 6 to 14 mm.

Egg.— There are two to five eggs resting perpendicular to the opening, they may be on the same plane or at slightly different elevations. Eggs rather small, smooth, polished without markings other than a narrow posterior ring of elongate punctures and a button-like extremity. Colour pinkish-yellow with a whitish bloom, posterior cap paler; length 4.5 mm.

***Gomphocerus clavatus* Thom. [*Aeropedellus clavatus* (Thomas)] [Gomphocerinae]**

Egg-sac.— Sub-cylindrical, about twice as long as wide, often sub-round or narrowly pyriform, the opening an angle, wide, a little concave. Empty neck very short; walls thick and tough. Length 6 to 8 mm.

Egg.— Number of eggs to a sac usually four rarely five, these are almost perpendicular and form two rows, the lower overlapping the upper one to about half their length. The eggs are smooth or very slightly wrinkled, the posterior cap button-like, ring normal. The surface rarely shows an obscure reticulation which looks as if it had been painted over. Colour creamy-white, the posterior extremity darker; length 6 mm.

***Ageneotettix deorum* (Scud.) [Gomphocerinae]**

Egg-sac.— Sub-pyriform or oval, the upper empty portion moderately, to very short or absent; opening as in *Gomphocerus* [*Aeropedellus clavatus*]: walls very thick and tough. Length 8 to 14 mm, width 7 mm.

Egg.— Three to five in number, arranged at slightly different elevations. Posterior extremity with a button-like knob; surface polished, smooth; colour creamy, the button darker; length 5 mm.

The egg-sacs are so tough that they retain their form for several years.

***Ageneotettix occidentalis* Brun. [now synonymized with *Ageneotettix deorum* (Scudder)] [Gomphocerinae]**

Egg-sac.— There is no appreciable difference between this and that of [*A.*] *deorum*.

Egg.— We can find no distinguishing features to separate this from the above mentioned species.

Specimens were obtained from British Columbia.

***Bruneria brunnea* (Thom.) [Gomphocerinae]**

Egg-sac.— Short, sub-cylindrical, usually more curved on the ventral side and flattened on the upper dorsal margin, the opening being at a distinct angle. Walls thick, tough and rather firmly attached to the eggs. Length 10 to 16 mm, width 4.5 to 5 mm.

Egg.— The eggs are five or six in number arranged in two rows at unequal heights, but overlapping. Since the sac rests obliquely in the soil the eggs are actually almost on the same level and their tips approximate the wide flattened area which constitutes the opening. The eggs are semi-smooth with what appears to be obscure reticulation, mostly hidden by an overcoating of varnish-like material. Cap — sub-button like; ring punctate; colour pale cream; length 5.5 mm.

***Aulocara elliotti* Thom. [Gomphocerinae]**

Egg-sac.— Elongate-cylindrical, of almost equal width throughout; empty neck occupying almost half the total length of sac; walls thick and tough. Length 12–20 mm.

Egg.— The eggs vary in number from two to seven, the average being five, they are in two overlapping rows being practically on a level when the row rests naturally on its side. The posterior extremity is little produced, the usual row of punctures rather obscure. Surface polished without reticulation. Colour creamy-white; length 5.5 mm.

The sacs might be mistaken for those of *Camnula*, the opening however, is nearly always on a slant and the eggs are quite different.

***Chorthippus curtipennis* (Harr.) [*Pseudochorthippus curtipennis curtipennis* (Harris)]**
[Gomphocerinae]

[Photomicrograph of chorion in Bushland (1934)]

Egg-sac.—Elongate-pyriform with a varied length of empty neck comprising from a third to half the length of sac. This neck tapers almost to a point so that the opening is usually small. The walls are rather thick and tough. Length 10 to 14 mm, width 5 to 7 mm.

Egg.—The eggs are practically on a level and they point directly upward, varying from 5 to 14 in number. Posterior cap widely rounded the extremity produced into broad, flat knob or button; ring indicated by the usual row of punctures. Surface faintly reticulated but hidden, as a rule, by an overcoating of varnish-like material. Colour creamy-white; length 5.5 mm.

***Phlibostroma quadrimaculatum* (Thom.) [Gomphocerinae]**

Egg-sac.—Elongate-cylindrical, slightly wider below, a little constricted at middle; the egg-free neck occupying half the total length of sac; walls rather thin but tough, paper-like, usually with roots embedded in them; length 24 mm.

Egg.—The eggs are in three row formation the rows at different elevations; there are an average of 16 eggs to a sac. Posterior cap a little produced, the ring obscure; surface smooth except the cap which is reticulated; cap brownish the rest flesh colour; length 5 mm.

Specimens obtained in Saskatchewan and Alberta.

***Psoloessa delicatula delicatula* (Scud.) [*Psoloessa delicatula* (Scudder)] [Gomphocerinae]**

Egg-sac.—Practically non-existent, it consists of a small amount of frothy matter deposited with the eggs to which a certain amount of earth adheres. This latter is easily removed and the eggs are then nude. Length of egg-mass 12 to 18 mm.

Egg.—The eggs are arranged in rather regular order of two, three, or four rows, usually two; there are from 6 to 16 eggs to a sac. The eggs are without markings other than an obscure posterior ring of elongate punctures. Colour cream, the surface sub-transparent, polished; length 5 to 6 mm.

***Orphulella speciosa* (Scud.) [Gomphocerinae]**

[Photomicrograph of chorion in Bushland (1934)]

Egg-sac.—Elongate-cylindrical, the walls thin but tough, wrapped closely round the eggs, not unlike coarse sacking through which the eggs bulge, this coating is glued tightly to the eggs. Length 18 to 20 mm., width 3.5 mm.

Egg.—The eggs are irregularly placed without definite arrangement, they vary in number but average 10 to a sac. The chorion is smooth but it is possible that the outer coating may hide an

obscure reticulation of which, however, there is little indication. The posterior cap is not button-like at its extremity and the ring is indefinite. Colour dark cream, length 4–5 mm.

***Orphulella pelidna* (Burm.) [Gomphocerinae]**

[Photomicrograph of whole egg in Tuck and Smith (1939)]

Egg-sac.— Similar to that of [*O.*] *speciosa*. Length 20 mm.

Egg.— Arrangement as in the former species they number from 6 to 14 to a sac. Posterior ring smooth with a row of elongate punctures; surface reticulated, but often obscurely so, or not discernible; the posterior cap, however, is always reticulated. Colour creamy-white; length 4.5 mm.

***Chloealtis conspersa* (Harr.) [Gomphocerinae]**

Egg-sac.— Elongate-cylindrical, rather narrow, about a third free of eggs. The walls are thin and they fit closely round the eggs the outline of which is discernible. Top capped by a saucer-like, shiny, detachable stopper; length 20 mm.

Egg.— The eggs are in two rows of uneven elevation and average 10 to a sac. The posterior cap is a little dilated and the ring indicated by a row of elongate punctures. Surface very obscurely reticulated due to a surface coating and the uniform colour which is cream, the extremities a little darker; length 5 mm.

***Chrysochraon abdominalis* Thom. [*Chloealtis abdominalis* (Thomas)] [Gomphocerinae]**

Egg-sac.— Elongate-cylindrical, the egg-free upper part approximating a tenth of the total length. Walls thin but tough, the opening capped by a concave, detachable stopper. Length 19–22 mm.

Egg.— The eggs are in an irregular two row formation and number 7 to 10, they are quite firmly cemented together with coarse frothy matter. Posterior cap a little produced, the ring with the usual line of elongate punctures. Surface in the form of elongate depressions and curved rows of sharp tubercles. Viewed from certain directions it appears reticulated. Colour pale yellow becoming darker with age. Length 5 mm.

***Stethophyma lineatum* (Scud.) [Oedipodinae]**

Egg-sac.— Very irregular in shape, pyriform or horizontally longer than high, usually pointed, the surface thin leather-like, polished, without adhering particles of earth; walls fitting closely round the eggs so that their outline is plainly showing.

Egg.— The eggs are in regular rows of from two in the smallest sac to four in the larger ones; they rest on a concave plane, and when the sacs lie on their sides, in a natural position, point directly upwards. These number from 4 to 28 eggs to a sac; they are firmly stuck together and difficult to clean. Posterior ring wide, its upper edge with a row of elongate punctures; chorion

thick, opaque; reticulation well defined the meshes round or obscurely angulate, dividing line wide a little rugose; meshes with a small central tubercle. Length 5.5 mm.

***Stethophyma gracile* (Scud.) [Oedipodinae]**

Egg-sac.— Similar to that of [*S.*] *lineatum* from which no constant difference has been discovered.

Egg.— Tightly packed as in [*S.*] *lineatum* averaging 24 to a sac, shape similar. The pattern seems to be distinctive but this may be due to the freshness of the eggs; length 5 mm.

GUIDE TO THE OEDIPODINAE

Egg-sac elongate-cylindrical, three or more times as long as wide; the walls either thick or thin, but never very tough. Eggs always in elongate rows and, with the exception of *Encoptolophus* and *Chortophaga*, always with a definite pattern, the meshes of the reticulation, in many instances, with a median tubercle. In general those eggs without the median tubercle become brown with age, or have pale streaks. This, with a few exceptions, distinguishes them from eggs of the “Acridinae” or “Cyrtacanthacrinae” [See the section “Guide to the ‘Cyrtacanthacrinae’” for interpretation of this name]. The eggs of eight genera, namely *Pardalophora*, *Xanthippus*, *Arphia*, *Spharagemon*, *Dissosteira*, *Trimerotropis*, *Circotettix*, and probably *Aerochoreutes* [now synonymized with *Circotettix*] are irregularly tuberculate or hispid along the dividing lines of the reticulation. Five, namely: *Hadrotettix*, *Cratypedes*, *Camnula*, *Metator*, and *Trachyrhachys* are apparently without such tubercles. Somewhat similar tubercles are present in the egg-chorion of *Asemoplus* of the Cyrtacanthacrinae [*Asemoplus* is now placed in Melanoplinae].

Oedipodinae Affinities

In attempting to trace affinities in this subfamily a number of perplexing problems are encountered the solution of which must necessarily be somewhat tentative.

Without doubt the best defined and most segregated group is represented in the genera *Encoptolophus* and *Chortophaga*. The chief peculiarities of this group are a smooth egg, with a posterior ring of elongate punctures, in which characters they are indistinguishable from certain “Acridinae”. In addition the egg-sacs are thin and fit closely round the eggs, while the nymphs have strikingly short thick antennae quite unlike those of any species met with in the Oedipodinae and only suggested in *Hypochlora* and *Hesperotettix* of the “Cyrtacanthacrinae” [Melanoplinae]. Since this group cannot be placed between any of those which follow we prefer to put it at the head of the subfamily.

The genus *Hadrotettix*, in its egg of extraordinary wide reticulation, seems to constitute a separate unit. If we are to rely upon the characters of the egg then it certainly does not show affinities with that extensive aggregation represented by those genera with a central tubercle in the reticulation, but, instead, seems to have a possible place in the group represented by *Pardalophora* and its allies. This relationship is also suggested by the early nymphal instars. It is

possible that this genus should come after *Arphia* next to *Trachyrhachys* but for the present we prefer to place it before that group.

In *Pardalophora*, *Xanthippus* and *Arphia* we seem to have another natural segregation to which *Hippiscus* [identity uncertain] may doubtless be assigned. The egg-sac, eggs and nymphal stages all suggest this arrangement.

Whether *Trachyrhachys* and *Metator* should follow is open to more question. This arrangement is indicated, especially in the egg-pattern of the first named species to which there is a resemblance in the fine angulate lines to *Hadrotettix*. The two genera have many characters in common and we believe form a natural group not very closely allied to any other referred to here.

The genus *Cratypedes* shows affinities with both *Xanthippus* and *Arphia*, in other respects, its nearest relation seems to be *Camnula*, this last is suggested by the egg-sac and egg. Both species show an obscure median tubercle in the reticulation of the egg chorion thus suggesting a development towards the genera which follow. *Camnula*, in particular, in its first nymphal instar is quite like *Spharagemon* and its allies. Placing *Camnula* with *Cratypedes* we next come to that perplexing aggregate in which all the remaining genera are involved. *Aerochoreutes* [*Circotettix*] has features which might fit it almost anywhere. In some of these it recalls *Metator* in others *Circotettix* while its habits are very like those of *Dissosteira*. We shall not do more than has been indicated here.

Probably *Dissosteira* as represented by *carolina* comes next, followed by *Spharagemon*. The cristate median carina of the adults suggests a connection with *Arphia*, in all other respects the relationship with *Trimerotropis* and *Circotettix* seems very close. The only feature of separation so far known is the colour of the eggs. Those of *Dissosteira* and *Spharagemon* being pinkish, while in the genera which follow they are light yellow. The nymphs cannot be told one from another.

It is probable that more than one genus is involved in *Trimerotropis*. Among the species which indicate this most clearly are [*T.*] *agrestis* and [*T.*] *pistrinaria*, both are well defined in so far as the immature stages are concerned.

Key to the Genera of Oedipodinae

[**Note:** the generic epithets in this key are those used by Criddle; the reader should consult the species treatments that follow to find the current names of taxa.]

- Egg-sac short in comparison to width with little or no egg-free neck 1
- Egg-sac more elongate, usually with an egg-free upper part occupying at least a quarter of the sac 2
- 1 Sac not exceeding 16 mm long [but see species description below], eggs in three rows, closely packed. Egg chorion rather thick, yellow or brownish with lighter streaks; meshes of reticulation small with an indefinite tubercle in their centre; dividing lines high; number of eggs 16 to 32. *Camnula*

	Sacs more than 16 mm long but not exceeding 20 mm; width greater; egg chorion very thick, otherwise as <i>Camnula</i>	<i>Cratypedes</i>
2	Sac thin and tough, closely fitting round the eggs the outlines of which are visible through it; egg-chorion smooth without markings	3
	Sac walls thicker, often corky, but brittle; outline of eggs rarely visible from without; egg-chorion with well-defined markings	4
3	Sac less than 25 mm long, number of eggs to a sac not exceeding 20.	<i>Encoptolophus</i>
	Sac more than 25 mm long, number of eggs to a sac greater ranging from 16 to 45	<i>Chortophaga</i>
4	Reticulation of egg-chorion without a central tubercle, walls of sack rather thick, corky	5
	Reticulation of egg-chorion with a central tubercle, sac walls less thick	9
5	Sac elongate-cylindrical; eggs becoming brown with age, in 3, 4 or 5 row formation	6
	Sac sub-cylindrical, distinctly wider below; walls less thick; eggs in 3–4 rows	7
6	Sac 9 mm wide, 40 to 50 mm long; eggs 36 to 73, in 4 or 5 rows; colour yellow becoming brown with age; chorion moderately thick; reticulation sub-angulate or rounded; length of eggs 6.5 mm	<i>Pardalophora</i>
	Sac 8 mm wide, 36 to 40 mm long, eggs 30 to 54 in number; chorion a little less thick; reticulation more angulate	<i>Xanthippus</i>
	Sac more narrow, 32 to 36 mm long; eggs in 3–4 rows, not exceeding 24 in number; reticulation as in previous genus, rarely with a central tubercle in the meshes	<i>Arphia</i>
7	Sac distinctly wider below; 33 mm long, empty portion short; eggs in 3 or 4 rows, reticulation sharply angulate the meshes much larger than in any other species.	<i>Hadrotettix</i>
	Sac smaller, eggs abnormally pointed; chorion very thick, colour becoming reddish-brown with paler streaks	8
8	Sac not exceeding 18 mm long; reticulation of chorion fine definitely angulate; length 5 mm	<i>Trachyrhachys</i>
	Sac larger, 23 to 31 mm long [but see species descriptions below]; markings of chorion in the form of large, shallow foveolae with thick dividing walls, the former having a series of minute black punctures in the centre; length of egg 6.5 mm	<i>Metator</i>
9	Sac moderately short but brittle, 35 to 40 mm long, the empty portion rather short; eggs in 4 rows, 35 to 60 in a sac; colour pinkish	<i>Dissosteira</i>
	Sac more thin but tougher, the empty portion long; length of sac 37 mm; eggs in 2 rows, 20 to 30 in a sac, colour clay-yellow, reticulation often obscured by an opaque coating	<i>Aerochoreutes</i>
	Sac shorter, the texture like <i>Dissosteira</i> but more frail; length not exceeding 30 mm	10
10	Eggs in 3 rows, not exceeding 25, the chorion with a pinkish tint	<i>Spharagemon</i>
	Eggs in 2 or 3 rows, colour pale yellow, occasionally becoming blackish, otherwise as the last	<i>Circotettix-</i> <i>Trimerotropis</i>

***Encoptolophus sordidus* (Burm.) [Oedipodinae]**
 [Photomicrograph of chorion in Bushland (1934)]

Egg-sac.—Elongate-cylindrical a little wider below; empty upper portion occupying about a third of the sac; walls thin fitting closely round the eggs so that their outline is visible; length 18 to 20 mm.

Eggs.—The eggs are arranged in a three row formation averaging [but see following paragraph] about 26 to a sac. Surface polished without reticulation, colour pale cream. Length 5 mm.

The above description is drawn from a single sac of old eggs taken at Clarenceville, Quebec.

***Encoptolophus costalis* (Scud.) [Oedipodinae]**

[Photomicrograph of chorion in Bushland (1934)]

Egg-sac.—Elongate-cylindrical, the upper third without eggs, narrower; walls tough but thin, fitting closely around the eggs so that their outline is often visible; length 16 to 20 mm.

Egg.—The eggs are arranged in a rather irregular three row formation and vary in number from 8 to 20, 14 being an average. Posterior ring indicated by a row of elongate punctures; surface smooth without reticulation. Colour pale creamy-white shading to light brown at the extremities; length 5 mm.

***Chortophaga viridifasciata* DeG. [Oedipodinae]**

[Photomicrograph of whole egg in Tuck and Smith (1939)]

Egg-sac.—Elongate-cylindrical, the empty portion occupying from a third to half the total length; walls thin but tough; closely wrapped round the eggs; length 25 to 30 mm.

Eggs.—The eggs are arranged in a three, or rarely four, row formation and vary from 6 to 45 in number, the average being 19. Surface smooth, the posterior ring indicated by a rather obscure row of elongate punctures. Colour pale, bright clay-yellow; length 5.5 mm.

***Hadrotettix trifasciatus* (Say) [Oedipodinae]**

[Drawing of chorion sculpture and photomicrograph of whole egg in Tuck and Smith (1939)]

Egg-sac.—Sub-cylindrical, almost two-thirds wider basally than above; egg-free neck short, not more than a quarter of the entire length of sac; walls moderately thick but breaking easily; length 33 mm, width about 7 mm, 4 mm above.

Egg.—The eggs are in three or four rows, semi-upright and number about 22 to a sac. Posterior ring wide, smooth, a little concave; chorion thick; reticulation sharply angulate the meshes very large, dividing lines fine in proportion. Colour creamy-yellow changing to olive green or brown-pink; length 7 mm.

Specimens were obtained from the Marias Hills in Montana.

***Pardalophora apiculata* (Harr.) [Oedipodinae]**

Egg-sac.—Elongate-cylindrical, large usually curved, a little narrower above; walls fairly thick, corky; top concave; the empty upper portion occupying from a third to half the length of sac; length about 50 mm, width 9 mm.

Egg.—The eggs are in an irregular 4–5 row formation and number from 36 to 73. Reticulation large; colour clay-yellow changing to dark reddish with age; length 7.5 mm.

***Xanthippus corallipes latefasciatus* Scud. [*Xanthippus corallipes* (Haldeman)] [Oedipodinae]**

Egg-sac.— Elongate-cylindrical, usually curved, the egg-free neck from a third to half the entire length of sac; walls thick corky; length 40 mm.

Egg.— In an irregular 4–5 row arrangement about 38 to a sac, moderately closely packed; posterior cap round, the ring wide, flat; reticulation large obscurely angulate. Colour, pale clay-yellow changing to reddish-brown; length 6.5 mm.

***Xanthippus montanus* (Thom.) [Oedipodinae]**

Egg-sac.— Very like that of *latefasciatus* [*X. corallipes*] length 30 to 40 mm.

Egg.— The eggs are arranged in irregular 3, 4 or 5 rows and number from 20 to 52 to a sac. Posterior extremity a little produced, the ring wide and flat; reticulation large the meshes definitely angulate, colour clay-yellow, becoming brown with age; length 6.2 mm.

***Arphia pseudonietana* (Thom.) [Oedipodinae]**

[Photomicrograph of chorion in Bushland (1934); drawing of chorion sculpture and photomicrograph of whole egg in Tuck and Smith (1939)]

Egg-sac.— Elongate-cylindrical, generally curved, the lower part a little wider than the upper; egg-free neck occupying half to two-thirds the entire sac; walls thick and corky; length 32 to 36 mm, width 6 mm.

Egg.— Arranged in a three or four row formation, numbering from 8 to 24 to a sac the average being 20. Posterior ring wide, slightly concave; surface widely reticulated with angulate meshes; there is occasionally a small tubercle in the centre of some of the meshes. Colour pale brown-ochre, lighter adjacent to other eggs; length 6 mm.

Occasionally sacs are met with an empty neck in which case they are much shorter than average.

***Arphia conspersa* Scud. [Oedipodinae]**

Egg-sac.— Elongate-cylindrical with a slightly narrower neck which comprises about two-thirds the length of sac; walls rather thin so that the outline of the eggs is occasionally visible; length 28 to 33 mm.

Egg.— Somewhat irregularly placed in three rows or more frequently the lower part with three and the upper with two rows. There are from 12 to 32 eggs in a sac. Posterior ring wide, smooth; general colour creamy changing to brown; length 6 mm.

***Cratypedes neglectus* (Thom.) [Oedipodinae]**

Egg-sac.— Elongate-cylindrical, about three times as long as wide, the empty portion very short; walls moderately thick but brittle; length 13 to 18 mm.

Egg.— Closely packed, usually in three rows, ranging from 8 to 26 to a sac; chorion rather thick, the surface deeply reticulated, usually with an obscure median tubercle in the meshes. Colour clay-yellow, often with a creamy bloom and pale streaks; length 6 mm.

The resemblance to *Camnula* both in the sacs and eggs is apparent.
Specimens obtained in British Columbia and Manitoba.

***Camnula pellucida* (Scud.) [Oedipodinae]**

Egg-sac.— Elongate-cylindrical, rarely curved, empty neck or lacking, the walls thick and moderately tough; length about 17 mm.

Egg.— Closely packed in a three row formation numbering 12 to 28 to a sac with an average of 18. Posterior ring narrow; reticulation deep, rather fine, with an obscure median tubercle in the meshes. Colour pale cream frequently with darker streaks, palest where contact is made with other eggs; length 4 to 6 mm.

***Trachyrhachys kiowa kiowa* (Thom.) [*Trachyrhachys kiowa* (Thomas)] [Oedipodinae]**
[Drawing of chorion sculpture and photomicrograph of whole egg in Tuck and Smith (1939)]

Egg-sac.— Elongate, sub-cylindrical, usually abnormally wide below, the walls rather thin and fitting closely to the eggs; empty part occupies half the sac; length 17 mm.

Egg.— Closely packed in three rows, more rarely in four, with an odd egg misplaced; average number of eggs 16, range of variation 10 to 25. Eggs rather pointed, posterior ring narrow, concave, chorion very thick; reticulation fine, angulate, the dividing lines thin. Colour pale brown to Indian-red, streaked with lighter shades adjacent to other eggs; length 4.8 mm.

***Metator pardalinus* (Saus.) [Oedipodinae]**

Egg-sac.— Elongate sub-cylindrical, wider below, the upper half without eggs. Walls thin and fragile; length 20 to 30 mm.

Egg.— The eggs are in four irregular rows, the number to a sac varying from 10 to 26. Size large, tapering abruptly at the posterior extremity, cap constricted and produced, ring narrow. Chorion thick, the surface semi-foveolate or obscurely reticulated, the meshes of various shapes but usually sub-angulate or round, containing a series of dark punctures; interspaces almost as wide as the foveolae. Colour at first, pale clay-yellow becoming brown ochre with pale streaks; length 6.5 mm.

Specimens obtained at Estevan, Sask., and Goodlands, Manitoba.

***Metator nevadensis* (Brun.) [Oedipodinae]**

Egg-sac.– Very similar to [*M.*] *pardalinus*, length 30 mm.

Egg.– Indistinguishable from those of the above species, either in shape, pattern, or colour; length 6.5 mm.

Material secured from British Columbia.

***Dissosteira carolina* (L.) [Oedipodinae]**

[Photomicrograph of chorion in Bushland (1934); drawing of chorion sculpture and photomicrograph of whole egg in Tuck and Smith (1939)]

Egg-sac.– Elongate-cylindrical, usually curved, the egg-free portion short not more than a quarter of the sac; walls moderately thick, more so than in *Spharagemon* but easily broken; length 31 to 50 mm.

Egg.– The eggs are in fairly regular four row formation and number from 26 to 69 with an average of 56. Chorion of moderate thickness, reticulation with fine dividing lines and a median tubercle which is easily rubbed off. Posterior ring wide, smooth; colour light brownish-pink, the dividing lines darker. Length 5 to 6 mm.

***Spharagemon aequale* (Say) [*Spharagemon equale* (Say)] [Oedipodinae]**

[Photomicrograph of whole egg in Tuck and Smith (1939)]

Egg-sac.– Elongate-cylindrical, usually curved, eggs occupying about half the sac; walls rather thin, fragile, an outline of the eggs being occasionally visible; length 18 to 22 mm.

Egg.– The eggs are in a fairly regular three row formation, they range from 6 to 22 to a sac, 14 being an average of six sacs. Posterior ring wide with a row of elongate punctures; chorion of moderate thickness, the reticulation fine, well defined, with a median tubercle. Colour pinkish-cream to dull salmon-pink; length 6 mm.

The specimens come from Alberta.

***Spharagemon collare* (Scud.) [Oedipodinae]**

[Photomicrograph of whole egg in Tuck and Smith (1939)]

Egg-sac.– Of the same general shape as *aequale* [*S. equale*], walls thin and fragile; length about 20 mm.

Egg.– The eggs are in three rows or rarely in two rows, and average from 10 to 20 in number. Posterior ring as in *aequale* [*S. equale*]; reticulation less well defined and larger. Colour creamy

with a pinkish tinge; length 5.5 to 6 mm. The pink colour seems to be peculiar to this genus and *Dissosteira*.

***Spharagemon bolli* (Scud.) [Oedipodinae]**

Egg-sac.— Like that of [*S.*] *collare*; length 10 to 20 mm, average 19 mm.

Egg.— As [*S.*] *collare*, ranging from 6 to 26 to a sac. The pattern is also similar but the meshes seem to be wider and frequently lack the central tubercle. Colour pale cream with a pinkish flush, later becoming darker; length 6 mm.

***Trimerotropis agrestis* McN. [Oedipodinae]**

Egg-sac.— Elongate-cylindrical, a little stout, the walls moderately thick but fragile; length 20 to 26 mm.

Egg.— Arranged in three or four rows, numbering about 22 to a sac; posterior cap a little produced, the ring wide and smooth. Colour dull clay-yellow, changing to pale brown; length 6 mm.

***Trimerotropis maritima maritima* (Harr.) [*Trimerotropis maritima* (Harris)] [Oedipodinae]**

Egg-sac.— Elongate-cylindrical, the egg-free neck rather short not exceeding a quarter of the total length of sac; walls rather thin and fragile; length 14 to 20 mm.

Egg.— The eggs are in three rows and number from 20 to 32 per sac. Posterior cap ill defined with a line of elongate punctures, chorion thin, the reticulation of moderate size, containing the usual central tubercle which is frequently rubbed off. Colour creamy with a slight brownish shade; length 5 mm. The eggs from which this description was made were old and rather dry.

The specimens came from Point Pelee, Ontario.

***Trimerotropis gracilis sordida* E.M.Walk. [*Trimerotropis gracilis* (Thomas)] [Oedipodinae]**

Egg-sac.— Elongate-cylindrical, narrow, the walls moderately thick but fragile; the egg-free portion comprises about a third of the sac; length about 20 mm.

Egg.— The eggs are in two or three rows and average 16 to a sac. Posterior cap produced into an obtuse sub-button shaped knob, the ring obscure; pattern normal. Colour pale cream; length 5 mm.

Specimens collected at Hatton, Saskatchewan.

***Trimerotropis sparsa* (Thom.) [Oedipodinae]**

Egg-sac.—Elongate-cylindrical, usually curved at lower third, the empty portion short; walls thin and fragile, the outline of the eggs being frequently visible; length 20 to 26 mm.

Egg.—The eggs are in three rows and number about 30. Posterior extremity a little produced, ring rather wide, concave; pattern similar to other species; length 5.2 mm.

The specimens came from the Marias Hills, Montana.

***Trimerotropis pallidipennis salina* McN. [*Trimerotropis salina* McNeill] [Oedipodinae]**

Egg-sac.—Of the usual shape but large, about half the total length being free of eggs; walls moderately thick but easily broken; length 30 mm.

Egg.—The eggs are in a three or four row formation and average 35 to a sac. Posterior ring wide, smooth; reticulation normal; colour creamy, to pale clay-yellow; length 4.5 mm.

***Trimerotropis laticincta* Saus. [*Trimerotropis latifasciata* Scudder] [Oedipodinae]**

Egg-sac.—Elongate-cylindrical, in all respects closely resembling the sac of [*T.*] *salina*; length 30 to 37 mm.

Egg.—The eggs are in three rows and average 30 to a sac. Posterior ring obscure with a row of elongate punctures. Pattern normal but apt to be obscured by a film of varnish-like matter. Colour pale clay-yellow, becoming more brown with age; length 5 to 5.5 mm.

The specimens were obtained from southern Saskatchewan.

***Trimerotropis campestris* McN. [*Spharagemon campestris* (McNeill)] [Oedipodinae]**

Egg-sac.—Elongate-cylindrical, usually curved, the empty portion occupying a third of the sac; walls rather thin and frail; length 15 to 20 mm.

Egg.—The eggs are in three rows and average 20 to a sac. Posterior extremity obscurely button-shaped, the ring indefinite or well defined, wide; reticulation fine, easily displaced. Colour at first pale creamy-yellow, later turning to dull brown or almost black; length 5 mm.

***Trimerotropis pistrinaria* Saus. [Oedipodinae]**

Egg-sac.—Of the usual shape, rather closely resembling that of [*Spharagemon*] *campestris*; the walls thin and frail; length 11 to 18 mm.

Egg.—Usually in two rows, averaging from 10 to 18 to a sac. Posterior ring narrow or moderately wide; reticulation fine often obscure. Colour pale cologne-earth, darkening with age; length 5.6 mm.

The specimens came from southern Alberta and Saskatchewan.

***Circotettix verruculatus* Kby. [*Trimerotropis verruculata verruculata* (Kirby)] [Oedipodinae]**

Egg-sac.—Elongate-cylindrical, usually curved, the portion containing the eggs a little wider than the upper empty half; walls rather thin and brittle; length 23 mm, width 4 mm.

Egg.—The eggs are in three rows and average 26 to a sac. Of 28 sacs examined the eggs ranged from 16 to 28. Posterior extremity rounded, the ring rather narrow, smooth, concave; surface finely reticulated, the meshes containing a median tubercle. Colour gamboge-yellow; length 4.5 to 5 mm.

***Circotettix rabula rabula* R. and H. [*Circotettix rabula* Rehn and Hebard] [Oedipodinae]**

Egg-sac.—Very similar to that of *verruculatus* [*Trimerotropis verruculata verruculata*], possibly averaging a little smaller.

Egg.—As *verruculatus* [*T. verruculata verruculata*], the eggs average 24 to a sac.

***Aerochoreutes carlinianus* (Thom.) [*Circotettix carlinianus* (Thomas)] [Oedipodinae]**

Egg-sac.—Very elongate, cylindrical, the egg cavity a little wider than the empty neck which comprises rather more than half the total length of sac; walls moderately thick and rather tough; length 37 mm.

Egg.—The eggs are in two rows, numbering from 20 to 30 to a sac. Posterior cap a little produced, the ring narrow, obscure; surface semi-smooth due to a thick coating of varnish-like matter which hides a well defined reticulation, this latter showing at the juncture of other eggs or where the coating has been removed. Colour clay-yellow, darker at the extremities. Length 5.6 mm. The above description is made from but three sacs of eggs, obtained from Saskatchewan.

GUIDE TO THE “CYRTACANTHACRINAE”

[The subfamily Cyrtacanthacrinae is now considered a synonym of Cyrtacanthacridinae, which continues to be a valid subfamily. However, with one exception, all the species Criddle included within the section “Cyrtacanthacrinae” are now in the subfamily Melanoplinae; the exception is *Schistocerca lineata*, which is in the Cyrtacanthacrinidae. To maintain the integrity of his key, we have retained Criddle’s use of “Cyrtacanthacrinae”, but identify it as inconsistent with current interpretation by placing it in quotation marks. The current subfamily of each species is given in the headings of the individual species treatments below.]

Egg-sac either short and wide or elongate-cylindrical; in the short sacs the walls are nearly always thick and tough; in the elongate ones they are usually corky and easily broken. The eggs, without exception are definitely reticulated and in no case is there a median tubercle in the meshes. A great majority of the eggs are pale in colour, rarely either brown or pink but there is

considerable variation in the thickness of the chorion. In the genus *Asemoplus* the eggs are hispid or tuberculate. It seems possible that *Bradynotus* [probably refers to *Bradynotes obesa* (Thomas)] may also have this characteristic.

“Cyrtacanthacrinae” Affinities

There are a number of interesting segregations suggested in the study of this subfamily. The first of these is in *Hypochlora* and *Hesperotettix* the close affinities of which are indicated in all stages of development. *Aeolopus* [*Aeoloplides turnbulli*] probably has a place here but we cannot be sure until the nymphal instars have been studied. It is possible too, that *Asemoplus* should be placed near the above mentioned species instead of after *Melanoplus*; this is suggested by the form of the egg-sac; but not so strikingly so by the nymph.

The species *Schistocerca lineata*, in the large egg-sac, suggests relationship with the *bivittatus* group of *Melanoplus* but not very close. It seems to fit as well here as anywhere else.

Both *Melanoplus bivittatus* and [*M.*] *differentialis* are closely allied and they form a well defined natural group worthy of at least sub-generic separation. This is shown by the large egg-sac with its great number of eggs and the unusual colour of the eggs.

The small unlike *Melanoplus dawsoni* follows next in our present classification but it does not seem to fit. Indeed the short egg-sac suggests [*Melanoplus*] *islandicus* as a near relation and this is also indicated by the egg, especially in the rather wide posterior ring. The nymph of *dawsoni* however, is very unlike any other species of the genus and it seems to have *luridus* [*Melanoplus keeleri luridus*] as its nearest ally. *Femur-rubrum* [*Melanoplus femurrubrum*] and *borealis junius* [*Melanoplus borealis*] may come next; this is suggested by the nymphal instars. There seems no doubt that [*Melanoplus*] *infantilis* and [*Melanoplus*] *gladstoni* are closely related, while [*Melanoplus*] *occidentalis*, [*Melanoplus*] *confusus*, and perhaps [*Melanoplus*] *kennicottii* seem to follow in a fairly natural sequence. *Mexicanus* [*Melanoplus sanguinipes sanguinipes*] and [*Melanoplus*] *bruneri* form a poorly defined group which seems to have strong affinities with the previous one. The two species [*Melanoplus*] *flavidus* and [*Melanoplus*] *bowditchi canus* constitute another group with suggestions towards the next, represented by *packardii* [*Melanoplus packardii packardii*], *foedus* [*Melanoplus foedus foedus*], [*Melanoplus*] *stonei* and [*Melanoplus*] *angustipennis*. *Melanoplus fasciatus* seems to have affinities with *mexicanus* [*Melanoplus sanguinipes sanguinipes*], [*M.*] *islandicus* and perhaps [*Melanoplus*] *montanus*.

The species [*M.*] *montanus* in the recent lists is placed before *dodgei huroni* [*Melanoplus huroni*] and the nymphal instars suggest this may be correct but there seems, in our mind, no doubt that the latter represents a well defined separate genus. This is suggested in all stages of development.

It is doubtful, as we have intimated above, whether *Asemoplus* should be associated near the first groups, or as it is in present lists, at the end of *Melanoplus*.

The genus *Phoetaliotes* seems poorly defined from *Melanoplus*, the nymphs are very like those of *M. luridus* [*M. keeleri luridus*].

Key to the Genera of the “Cyrtacanthacrinae”

[**Note:** the nomenclature in this key is that used by Criddle; the reader should consult the species treatments that follow to find the current names of taxa.]

- Sacs not more than three times as long as wide, the walls thick and tough. Eggs on a single plane or more rarely in two layers [but see contradictory statement below for *Asemoplus*]. 1
- Sacs usually more than three times as long as wide; less tough; the eggs in elongate rows 4
- 1 Opening to sac on the side, concave, exceeding half the length of sac *Aeolopus*
- Opening on top, oblique or not, length less than half that of sac 2
- 2 Sac cylindrical or sub-cylindrical *Hypochlora*
- Sac pyriform or oval 3
- 3 Sacs almost as wide as long, the opening usually oblique, eggs approximately on the same plane number 9 to 14. *Hesperotettix*
- Sacs, as a rule, distinctly longer than wide the opening horizontal or nearly so; eggs in 2 or 3 rows, 7 to 8 in a sac *Asemoplus*
- 4 Sacs very large, eggs exceeding 35 to a sac 5
- Sacs of medium size the number of eggs rarely exceeding 25 6
- 5 Sacs 45 mm long, the walls somewhat felty. Eggs without definite arrangement, 35 to 64 in number. *Schistocerca*
- Sacs less large, about 30 mm long, the walls not felty. Eggs in an irregular 4 row formation *varying* in number from 34 to more than 100; colour brown-pink *Melanoplus bivittatus* and [*M.*] *differentialis*
- 6 Sacs narrow, elongate-cylindrical, usually abruptly curved at lower third, the egg-free portion occupying two-thirds of sac; length 24-27 mm. Eggs in two or three rows; polished, reticulation fine, without colour contrast except at the posterior extremity where it is darker. *Phoetaliotes*
- Sacs usually less narrow and not as long. Reticulation darker than background, not in contrast at the extremity; colour usually pale yellow *Melanoplus* proper
- Sac sub-pyriform or definitely wider below. Chorion thick, opaque, the surface sub-foveolate or obscurely reticulated, the meshes round, oval or oblong, not angulate, interspaces wide; colour reddish-brown *Melanoplus dodgei huroni*

***Hypochlora alba* (Dodge) [Melanoplinae]**

[Drawing of chorion sculpture and photomicrograph of whole egg in Tuck and Smith (1939)]

Egg-sac.— Cylindrical to narrowly pyriform, the empty portion occupying about a third of the total length of sac; opening horizontal or a little oblique; walls moderately thick and tough; length 12 to 14 mm.

Egg.— The eggs are in an oblique position but when the sac rests naturally, point directly upward; they vary from 7 to 16 in number. Generally five or six rest side by side with others lower down in less regular formation. In other sacs the arrangement is almost exactly like that of

Hesperotettix. Posterior ring plain or not, usually darker than the rest of chorion; reticulation well defined, usually five-sided. Colour bright clay-yellow; length 4 mm.

The specimens were obtained from North Dakota. Some 70 sacs of eggs were examined.

***Hesperotettix viridis pratensis* (Scud.) [Melanoplinae]**

[Drawing of chorion sculpture in Tuck and Smith (1939)]

Egg-sac.— Short, semi-round or pyriform only slightly longer than wide, the opening usually at an angle, concave, occupying almost half the length of sac; walls thick and tough; length 8 mm, width 6.5 mm.

Egg.— The eggs are at somewhat different elevations but appear almost on the same level when the sac is in its natural position, they number from 9 to 14. To begin with the eggs are tightly packed in the sac. Posterior cap produced into a button-like protuberance, the ring obscure. The chorion is a little thicker than that of *Hypochlora*, the reticulation smaller and less definitely angulate. Colour dull clay-yellow, lighter where it comes in contact with other eggs; length 5 mm.

Description made from 45 sacs of eggs obtained at Estevan, Sask., and Lethbridge, Alberta.

***Aeolopus turnbulli* (Thom.) [*Aeolopides turnbulli* (Thomas)] [Melanoplinae]**

[Drawing of chorion sculpture and photomicrograph of whole egg in Tuck and Smith (1939)]

Egg-sac.— Short sub-cylindrical, about twice as long as wide, the upper side flattened and somewhat concave for more than half the length of sac. There is no empty neck; walls moderately thick and very tough; length 10 mm, width 5 mm.

Egg.— The eggs are tightly packed in rows of four so that their upper extremity faces the elongate opening in the side of the sac; the number of eggs to a sac range from 16 to 34, the average being 22. Posterior cap produced into a broad button-like projection, ring narrow, concave; chorion moderately thick, the reticulation large, the meshes angulate usually five or six-sided, the dividing ridges stout and well defined. Colour clay-yellow, darker at the extremities; length 4.2 mm.

Adults were collected at Kincaid and Hatton, Sask.

***Asemoplus montanus* (Brun.) [Melanoplinae]**

Egg-sac.— Short sub-pyriform, the best defined sacs having a slightly rimmed, short neck with a deeply concave top; the walls are thick and tough; length 8 to 14 mm, width 5 to 6 mm.

Egg.— The eggs are in two or three rows and number from seven to eight, since, however, the sac rests sub-horizontally the eggs point almost directly upwards. They are tightly packed and stuck

together. Posterior cap slightly produced, the ring narrow; chorion of moderate thickness; dividing lines of reticulation with strong pointed tubercles. Colour clay-yellow; length 5 mm.

More than 50 egg-masses were examined, the adults coming from British Columbia.

***Asemoplus somesi* Hebard [*Buckellacris nuda nuda* (Walker)] [Melanoplinae]**

Egg-sac.— Apparently like [*A.*] *montanus*. The specimens came from Waterton Lakes, Alberta.

***Schistocerca lineata* Scud. [Cyrtacanthacridinae]**

[Photomicrograph of whole egg in Tuck and Smith (1939)]

Egg-sac.— Elongate-cylindrical, the lower third containing the eggs, distinctly dilated; walls moderately thick, somewhat felty; length 52 mm, width of neck 6.5 mm, egg-chamber 10 mm.

Egg.— The eggs are in an elongate mass without definite arrangement, most of them point upwards, others are oblique; the number varies from 35 to 64. Posterior cap rounded, the ring wide, concave. Chorion rather thick the reticulation more or less coated over with a film of sub-opaque matter. Colour Van Dyke brown, paler where the eggs come in contact with each other; length 6.4 mm.

The specimens came from Medicine Hat and were secured by the aid of Mr. S.F. Carr.

***Melanoplus bivittatus* (Say) [Melanoplinae]**

[Photomicrograph of chorion in Bushland (1934); photomicrograph of whole egg in Tuck and Smith (1939)]

Egg-sac.— Elongate-cylindrical, usually curved, the egg-free portion occupying about half the total length. Walls moderately thick but easily broken; length about 35 mm.

Egg.— The eggs are in very irregular four rows, rarely five, and occasionally reduced to three at the extremities. Number to a sac from 34 to 114, 68 being an average. Posterior ring obscure; reticulation rather large; colour brown-pink, or greenish-orange, gamboge yellow when freshly laid; length 5.1 mm.

***Melanoplus differentialis* (Thom.) [Melanoplinae]**

[Photomicrograph of chorion in Bushland (1934); photomicrograph of whole egg in Tuck and Smith (1939)]

Egg-sac.— Practically as [*M.*] *bivittatus*.

Egg.— The irregular arrangement of the eggs, their number and colour closely resemble those of *bivittatus*.

Specimens were secured from Utah and South Dakota.

***Melanoplus femur-rubrum femur-rubrum* (DeG.) [*Melanoplus femurrubrum* DeGeer]**
[Melanoplinae]

[Photomicrograph of chorion in Bushland (1934); photomicrograph of whole egg in Tuck and Smith (1939)]

Egg-sac.—Elongate-cylindrical, not appreciably wider below, the egg-chamber occupying half the total length; walls moderately thick, rather brittle; length 4.5 mm [Probably an error as the egg-sac cannot be shorter than egg length].

Egg.—The eggs are in an irregular three-row formation and number about 23 to a sac. Posterior ring obscure a little concave; reticulation close and even; colour clay-yellow, the cap darker; length 5 mm.

***Melanoplus keeleri luridus* (Dodge) [Melanoplinae]**

[Photomicrograph of chorion in Bushland (1934)]

Egg-sac.—Elongate-cylindrical, a little more narrow above the egg-chamber occupying from a third to half the sac; walls moderately thick and brittle; length 18 mm.

Egg.—Number of eggs to a sac 10 to 20 arranged in fairly regular two or three rows. Posterior ring narrow; chorion rather thick the surface strongly reticulated; colour bright clay-yellow; length 5 mm.

***Melanoplus dawsoni* Scud. [Melanoplinae]**

[Photomicrograph of chorion in Bushland (1934)]

Egg-sac.—Sub-cylindrical, widest below the egg chamber comprising about two-thirds the length of sac; walls thick and tough; length approximately 12 mm.

Egg.—Average number of eggs 11, these are in a close-packed double row. Posterior cap somewhat produced, ring wide, concave; reticulation prominent; colour bright clay-yellow; length 4.8 to 5 mm.

***Melanoplus occidentalis occidentalis* (Thom.) [*Melanoplus occidentalis* (Thomas)]**
[Melanoplinae]

Egg-sac.—Elongate-cylindrical, rather slender, the egg-chamber occupying about half the total length; walls rather thin and weak; length 20 mm.

Egg.—The eggs are in two rows and number 5 to 14. Posterior ring narrow, reticulation normal; colour pale clay-yellow; length 5 mm.

The single adult was obtained from the Marias Hills, Montana.

***Melanoplus borealis junius* (Dodge) [*Melanoplus borealis* (Fieber)] [Melanoplinae]**

Egg-sac.— Elongate-cylindrical, the egg-chamber occupying half the entire length of sac; walls rather thin and weak; length 21 to 25 mm.

Egg.— The eggs are in two or three rows and average 14 to a sac. Posterior ring rather narrow; reticulation normal; colour bright, pale, clay-yellow; length 5.5 mm.

***Melanoplus infantilis* (Scud.) [Melanoplinae]**

Egg-sac.— Elongate cylindrical, the egg-chamber occupying more than a third the length of sac; walls rather thin and weak; length 15 mm.

Egg.— The eggs are in two row formation and number about 12 to a sac; other features normal, colour pale clay-yellow; length 5 mm.

***Melanoplus gladstoni* Scud. [Melanoplinae]**

[Photomicrograph of chorion in Bushland (1934); photomicrograph of whole egg in Tuck and Smith (1939)]

Egg-sac.— Elongate-cylindrical, a little narrower above, the egg-chamber about two-thirds the total length of sac, occasionally the neck is longer; walls moderately thick; fragile; length 12 to 21 mm.

Egg.— The eggs are in three irregular rows and number 10 to 18. Posterior cap a little produced, the ring poorly defined; reticulation normal; colour bright clay-yellow; length 5 mm.

***Melanoplus kennicotti kennicotti* (Thom.) [*Melanoplus kennicotti* Scudder] [Melanoplinae]**

Egg-sac.— Elongate-cylindrical, a little wider below; egg chamber occupying half the sac; walls normal for the genus; length 19 to 28 mm; width 4 mm.

Egg.— The eggs are in two rows of unequal height, they number 8 to 12 in a sac. Posterior ring wide, shallowly concave; chorion thin reticulation uniform; colour pale clay-yellow; length 5 mm.

Specimens were obtained from Jasper, Alberta. The study included 44 sacs of eggs.

***Melanoplus confusus* Scud. [Melanoplinae]**

[Photomicrograph of whole egg in Tuck and Smith (1939)]

Egg-sac.— Elongate-cylindrical, the walls moderately thick but easily broken; egg-chamber occupying half the length of sac; length 22 mm.

Egg.— Arranged in two or three rows and average 14 in number. Posterior cap a little produced, the ring narrow; chorion of moderate thickness; reticulation like that of [*M.*] *kennicottii* but more irregular. Colour bright clay-yellow; length 5 mm.

***Melanoplus mexicanus* (Saus.) [*Melanoplus sanguinipes sanguinipes* (Fabricius)]**
[Melanoplinae]

Egg-sac.— Elongate-cylindrical, usually a little wider below, the egg chamber occupying half the length of sac; walls of moderate thickness but easily broken; length 19 to 28 mm.

Egg.— The eggs are generally in three rows, more rarely in two rows; they number 10 to 20 to a sac. Posterior cap somewhat produced the ring moderately wide, concave, reticulation very like that of [*M.*] *confusus*; colour pale clay-yellow; length 5.5 mm.

***Melanoplus bruneri* Scud. [Melanoplinae]**

Egg-sac.— Elongate-cylindrical, very like that of *mexicanus* [*M. sanguinipes sanguinipes*]; length 24 mm.

Egg.— The eggs are in three rows and average 16 to a sac, the greatest number found being 22. Posterior ring fairly wide, concave; chorion as in *mexicanus* [*M. sanguinipes sanguinipes*]; colour clay-yellow, the cap a little darker, length 5.3 mm.

***Melanoplus bowditchi canus* Hebard [Melanoplinae]**

Egg-sac.— Elongate-cylindrical, slightly wider below, the walls thin and flimsy, breaking away from the eggs very readily; about a third is free of eggs; length 20 mm.

Egg.— The eggs are in a rather irregular three-row formation and number from 8 to 20. Eggs tapering rather abruptly at the posterior end, the ring moderately wide, concave, giving the appearance of being dilated. Chorion rather thick the reticulation fine with indistinctly angulate meshes. Colour pale cream to bright clay-yellow; length 5 to 6 mm.

The specimens came from Medicine Hat, Alberta. Only eleven sacs of eggs were examined.

***Melanoplus flavidus* Scud. [Melanoplinae]**

Egg-sac.— Elongate- cylindrical, a little wider below; the egg-chamber occupying from a half to two-thirds of the entire length of sac; walls thin and weak; length 23 mm.

Egg.— The eggs are in three irregular rows and number about 10 to a sac. Posterior cap a little produced, the ring wide, concave; chorion rather thick, reticulation as in *canus* [*M. bowditchi canus*]. Colour pale clay-yellow; length 5 mm.

***Melanoplus packardii* Scud. [*Melanoplus packardii packardii* Scudder] [Melanoplinae]**
[Photomicrograph of chorion in Bushland (1934); drawing of chorion sculpture and photomicrograph of whole egg in Tuck and Smith (1939)]

Egg-sac.— Elongate-cylindrical, rather stout, walls fragile; length 18 to 24 mm.

Egg.— The eggs are in three irregular rows more rarely in four rows, and average 18 to a sac. Posterior cap scarcely produced, the ring indefinite; chorion rather thick, the reticulation fine. Colour pale clay-yellow; length 5.5 to 6 mm.

***Melanoplus foedus foedus* Scud. [Melanoplinae]**

[Photomicrograph of whole egg in Tuck and Smith (1939)]

Egg-sac.— Very like that of *packardii* [*M. packardii packardii*]

Egg.— We can discern no constant difference between this egg and those of *packardii* [*M. packardii packardii*].

***Melanoplus foedus stonei* Rehn [Melanoplus stonei Rehn] [Melanoplinae]**

Egg-sac.— Elongate-cylindrical. Very like *foedus* [*M. foedus foedus*]; the egg-chamber comprising from a third to half the total length of sac; walls fragile; length 18 to 22 mm.

Egg.— The eggs are arranged in a three or four row formation and number from 6 to 22, 14 being an average. Posterior cap a little produced, the ring moderately wide, smooth; chorion rather thick, reticulation well defined; length 5.5 mm.

Described from 36 sacs of eggs.

***Melanoplus angustipennis* Dodge [Melanoplinae]**

[Photomicrograph of whole egg in Tuck and Smith (1939)]

Egg-sac.— Elongate-cylindrical, the egg-chamber occupying from a third to half the sac; walls thin and fragile; length about 20 mm.

Egg.— Usually in three rows, rarely in two rows, they average 14 to a sac; posterior cap a little produced, the ring narrow; chorion rather thick, the reticulation fine; colour pale clay-yellow; length 5 to 5.5 mm.

***Melanoplus islandicus* Blat. [Melanoplinae]**

Egg-sac.— Elongate, sub-cylindrical usually distinctly wider below, more rarely of almost equal width throughout; the empty part comprising about half the total length of sac; walls moderately thick and fairly tough; length 12 to 15 mm.

Egg.— The eggs are in two or three rows which overlap so that when the sac rests naturally they are almost on a level; posterior cap a little produced, the ring moderately wide, concave; chorion thick, opaque; reticulation fine, irregular. Colour clay-yellow becoming brown with age, lighter adjacent to other eggs; length 5.5 mm.

***Melanoplus fasciatus* (F. Walk.) [Melanoplinae]**

Egg-sac.— Elongate-cylindrical, a little wider below, the egg chamber occupying half the total length of sac; walls moderately thick and tough; length 14 to 16 mm.

Egg.— The eggs are in an irregular four-row formation and average 11 to a sac; posterior ring narrow, smooth; chorion moderately thick; reticulation fine and irregular. Colour bright clay-yellow with darker suffusions, length 5 mm.

***Melanoplus montanus* (Thom.) [Melanoplinae]**

Egg-sac.— Elongate-cylindrical, the egg-chamber occupying from a third to three-quarters of the entire sac; walls of moderate thickness; length 24 mm, width 5 mm.

Egg.— The eggs are in two rows and vary in number from 10 to 12. Posterior cap a little produced, the ring obscure; chorion of moderate thickness, the reticulation fairly uniform. Colour clay-yellow; length 5 mm.

Twelve sacs of eggs obtained from Blairmore, Alberta.

***Melanoplus dodgei huroni* Blat. [*Melanoplus huroni* Blatchley] [Melanoplinae]**

Egg-sac.— Sub-cylindrical or elongate, pyriform, variable but usually distinctly wider below and tapering apically; walls rather thick and tough; length 20 mm.

Egg.— The eggs are in a fairly uniform three-row formation and number about 20 to a sac. Posterior cap obtuse at tip, the ring rather wide, concave; chorion thick, opaque, the pattern semi-foveolate or obscurely reticulated, the meshes round, oval or oblong, interspaces wide. Colour reddish-brown, paler at the junction of other eggs; length 6 mm.

***Phoetaliotes nebrascensis* (Thom.) [Melanoplinae]**

[Photomicrograph of chorion in Bushland (1934)]

Egg-sac.— Elongate-cylindrical, usually abruptly curved at lower third, the eggs occupying about a third of the sac; walls of moderate thickness and fairly strong; length 24 to 27 mm., width 3 to 4 mm.

Egg.— The eggs are in two rows, rarely three rows, they vary in number from 10 to 20. Posterior cap a little produced, the ring consisting of a row of elongate, dark punctures; chorion of moderate thickness, the reticulation obscured by an over-coating of sub-opaque material. The dividing lines are fine and being of the same colour as the background are difficult to see. The lines on the posterior cap are dark thus providing a marked contrast to the rest. Length 4.5 to 5 mm.

Specimens were secured in North Dakota and Alberta.

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APPENDIX: Slides of egg chorions prepared by N. Criddle and his colleagues and now in the J.B. Wallis/R.E. Roughley Museum of Entomology, University of Manitoba.

Notes:

1. With the exception of the column headed "Current Name", all information in the table is exactly as presented on the slide labels.
2. It should be noted that specimens listed below are not necessarily those upon which Criddle based his descriptions and keys.

Genus on Label	Species on Label	Current Name	Date	Year	Preparator's Name	Slide Number	Comments
<i>Contypides</i>		{perhaps <i>Cratypedes</i> }	14.ix.1931	1931	R.M.W.	15	BC
<i>Acrolophitus</i>	<i>Hirtipes</i>	<i>Acrolophitus hirtipes</i> (Say, 1825)	25.ix.1930	1930	N. Criddle	45	Egg Chorion Lethbridge Alta
<i>Eeoloplus</i>	<i>Turnbulli</i>	<i>Aeoloplides turnbulli turnbulli</i> (Thomas, 1872)	23.x.1931	1931	R.M. White		Egg Chorions of
<i>Aerochoreutes</i>	<i>carlinianus Thom</i>	<i>Circotettix carlinianus</i> (Thomas, 1870)	7.ix.32	1932			Alberta
<i>Aerochoreutes</i>	<i>carlinianus Th</i>	<i>Circotettix carlinianus</i> (Thomas, 1870)	7.vii.1932	1932		62	Sask
<i>Aerochoreutes</i>	<i>carlinianus</i>	<i>Circotettix carlinianus</i> (Thomas, 1870)	23.x.1931	1931	R.M. White		Egg Chorion of
<i>Arphia</i>	<i>Frigida</i>	<i>Arphia conspersa</i> Scudder, 1875	20.vii.29	1929	N. Criddle	22	Aweme Man.
<i>Arphia</i>	<i>Frigida</i>	<i>Arphia conspersa</i> Scudder, 1875	20.vii.29	1929	N. Criddle		Aweme Man
<i>Arphia</i>	<i>Frigida</i>	<i>Arphia conspersa</i> Scudder, 1875	7.vii.37	1937	DSS	3 8489	Egg chorion
<i>Arphia</i>	<i>Frigida</i>	<i>Arphia conspersa</i> Scudder, 1875	7.vii.37	1937	D.S.S.	4 8489	Egg chorion
<i>Arphia</i>	<i>pseudonietana</i>	<i>Arphia pseudonietana</i> (Thomas, 1870)	1.xi.1929	1929			
<i>Arphia</i>	<i>pseudonietana</i>	<i>Arphia pseudonietana</i> (Thomas, 1870)	13.x.1930	1930	N. Criddle	46	Egg Chorions
<i>Asemoplus</i>	<i>Montanus</i>	<i>Asemoplus montanus</i> (Bruner, 1885)	14.ix.1931	1931	RMW	6	Egg Chorion
<i>Asemoplus</i>	<i>herpedulus</i>	<i>Asemoplus montanus</i> (Bruner, 1885) [probably]				17	Waterton Alta
<i>Aulocara</i>	<i>Elliotti</i>	<i>Aulocara ellioti</i> (Thomas, 1870)	14.ix.1931	1931	R.M.W.		Egg Chorion
<i>Bruneria</i>	<i>Brunnea</i>	<i>Bruneria brunnea</i> (Thomas, 1871)	2.xi.1929	1929			
<i>Bruneria</i>	<i>Brunnea</i>	<i>Bruneria brunnea</i> (Thomas, 1871)	2.v.1929	1929		21	
<i>Camnula</i>	<i>Pellucida</i>	<i>Camnula pellucida</i> (Scudder, 1862)	4.xi.1932	1932			Carman, Man
<i>Camnula</i>	<i>Pellucida</i>	<i>Camnula pellucida</i> (Scudder, 1862)	29.iv.'29	1929			
<i>Camnula</i>	<i>Pellucida</i>	<i>Camnula pellucida</i> (Scudder, 1862)	4.xi.1932	1932		53	Carman, Man
<i>Camnula</i>	<i>Pellucida</i>	<i>Camnula pellucida</i> (Scudder, 1862)	Ap. 22 1932	1932		50	Altona Man

Genus on Label	Species on Label	Current Name	Date	Year	Preparator's Name	Slide Number	Comments
<i>Cammula</i>	<i>Pellucida</i>	<i>Cammula pellucida</i> (Scudder, 1862)	2.v.1929	1929		25	
<i>Chrysochraon</i>	<i>abdominalis</i>	<i>Chloealtis abdominalis</i> (Thomas, 1873)	4.xi.1929	1929		20	
<i>Choealtis</i>	<i>Conspersa</i>	<i>Chloealtis conspersa</i> (Harris, 1841)	25.ix.1930	1930	N. Criddle	41	Egg Chorions Aweme Man.
<i>Chorthippus</i>	<i>curtipennis</i>	<i>Pseudochorthippus curtipennis curtipennis</i> (Harris, 1835)	13.x.1930	1930	N. Criddle	42	Egg Chorions
<i>Circotettix</i>	<i>Rabula</i>	<i>Circotettix rabula</i> Rehn & Hebard, 1906	1.xi.1929	1929	NC		
<i>Circotettix</i>	<i>Rabula</i>	<i>Circotettix rabula</i> Rehn & Hebard, 1906	1.xi.1929	1929		26	
<i>Cordellacris</i>		<i>Cordillacris occipitalis</i> (Thomas, 1873) [probably]	14.ix.1931	1931	R.M.W.		
<i>Cratypedes</i>	<i>Neglectus</i>	<i>Cratypedes neglectus</i> (Thomas, 1870)	2.xi.1929	1929		23	
<i>Cratypedes</i>	<i>Neglectus</i>	<i>Cratypedes neglectus</i> (Thomas, 1870)	Ap 22 1932	1932		51	B.C.
<i>Cratypedes</i>	<i>neglectus Sc.</i>	<i>Cratypedes neglectus</i> (Thomas, 1870)	12.viii.1932	1932	NC	54	Aweme Man
<i>Dissosteira</i>	<i>Carolina</i>	<i>Dissosteira carolina</i> (Linnaeus, 1758)	1.xi.1929	1929		29	
<i>Dissosteira</i>	<i>carolina ?</i>	<i>Dissosteira carolina ?</i> (Linnaeus, 1758)	2.v.1929	1929		25	
<i>Dissosteira</i>	<i>carolina ?</i>	<i>Dissosteira carolina ?</i> (Linnaeus, 1758)	2.v.1929	1929		25	
<i>Hadrotettix</i>	<i>trifasciatus</i>	<i>Hadrotettix trifasciatus</i> (Say, 1825)	23.x.1931	1931	R.M. White	13	Egg Chorion of
<i>Hesperotettix</i>	<i>pratensis</i>	<i>Hesperotettix viridis pratensis</i> Scudder, 1897	25.ix.1930	1930	N. Criddle	39	Egg Chorions - immature Estevan Sask
<i>Hesperotettix</i>	<i>pratensis</i>	<i>Hesperotettix viridis pratensis</i> Scudder, 1897	30.ix.1929	1929		16	Egg Chorion
<i>Hypochlora</i>	<i>alba</i>	<i>Hypochlora alba</i> (G.M. Dodge, 1876)	28.x.1929	1929	N. Criddle	14	
<i>Melanoplus</i>	<i>angustipennis</i>	<i>Melanoplus angustipennis</i> (G.M. Dodge, 1877)	29.iv.'29	1929		16	
<i>Melanoplus</i>	<i>angustipennis</i>	<i>Melanoplus angustipennis</i> (G.M. Dodge, 1877)	30.iv.1929	1929		23	
<i>M</i>	<i>angustipennis</i>	<i>Melanoplus angustipennis</i> (G.M. Dodge, 1877)	2.v.1929	1929		24	
<i>Melanoplus</i>	<i>angustipennis</i>	<i>Melanoplus angustipennis</i> (G.M. Dodge, 1877)	30.iv.1929	1929		23	
<i>Melanoplus</i>	<i>bivittatus</i>	<i>Melanoplus bivittatus</i> (Say, 1825)	30.iv.'29	1929		13	
<i>Melanoplus</i>	<i>bivittatus</i>	<i>Melanoplus bivittatus</i> (Say, 1825)	15/8/39	1939	DSS	8489-10	Egg Chorion
<i>Melanoplus</i>	<i>bivittatus</i>	<i>Melanoplus bivittatus</i> (Say, 1825)	Dec. 3.1931	1931		2	Wiley, Colorado
<i>Melanoplus</i>	<i>bivittatus</i>	<i>Melanoplus bivittatus</i> (Say, 1825)	Dec. 3 1931	1931			Wiley, Colorado
<i>Melanoplus</i>	<i>bivittatus</i>	<i>Melanoplus bivittatus</i> (Say, 1825)	15/viii/39	1939		8489-9	Egg Chorion
<i>Melanoplus</i>	<i>bivittatus</i>	<i>Melanoplus bivittatus</i> (Say, 1825)	8.x.1932	1932	NC	65	Souris Man

Genus on Label	Species on Label	Current Name	Date	Year	Preparator's Name	Slide Number	Comments
<i>Melanoplus</i>	<i>bivittatus</i>	<i>Melanoplus bivittatus</i> (Say, 1825)	1.v.29	1929			Xylol 2.40 NaOH-20
<i>Melanoplus</i>	<i>borealis extremus</i>	<i>Melanoplus borealis</i> (Fieber, 1853)	12.viii.1932	1932		55	Aweme Man
<i>Melanoplus</i>	<i>extremus</i>	<i>Melanoplus borealis</i> (Fieber, 1853)	30.iv.'29	1929		7	
<i>Melanoplus</i>	<i>bowditchi canus</i>	<i>Melanoplus bowditchi canus</i> Hebard, 1925	13.x.1930	1930	N. Criddle	37	Egg Chorions
<i>Melanoplus</i>	<i>bruneri</i>	<i>Melanoplus bruneri</i> Scudder, 1897	12.viii.1932	1932		57	Aweme Man
<i>Melanoplus</i>	<i>bruneri</i>	<i>Melanoplus bruneri</i> Scudder, 1897	2.xi.1929	1929		3	
<i>Melanoplus</i>	<i>confusus</i>	<i>Melanoplus confusus</i> Scudder, 1897	8.viii.1930	1930	N. Criddle	34	Egg Chorions
<i>Melanoplus</i>	<i>confusus</i>	<i>Melanoplus confusus</i> Scudder, 1897	8.viii.1930	1930	N. Criddle	34	Egg Chorions
<i>Melanoplus</i>	<i>dawsoni</i>	<i>Melanoplus dawsoni</i> (Scudder, 1875)	13.x.1930	1930	N. Criddle	36	Egg Chorions
<i>Melanoplus</i>	<i>dawsoni</i>	<i>Melanoplus dawsoni</i> (Scudder, 1875)	12.iv.'39	1939		8489-#	
<i>Melanoplus</i>	<i>dawsoni</i>	<i>Melanoplus dawsoni</i> (Scudder, 1875)			DSS	8489-12	Egg Chorion
<i>Melanoplus</i>	<i>dawsoni</i>	<i>Melanoplus dawsoni</i> (Scudder, 1875)	12.iv.'39	1939		8489-12 (crossed out)	Chorion
<i>Melanoplus</i>	<i>dawsoni</i>	<i>Melanoplus dawsoni</i> (Scudder, 1875)			DSS	8489-13	Egg Chorion
<i>Melanoplus</i>	<i>differentialis</i>	<i>Melanoplus differentialis nigricans</i> Cockerell, 1917	Dec. 3 1931	1932		1	Wiley, Colorado
<i>Melanoplus</i>	<i>differentialis</i>	<i>Melanoplus differentialis nigricans</i> Cockerell, 1917	Dec. 3 1931	1931			Wiley, Colorado
<i>Melanoplus</i>	<i>fasciatus</i>	<i>Melanoplus fasciatus</i> (F. Walker, 1870)	2.xi.1929	1929		6	
<i>Melanoplus</i>	<i>femur-rubrum</i>	<i>Melanoplus femurrubrum</i> (DeGeer, 1773)	8.x.1932	1932	NC	67	Aweme Man
<i>Melanoplus</i>	<i>f.r. femur-rubrum</i>	<i>Melanoplus femurrubrum</i> (DeGeer, 1773)	14/8/39	1939	DSS	8489-16	
<i>Melanoplus</i>	<i>f.r. femur-rubrum</i>	<i>Melanoplus femurrubrum</i> (DeGeer, 1773)			DSS	8489-14	Egg Chorion
<i>Melanoplus</i>	<i>femur-rubrum</i>	<i>Melanoplus femurrubrum</i> (DeGeer, 1773)	2.xi.1929	1929		5	
<i>Melanoplus</i>	<i>flavidus</i>	<i>Melanoplus flavidus</i> Scudder, 1878	1.xi.1929	1929		10	
<i>Melanoplus</i>	<i>flavidus</i>	<i>Melanoplus flavidus</i> Scudder, 1878	15/8/39	1939	DSS	8489-17	
<i>Melanoplus</i>	<i>flavidus</i>	<i>Melanoplus flavidus</i> Scudder, 1878	14/8/39	1939	DSS	8489-18	
<i>Melanoplus</i>	<i>foedus foedus</i>	<i>Melanoplus foedus foedus</i> Scudder, 1878	16/8/39	1938	DSS	8489-20	
<i>Melanoplus</i>	<i>foedus foedus</i>	<i>Melanoplus foedus foedus</i> Scudder, 1878	16/8/39	1939	DSS	8489-21	
<i>Melanoplus</i>	<i>foedus foedus</i>	<i>Melanoplus foedus foedus</i> Scudder, 1878	16/8/39	1939	DSS	8489-19	
<i>Melanoplus</i>	<i>gladstoni</i>	<i>Melanoplus gladstoni</i> Scudder, 1897	2.xi.1929	1929			No 2

Genus on Label	Species on Label	Current Name	Date	Year	Preparator's Name	Slide Number	Comments
<i>Melanoplus</i>	<i>huronii</i>	<i>Melanoplus huronii</i> Blatchley, 1898	3.v.1929	1929		11	
<i>Melanoplus</i>	<i>huronii</i>	<i>Melanoplus huronii</i> Blatchley, 1898	3.v.1929	1929		71	
<i>Melanoplus</i>	<i>infantilis</i>	<i>Melanoplus infantilis</i> Scudder, 1878	16/8/39	1939	DSS	8489-24	
<i>Melanoplus</i>	<i>infantilis</i>	<i>Melanoplus infantilis</i> Scudder, 1878	23.viii.37	1937	DSS	8489-7	Egg Chorion
<i>Melanoplus</i>	<i>infantilis</i>	<i>Melanoplus infantilis</i> Scudder, 1878	12.iv.'39	1939		8489-48	Chorion
<i>Melanoplus</i>	<i>infantilis</i>	<i>Melanoplus infantilis</i> Scudder, 1878	16/8/39	1939	DSS	8489-23	
<i>Melanoplus</i>	<i>infantilis</i>	<i>Melanoplus infantilis</i> Scudder, 1878	23.viii.'37	1937	DSS	8489-8	Egg Chorion
<i>Melanoplus</i>	<i>infantilis</i>	<i>Melanoplus infantilis</i> Scudder, 1878	12.iv.39	1939		8489-7 ?	Chorion
<i>Melanoplus</i>	<i>infantilis</i>	<i>Melanoplus infantilis</i> Scudder, 1878	16/8/39	1939	DSS	8489-22	
<i>Melanoplus</i>	<i>infantilis</i>	<i>Melanoplus infantilis</i> Scudder, 1878	4.xi.1929	1929			
<i>Melanoplus</i>	<i>infantilis</i>	<i>Melanoplus infantilis</i> Scudder, 1878	4.xi.1929	1929		8	
<i>Melanoplus</i>	<i>islandicus</i>	<i>Melanoplus islandicus</i> Blatchley, 1898	8.viii.1930	1930	N. Criddle	710	Egg Chorions
<i>Melanoplus</i>	<i>lurida</i>	<i>Melanoplus keeleri luridus</i> (G.M. Dodge, 1876)	23.x.1931	1931	R.M. White	3	Egg Chorion of
<i>M.</i>	<i>luridus</i>	<i>Melanoplus keeleri luridus</i> (G.M. Dodge, 1876)	2.v.1929	1929		9	
<i>Melanoplus</i>	<i>kennicotti</i>	<i>Melanoplus kennicottii</i> Scudder, 1878	26.ix.1932	1932		63	Jasper, Alta.
<i>Melanoplus</i>	<i>kennicotti</i>	<i>Melanoplus kennicottii</i> Scudder, 1878	16.ix.1932	1932	N. Criddle		Jasper, Alta.
<i>Melanoplus</i>	<i>montanus</i>	<i>Melanoplus montanus</i> (Thomas, 1873)	30.x.'30	1930	N. Criddle	35	Egg Chorions Blairmore Alta
<i>Melanoplus</i>	<i>montanus</i>	<i>Melanoplus montanus</i> (Thomas, 1873)	20.vii.1932	1932		56	Blairmore Alta.
<i>Melanoplus</i>	<i>occidentalis</i>	<i>Melanoplus occidentalis</i> (Thomas, 1872)	23.x.1931	1931	R.M. White		Egg Chorion of
<i>Melanoplus</i>	<i>packardii</i>	<i>Melanoplus packardii packardii</i> Scudder, 1878	6.ix.1932	1932		61	new eggs Goodlands Man
<i>Melanoplus</i>	<i>packardii</i>	<i>Melanoplus packardii packardii</i> Scudder, 1878	8.ix.1931	1931		61	Old eggs Goodlands Man
<i>Melanoplus</i>	<i>packardii</i>	<i>Melanoplus packardii packardii</i> Scudder, 1878	1.xi.1929	1929		12	
<i>Melanoplus</i>	<i>atlantis</i>	<i>Melanoplus sanguinipes sanguinipes</i> (Fabricius, 1798)	29.iv.'29	1929		4	
<i>Melanoplus</i>	<i>mexicanus</i>	<i>Melanoplus sanguinipes sanguinipes</i> (Fabricius, 1798)	14.ix.1931	1931		4	Egg Chorion
<i>Melanoplus</i>	<i>stonei</i>	<i>Melanoplus stonei</i> J.A.G. Rehn, 1904	25.ix.1930	1930	N.C.	38	Egg Chorions Cowan Man
<i>Metator</i>	<i>pardalinis</i>	<i>Metator pardalinus</i> (Saussure, 1884)	22.viii.1930	1930	N. Criddle	48	Egg Chorions Estevan Sask
<i>Metator</i>	<i>pardalinis</i>	<i>Metator pardalinus</i> (Saussure, 1884)	22.viii.1930	1930	N. Criddle	99	Egg Chorions Goodlands Man

Genus on Label	Species on Label	Current Name	Date	Year	Preparator's Name	Slide Number	Comments
<i>Orphulella</i>	<i>palidna</i>	<i>Orphulella palidna</i> (Burmeister, 1838)	2.xi.1929	1929		18	
<i>Orphulella</i>	<i>speciosa</i>	<i>Orphulella speciosa</i> (Scudder, 1862)	4.xi.1929	1929		19	
<i>Pardalophora</i>	<i>apiculata</i>	<i>Pardalophora apiculata</i> (Harris, 1835)	7.vii.37	1937	DSS	6 8489	Egg Chorion
<i>Pardalophora</i>	<i>apiculata</i>	<i>Pardalophora apiculata</i> (Harris, 1835)	23.vi.1932	1932			Aweme Man
<i>Pardalophora</i>	<i>apiculata</i>	<i>Pardalophora apiculata</i> (Harris, 1835)	13.vi.1932	1932		52	Aweme Man
<i>Pardalophora</i>	<i>apiculata</i>	<i>Pardalophora apiculata</i> (Harris, 1835)	vi.16.37	1937		1 8989	Chorion of... Egg taken from oviduct & unfixed
<i>Pardalophora</i>	<i>apiculata</i>	<i>Pardalophora apiculata</i> (Harris, 1835)	?vii.37	1937	DSS	2 8489	Egg Chorion
<i>Pardalophora</i>	<i>apiculata</i>	<i>Pardalophora apiculata</i> (Harris, 1835)	7.vii.37	1937	DSS	5 8489	Egg Chorion
<i>Phoetaliotes</i>	<i>nebrascensis</i>	<i>Phoetaliotes nebrascensis</i> (Thomas, 1872)	4.ix.1929	1929		15	
<i>Psolossa</i>	<i>delicatula</i>	<i>Psolossa delicatula</i> (Scudder, 1876)	16.vii.32	1932		64	
<i>Schistocerca</i>	<i>lineata</i>	<i>Schistocerca lineata</i> Scudder, 1899	13.x.1930	1930	N. Criddle	40	Egg Chorion
<i>Schistocerca</i>	<i>lineata</i>	<i>Schistocerca lineata</i> Scudder, 1899	17.x.1930	1930	N. Criddle	40	Egg Chorion
<i>Spharagemon</i>	<i>collare</i>	<i>Spharagemon collare</i> (Scudder, 1872)	12.viii.1932	1932	N.C.	58	Aweme Man
<i>Spharagemon</i>	<i>bolli</i>	<i>Spharagemon bolli</i> Scudder, 1875	1.xi.1929	1929		30	
<i>Spharagemon</i>	<i>collare</i>	<i>Spharagemon collare</i> (Scudder, 1872)	30.iv.'29	1929		17	
<i>Spharagemon</i>	<i>collare</i> ?	<i>Spharagemon collare</i> ? (Scudder, 1872)	2.v.1924	1924		26	
<i>Spharagemon</i>	<i>aequale</i>	<i>Spharagemon aequale</i> (Say, 1825)	10.x.1930	1930	N. Criddle	49	Egg Chorions From Medicine Hat, Alta.
<i>Spharagemon</i>		<i>Spharagemon</i> sp.	2.v.1929	1929		31 27	
<i>Steiroxys</i>	<i>trilineatus Thom</i>	<i>Steiroxys trilineata</i> (Thomas, 1870)	30.x.'30	1930	N. Criddle	37	Egg Chorion Blairmore, Alta. Tettigoniidae
<i>Stethophyma</i>	<i>gracile</i>	<i>Stethophyma gracile</i> (Scudder, 1862)	13.x.1930	1930	N. Criddle	68	Egg Chorion
<i>Stethophyma</i>	<i>lineatum</i>	<i>Stethophyma lineatum</i> (Scudder, 1863)	13.x.1930	1930	N. Criddle	44	Egg Chorions
<i>Stictippus</i>		<i>Stictippus</i> sp. ?	14.ix.1931	1931		9	Egg Chorions
<i>Mestobregma</i>	<i>kiowa</i>	<i>Trachyrhachis kiowa</i> (Thomas, 1872)	1.xi.29	1929		27	This genus does not appear in the key.
<i>Mestobregma</i>	<i>kiowa</i>	<i>Trachyrhachys kiowa</i> (Thomas, 1872)	1.xi.29	1929	N.C.		This genus does not appear in the key.
<i>Trachyrachus</i>	<i>kiowa</i> ?	<i>Trachyrhachys kiowa</i> (Thomas, 1872)	20.ix.1932	1932		60	? This genus does not appear in the key.
<i>Trimerotropis</i>	<i>agrestis</i>	<i>Trimerotropis agrestis</i> McNeill, 1900	2.xi.1929	1929		32	
<i>Trimerotropis</i>	<i>agristis</i>	<i>Trimerotropis agristis</i> McNeill, 1900	17.viii.1932	1932	NC		Onah Man

Genus on Label	Species on Label	Current Name	Date	Year	Preparator's Name	Slide Number	Comments
<i>Trimerotropis</i>	<i>agristis</i>	<i>Trimerotropis agrestis</i> McNeill, 1900	17.viii.1932	1932	NC	59	Onah Man
<i>Trimerotropis</i>	<i>campestris</i>	<i>Spharagemon campestris</i> McNeill, 1901	25.ix.1930	1930	N. Criddle	50	Egg Chorions
<i>Trimerotropis</i>	<i>campestris</i>	<i>Spharagemon campestris</i> (McNeill, 1901)	25.ix.1930	1930	N. Criddle	50	Egg Chorions
<i>Trimerotropis</i>	<i>maritima</i> Harr	<i>Trimerotropis maritima</i> (Harris, 1841)	27.x.1932	1932		66	Ontario
<i>Trimerotropis</i>	<i>maritima</i> Harr	<i>Trimerotropis maritima</i> (Harris, 1841)	27.x.1932	1932			Ont.
<i>Trimerotropis</i>	<i>salina</i>	<i>Trimerotropis salina</i> McNeill, 1900	1.xi.1929	1929		28	
<i>Trimerotropis</i>	<i>pistrinaria</i>	<i>Trimerotropis pistrinaria</i> Saussure, 1884	14.ix.1931	1931	RMW	14	Egg Chorion
<i>T</i>	<i>bruneri</i>	<i>Trimerotropis pistrinaria</i> Saussure, 1884	14.x.1931	1931	R.M. White		Egg Chorion (specimen and coverslip fallen off)
<i>Trimerotropis</i>	<i>sordida</i>	<i>Trimerotropis gracilis</i> (Thomas, 1872)	23.x.1931	1931	R.M. White	12	Egg Chorions of
<i>Trimerotropis</i>	<i>sp. No. 1</i>	<i>Trimerotropis</i> sp. No. 1	23.x.1931	1931	R.M. White		Egg Chorions of
<i>Trimerotropis</i>	<i>sp. No. 1</i>	<i>Trimerotropis</i> sp. No. 1	23.x.1931	1931	R.M. White		
<i>Trimerotropis</i>	<i>sparsa</i>	<i>Trimerotropis sparsa</i> (Thomas, 1875)	23.x.1931	1931	R.M. White	16	Egg Chorion
<i>Circotettix</i>	<i>verruculatus</i>	<i>Trimerotropis verruculata verruculata</i> (W. Kirby, 1837)	14.ix.1931	1931	RMW	10	Egg Chorion
<i>Xanthippus</i>	<i>latifasciatus</i>	<i>Xanthippus corallipes</i> (Haldeman, 1852)	20.vii.1929	1929		24	Aweme Man
<i>Xanthippus</i>	<i>montanus</i>	<i>Xanthippus montanus</i> (Thomas, 1872)	8.viii.30	1930	N. Criddle	47	Egg Chorions - immature
<i>Xanthippus</i>	<i>montanus</i>	<i>Xanthippus montanus</i> (Thomas, 1872)	14.ix.1931	1931	R.M.W.	11	Egg Chorions

ROSE GALL WASPS (CYNIPIDAE: *DIPLOLEPIS*) OF MANITOBA, INCLUDING A NEW PROVINCIAL RECORD

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ABSTRACT

We report the first provincial record of the rose gall wasp *Diplolepis gracilis* (Ashmead) in Manitoba. In addition, we review the distribution and hosts of the 11 *Diplolepis* species previously reported for the province using museum records and citizen science observations through iNaturalist. Our study highlights the value of community science platforms such as iNaturalist for documenting records of otherwise poorly known taxa

INTRODUCTION

Diplolepis Geoffroy (Hymenoptera: Cynipidae) is a Holarctic genus of approximately 50 species, 31 of which are known from North America (Zhang *et al.* 2020). As with most cynipid taxa, *Diplolepis* is in need of revisionary taxonomic work. The lack of detailed descriptions for many species and the absence of identification keys make it challenging to identify Nearctic specimens without gall association. Fortunately, there is renewed interest in cynipids and recent (Zhang *et al.* 2019, 2020) and ongoing work will hopefully clarify species boundaries of the Nearctic fauna.

All species of *Diplolepis* induce galls only on roses (Rosaceae: *Rosa* L.) (Shorthouse 2010; Zhang *et al.* 2014). Most *Diplolepis* species can induce galls on several different species of roses (Shorthouse 2010; Zhang *et al.* 2014; Nastasi and Deans 2021), though comprehensive knowledge of host associations and preference is lacking. The use of ornamental roses as hosts has been reported in other parts of North America, but such occurrences appear to be rare (Shorthouse 2001, J.D. Shorthouse unpublished data).

Diplolepis species reported for Manitoba are univoltine (Shorthouse 2010). The seasonal timing of oviposition varies by species. Adults of some species lay eggs in spring while others do so later in the growing season (Shorthouse 2010). Gall development begins before eggs hatch and larvae are usually surrounded by gall tissue shortly after they begin feeding (Shorthouse 2010). Individuals over-winter in their galls as pre-pupae, and adults emerge the following year to mate (although some species are parthenogenetic) and lay eggs (Shorthouse 2010). Aside from one week as an egg and a week as an adult, a *Diplolepis* wasp spends its entire life within its gall (Shorthouse 2010).

Gall placement and morphology are usually species-specific and can often be used to determine the gall-inducing species (Shorthouse *et al.* 2005). However, the presence of inquilines and parasitoids can alter gall morphology (Shorthouse 2010), making identification of the inducer difficult in some cases. Galls induced by North American *Diplolepis* species host both inquilines (Cynipidae: *Periclistus* Foerster) and numerous parasitoids including Ichneumonidae (*Orthopelma* Taschenberg), Eulophidae (*Aprostocetus* Westwood), Eupelmidae (*Eupelmus* Dalman), Eurytomidae (*Eurytoma* Illiger, *Tenuipetiolus* Bugbee), Ormyridae (*Ormyrus* Westwood), Pteromalidae (*Pteromalus* Swederus), and Torymidae (*Glyphomerus* Foerster, *Torymus* Dalman) (Shorthouse 2010; Zhang *et al.* 2014, 2019).

Four species of wild rose are present in Manitoba: *Rosa acicularis* Lindl., *R. arkansana*, *R. blanda* Aiton, and *R. woodsii* Lindl. Identification to species can be challenging as all are phenotypically variable and can hybridize (Scoggan 1957; Flora of North America Editorial Committee 2014). *Rosa acicularis* is a woodland species that occurs throughout the province except the extreme north (Scoggan 1957). *Rosa blanda* and *R. woodsii* are likewise most often found in woodlands though their occurrence is limited to the southern half of the province (Scoggan 1957). *Rosa arkansana* is a grassland species and is limited to such habitats in the southern portion of Manitoba (Scoggan 1957).

Very little focussed survey work has been done for *Diplolepis* in Manitoba. Joseph D. Shorthouse has done significant work documenting the distribution of *Diplolepis* in Canada, but most of his work was done in Alberta, British Columbia, Ontario, Quebec, and Saskatchewan. Both taxonomic and geographic representatives of his collection are housed, in part, at the Canadian National Collection (CNCI) and the Smithsonian National Museum of Natural History (USNM), yet Manitoba material appears limited to 42 specimens of *D. spinosa* (Ashmead) from a single collecting event at Morden (A.M.R. Bennett, pers. com.). Another significant portion of his collection is at the University of Edinburgh that includes some material from Manitoba in unsorted vials (J.D. Shorthouse pers. comm.). The Manitoba Museum (MM) collection has no *Diplolepis* specimens catalogued, though it is possible (but unlikely) that such specimens are present amongst unsorted/unidentified material (R.D. Mooi, pers. comm.). The material identified to species in the J. B. Wallis / R. E. Roughley collection (WRME) consists of a long series of *D. spinosa* and a few specimens of *D. radicum* (Osten Sacken) (J. Gibbs, pers. comm.).

Thirteen native species and two introduced species of *Diplolepis* are known from Canada (Shorthouse 2010; Zhang *et al.* 2019). Shorthouse (2010) explicitly included Manitoba in the range of one species, *D. polita* (Ashmead), and implicitly included the province in the range of nine others. It is unclear which, if any, of these reports are based on actual specimens or gall observations as opposed to inferring presence in Manitoba based on the general distribution of species. Nastasi and Deans (2021) include Manitoba in the range of seven of the ten species included by Shorthouse (2010) based on that work and observations recorded on the citizen science platform iNaturalist (www.inaturalist.org). In addition to these 10 species, there is a specimen labelled as *Diplolepis tuberculator* (Cockerell) at the American Museum Natural History. Thus, there are 11 nominate species reported for Manitoba (Table 1). Morphological characteristics and recent phylogenetic work suggest *D. nebulosa* (Bassett)

is a junior synonym of *D. ignota* (Osten Sacken) (Zhang *et al.* 2019, 2020) and *D. tuberculator* is synonymous with the older name *D. spinosa* (Shorthouse 1988; Y.M.Z. unpublished data), though we await confirmation of this through the revisionary work now underway. Nonetheless, in this paper we will treat these as two species-pairs rather than four individual species, in which case there are nine species reported for Manitoba prior to this paper. Note that we are treating *D. rosaefolii* (Cockerell) and *D. fusiformans* (Ashmead) as two separate species given their distinct gall morphology (leaf blister vs. stem swelling), despite the two having relatively low COI divergence of 2.4% (Zhang *et al.* 2019).

MATERIALS & METHODS

In this paper, we report one additional species for Manitoba, *D. gracilis* (Ashmead), and provide a summary of what is known about the distribution and host use of all *Diplolepis* species in the province. The distribution and host use information presented here comes from two sources: 1) opportunistic surveys conducted by C.F. in 2020 and 2021, the results of which have been uploaded to iNaturalist, and 2) observations uploaded to iNaturalist by other users through 27 October 2021. All observations were reviewed by Y.M.Z. to confirm the identification of the inducer based on Shorthouse (2010) and the gall voucher collection housed at USNM. C.F. has reviewed most observations to determine, where possible, the identity of the host plant using Scoggan (1957) and the Flora of North America (Flora of North America Editorial Committee 2014).

RESULTS

This is the first report of *Diplolepis gracilis* in Manitoba (Fig. 1). Galls were observed by C.F. on the underside of *R. woodsii* leaves in a remnant balsam poplar (*Populus balsamifera* L. (Salicaceae)) woodland in Warren (50.12928N, 97.54083W) on 19 September 2021 (Fig. 1 A–C). It has since been observed elsewhere in Warren on *R. woodsii* growing under bur oak (*Quercus macrocarpa* Michx. (Fagaceae)). Several galls were collected for rearing adults.

Prior to this report the distribution of *D. gracilis* in the prairie provinces was restricted to Alberta and western Saskatchewan (Shorthouse 2010). It has also been reported in southern Ontario (Beutenmuller 1914) and Minnesota (Olson 1964), so its occurrence in Manitoba is expected. Its range likely includes most of southern Manitoba, though it has been noted as rare in other parts of its range so it may not be abundant here (Shorthouse 2010). Previously reported hosts of *D. gracilis* include *R. woodsii*, *R. acicularis*, and *R. blanda* (Beutenmuller 1914; Shorthouse 2010; Looney and Eigenbrode 2011). Subsequent examination of Cynipidae material at WRME revealed a *D. gracilis* gall collected at Erickson on 30.viii.1997 along with the adult *Diplolepis* wasp that emerged from it (JBWM0210963).

Adult *D. gracilis* (Fig. 1 E–F) are active from mid-June through mid-July, with galls maturing in autumn and dropping with their host leaves (Shorthouse 1998). Eggs are laid and galls are induced on the underside of leaves. Shorthouse (1998) noted there is often a patch of red cells on the upper surface of leaves at the point of gall attachment; this discoloration of the upper leaf surface was also observed by C.F. on many of the galled leaves found in Warren.

In total, 179 observations of *Diplolepis*-induced galls were uploaded to iNaturalist through 27 October 2021, 166 for which the inducer could be determined with confidence (there are no observations showing adults). Twelve of these observations are of *Periclistus*-modified *D. nodulosa* (Beutenmeuller) galls for which the iNaturalist identification is *Periclistus*; unmodified *D. nodulosa* galls are inconspicuous stem swellings that are easily overlooked whereas galls modified by *Periclistus* are much larger (Brooks and Shorthouse 1998). There are no observations of *D. fusiformans* (Ashmead) galls in Manitoba on iNaturalist. Observations of conspicuous galls, such as those induced by *D. polita* (n=24) and *D. spinosa* (n=78), are relatively more abundant on iNaturalist compared to galls induced by *D. rosaefolii* (n=9, all by C.F.) which may not be recognized as galls by most iNaturalist users, or *D. radicum* (n=4) which occur at or just below ground level. However, this does not appear to be the case for *D. bicolor* (Harris), which produces showy galls yet only four observations have been uploaded to iNaturalist, perhaps indicating that it is uncommon in Manitoba.

Table 1. Species of *Diplolepis* reported in Manitoba. Species reported in Manitoba by previous authors are indicated by numbers: Shorthouse 2010 = 1, Deans and Nastasi 2021 = 2. SWPP = Spruce Woods Provincial Park, RMNP = Riding Mountain National Park.

Species	Exemplary iNaturalist Observation	Documented Distribution in Manitoba	Recorded Host(s) in Manitoba	Gall Location on Host
<i>D. bicolor</i> ^{1,2} (Harris)	90383041	Whiteshell; Grand Beach; Hecla; SWPP	<i>R. woodsii</i>	leaf
<i>D. fusiformans</i> ¹ (Ashmead)	n/a			stem
<i>D. gracilis</i> (Ashmead)	95416841	Warren; Erickson	<i>R. woodsii</i>	leaf (underside)
<i>D. ignota</i> ¹ (Osten Sacken) + <i>D. nebulosa</i> ¹ (Bassett)	95589462	Winnipeg; Warren; St. Ambroise; Treesbank; SWPP; St. Lazare	<i>R. arkansana</i>	leaf (underside)
<i>D. nodulosa</i> ¹ (Beutenmuller)	99142370 (only <i>Periclistus</i> -modified galls observed)	southern Manitoba north to RMNP	<i>R. woodsii</i>	stem
<i>D. polita</i> ^{1,2} (Ashmead)	30460026	southern Manitoba; disjunct observations at The Pas and Churchill	<i>R. arkansana</i> <i>R. acicularis</i>	leaf (upperside)
<i>D. radicum</i> ^{1,2} (Osten Sacken)	31204644	Winnipeg; Oak Hammock; Hadashville; Brokenhead; Erickson	<i>R. acicularis</i> <i>R. woodsii</i> x <i>R. rugosa</i>	adventitious shoots

<i>D. rosaefolii</i> ^{1,2} (Cockerell)	90381640	Warren; Portage Sandhills; Treesbank; SWPP; RMNP	<i>R. arkansana</i> , <i>R. woodsii</i> <i>R. acicularis</i>	leaf (underside)
<i>D. spinosa</i> ^{1,2} (Ashmead) + <i>D. tuberculator</i> (Cockerell)	98405613	southern Manitoba north to Hecla and RMNP	<i>R. woodsii</i> <i>R. acicularis</i> <i>R. blanda</i> , <i>R. woodsii</i> x <i>R. rugosa</i>	stem
<i>D. triforma</i> ^{1,2} Shorthouse & Ritchie	52707388	Warren; St. Lazare	<i>R. woodsii</i>	stem

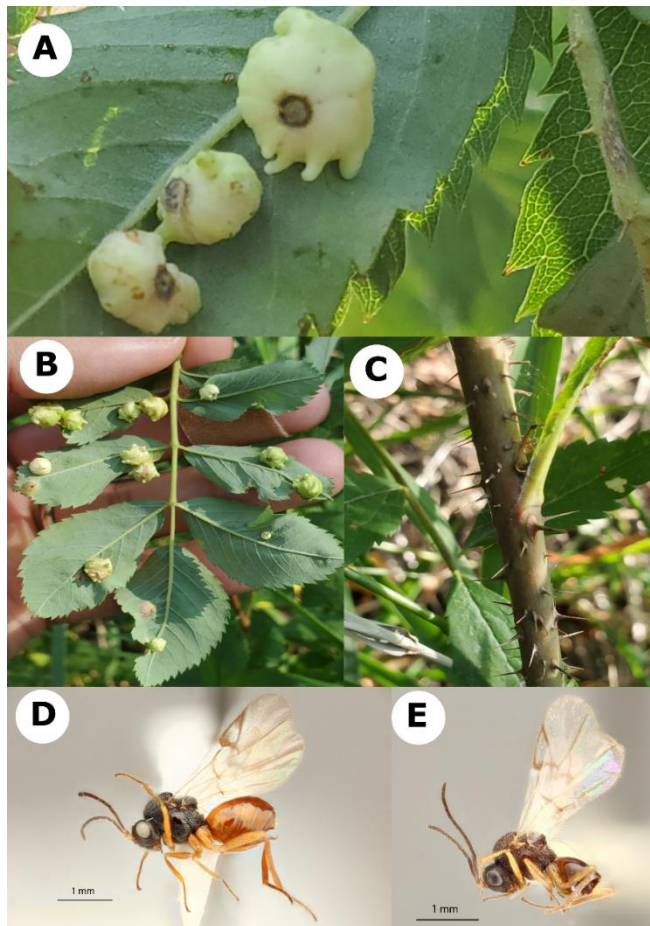


Figure 1. A-B) Gall of *Diplolepis gracilis*; C) Host plant *Rosa woodsii* showing the characteristic infrastipular prickles with enlarged bases; D) Lateral habitus of adult female *D. gracilis*; E) Lateral habitus of adult male *D. gracilis*.

DISCUSSION

A significant priority for future work on all *Diplolepis* species in Manitoba is to better understand and document their distribution. The northern extent of their ranges in Manitoba is unknown. Only *D. polita* has been recorded north of the line between Riding Mountain National Park and Hecla (51.2° latitude). Records of most *Diplolepis* species in Manitoba is based on the presence of their galls. Except for *D. spinosa* (CNCI, WRME), *D. gracilis* (WRME), and *D. radicum* (WRME), adult specimens of *Diplolepis* from Manitoba are either unidentified or not present in the collections checked. At least one additional species (*D. rosae* L.) may occur in Manitoba but has yet to be reported in the province. This introduced species from Europe is widely distributed in North America, but records are scarce in the northern great plains (Nastasi and Deans 2021).

The community science platform iNaturalist has proven valuable for documenting the presence and distribution of *Diplolepis* galls in Manitoba. Cynipid adults are small and inconspicuous and would rarely be observed and recorded by naturalists; the galls, however, are often noted even by those who are not looking for them. Additionally, the iNaturalist platform has provided many opportunities to engage with amateur naturalists to facilitate

information sharing about rose galls and increase general interest in looking for and documenting them. Indeed, there is an active community of gall enthusiasts on iNaturalist that identify observations and act as a resource for those wishing to learn more about these systems. The website www.gallformers.org provides additional gall identification resources.

ACKNOWLEDGEMENTS

We would like to thank the following curators for providing information on Manitoba specimens: Andrew Bennett (CNCI), Jason Gibbs (WRME), and Randall Mooi (MM). We would also like to thank Joe Shorthouse and three additional reviewers that have provided valuable feedback to the earlier draft of the manuscript. USDA is an equal opportunity employer and provider. Mention of trade names herein is for informational purposes only and does not reflect endorsement by USDA. Y.M.Z. is supported by the Oak Ridge Institute for Science and Education (ORISE) fellowship.

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77TH ANNUAL MEETING OF THE ENTOMOLOGICAL SOCIETY OF MANITOBA

ABSTRACTS

MISCARRIAGES OF JUSTICE RESOLVED BY FORENSIC ENTOMOLOGY

Gail S. Anderson, Simon Fraser University, School of Criminology, Burnaby, BC, Canada

Forensic entomology is well known in criminal investigations. Carrion insects colonize carrion, or in the case of a criminal case, a human or animal body, in a predictable sequence and develop in a predictable manner. An analysis of the insects on a body can be used to estimate the minimum period of insect activity and so infer a minimum elapsed time since death. Insects may also be used to determine wound sites, whether the body has been moved or disturbed as well as length of time of neglect. In this talk, we will discuss three very unusual forensic entomology cases in which forensic entomology was instrumental in righting major miscarriages of justice. **WARNING** true case histories will be shown and discussed.



QUANTITY OF SEMINAL FLUID PROTEINS MIGHT BE CRITICAL FOR POSTMATING REPRODUCTIVE SUCCESS IN *DROSOPHILA***Alberto Civetta**, University of Winnipeg, Department of Biology, Winnipeg, MB, Canada

Post-mating competition between males, and male \times female interactions, have been proposed to drive rapid evolution of seminal fluid proteins (SFPs). However, a population genetics survey of SFPs has revealed that the rapid gene sequence evolution of SFPs has been driven by relaxed selection, with only 7–12% showing evidence of positive selection and 35–37% being selectively constrained. The discrepancy between a large proportion of selectively relaxed SFPs and their known importance in competition for fertilization phenotypes is intriguing. One possible explanation is that adjustments in gene expression, rather than changes in protein sequence, are essential for post-mating function. We have explored and found that gene expression manipulation of several SFPs with known or presumed roles in non-competitive fertilization phenotypes can drastically affect sperm competitive phenotypes in *Drosophila melanogaster*. Moreover, we hypothesize that newly evolved genes or genes that have been evolutionary co-opted to be expressed in the glands that produce SFPs in a species-specific manner might be likely candidates for a role in conspecific sperm precedence, a form of post-mating reproductive isolation between species. Testing whether SFPs that influence sperm competitiveness (a form of postcopulatory sexual selection) also mediate conspecific sperm precedence (i.e. reproductive isolation) is needed to address the role of sexual selection as a possible driver of speciation.

ENDANGERED *OARISMA POWESHIEK* BUTTERFLY LARVAL HOST FORAGING AND ADULT HABITAT ACTIVITIES IN MANITOBA, CANADA

Justis Henault and Richard Westwood, University of Winnipeg, Department of Biology, Bioscience, Technology and Public Policy, Winnipeg, MB, Canada

The Poweshiek skipperling (*Oarisma poweshiek*) is endemic to the tall grass prairie in North America, and is now critically endangered worldwide. Existing populations are scattered amongst tall grass prairie remnants. The host food plants eaten by Poweshiek skipperling larvae as well as vegetative and physical descriptions of locations which facilitate various adult activities, such as egg laying and resting, in Manitoba tall grass prairie are unknown. We hypothesized that various adult activities would be facilitated along a soil moisture gradient, and that larvae may navigate their microhabitat to locate host food species. To address these ideas, we followed *O. poweshiek* adults in natural habitat to identify locations which facilitated various adult activities. We measured vegetative, structural and microclimatic attributes at each location. At locations where eggs were laid in the field, larval foraging was observed using an enclosure. During our research, we observed individual larvae consuming shoots of several graminoid species, travelling amongst species throughout their development. Adult activities were associated with a soil moisture gradient in prairie plant communities, where the vegetative and structural attributes may have facilitated specific adult behaviours. Ideally our research will guide habitat stewardship to ensure high quality habitat is available for every life stage, inform reintroduction activities to ensure potential release locations contain required habitat features, and increase details of critical habitat descriptions. Now, with a greater understanding of larval foraging and adult interactions, we may hopefully generate potential causes which explain the decline of *O. Poweshiek*, and identify possible solutions to facilitate its successful recovery!



Adult *Oarisma poweshiek* (Poweshiek skipperling) resting on a leaf of *Glycyrrhiza lepidota* (Licorice) in the Manitoba Tall Grass Prairie Preserve

THE RAVENOUS ROVE BEETLES OF THE NORTHERN TALL GRASS PRAIRIE

Ried Miller¹, Jason Gibbs¹, and Adam Brunke², ¹University of Manitoba, Department of Entomology, Winnipeg, MB, Canada, ²Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, ON, Canada

The tall grass prairie (TGP) is one of the most endangered ecosystems in North America and reaches its northern limit in southern Manitoba. Despite studies that have quantified many of the prairie's charismatic plant and animal species, numerous (largely nocturnal) arthropods that live in or under detrital layers remain severely undersampled and understudied. An M.Sc. project aimed at understanding how beneficial TGP insects respond to different types of disturbance, landscape composition, and groundcover characteristics yielded several new provincial beetle records, as well as a potentially undescribed species. Most of these records belong to the family Staphylinidae (Rove Beetles), arguably the largest and most diverse family of organisms on Earth. Here, we present the fascinating predatory and decomposer beetle species captured in pitfall traps over two growing seasons, as well as the broader findings of the experiment itself. This study highlights the need to better sample the hidden, and sometimes messy side of the arthropod communities present in Manitoba's preserved habitats, and hopefully hints at future opportunities for exploration owing to how much of Canada's native entomofauna remains to be discovered.



THE EFFECT OF OLFACTORY AND TACTILE CUES ON WHEAT MIDGE *SITODIPLOSIS MOSELLANA* (GÉHIN) (DIPTERA: CECIDOMYIIDAE) BEHAVIOR ON PRE AND POSTANTHESIS SUSCEPTIBLE WHEAT

Chaminda De Silva Weeraddana¹, Wendy Hillier², Taylor Swanburg², N. Kirk Hillier², Tom Ward³, Ramya Wijesundara¹, Curt McCartney⁴, Tyler Wist⁵, Ian Wise¹, Sheila Wolfe⁶ and Alejandro C. Costamagna¹, ¹University of Manitoba, Department of Entomology, Winnipeg, MB, Canada, ²Acadia University, Department of Biology, Wolfville, NS, Canada, ³University of Manitoba, Department of Chemistry, Winnipeg, MB, Canada, ⁴University of Manitoba, Department of Plant Science, Winnipeg, MB, Canada, ⁵Agriculture and Agri-food Canada, Saskatoon Research and Development Centre, Saskatoon, SK, Canada, ⁶Agriculture and Agri-food Canada, Morden Research and Development Centre, Winnipeg, MB, Canada

The orange wheat blossom midge (hereafter named as 'wheat midge'), *Sitodiplosis mosellana* (Géhin) (Diptera: Cecidomyiidae), is a significant pest of wheat *Triticum aestivum* L. (Poaceae). The phenology of its host plant is a crucial factor for wheat midge oviposition, and wheat midge prefers to lay more eggs on wheat spikes preanthesis than postanthesis. We hypothesized that wheat midge behavior on pre and postanthesis wheat might be influenced by olfactory and tactile cues present at these two wheat stages. We examined volatile organic compounds (VOCs) and wheat surface wax using a susceptible wheat line cv. Roblin at preanthesis and postanthesis. Results showed that a higher amount of *cis*-3-hexenyl acetate was emitted at preanthesis than postanthesis. In contrast, higher amounts of methyl ketones: 2-tridecanone, 2-pentadecanone and 2-undecanone were emitted at postanthesis. Wheat midge antennal sensitivity was tested for these key VOCs using GC-EAD. Antennae of adult females were electrophysiologically active for these compounds, suggesting that wheat midge females are sensitive to shifts in these key VOCs. In the Y-tube olfactometer, adult females were more attracted to preanthesis than to postanthesis wheat. Olfactometer bioassays on these VOCs presented individually are underway. Wheat surface wax analysis showed that a higher amount of surface wax was present in postanthesis wheat and this wheat had a different wax profile than preanthesis wheat. Currently, behavioral bioassays on surface waxes are ongoing.

ADDITIVE EFFECTS OF CHEMICAL TREATMENTS AND SEED DENSITY REDUCE CANOLA DAMAGE BY FLEA BEETLES

Maxime Damien¹, Shayla Storozuk¹, Robert W. Duncan², John Gavloski³, Alejandro Costamagna¹, ¹University of Manitoba, Department of Entomology, Winnipeg, MB, Canada, ²University of Manitoba, Department of Plant Science, Winnipeg, MB, Canada, ³Manitoba Agriculture and Resource Development, Carman, MB, Canada

Canola crops are highly susceptible to defoliation from two invasive pests, the crucifer and the striped flea beetles (Coleoptera: Chrysomelidae). The lack of specialized natural enemies results in a need to develop integrated pest management methods to maximize yield at low economic and environmental costs. Using a split-plot field experimental design, we aimed to identify the best combination between chemical treatments (i.e. insecticide-treated seeds [ITS], prophylactic foliar insecticide [PFI], foliar insecticide application at 25% defoliation [FI], and a control without treatment) and canola seed density (i.e. three, six and nine plants per square foot) to decrease defoliation and maximize yield. No interaction was observed between chemical treatment and seed density on defoliation rates or yield. Canola with treated seeds had the lowest defoliation rate, whereas insecticide application (from PFI or FI) didn't significantly reduce defoliation, although it did somewhat reduce it. Less damage occurred at the higher plant density. There was no difference among chemical treatments but all of them provided better yield than the control, so did the highest plant density. Our results showed additive effects of chemical treatments and seed density on reducing damage from flea beetles. The treated seeds at high plant density provided the best protection. However, the application of foliar insecticide when 25% defoliation is observed can also protect yield. Independent of chemical treatments, increasing seed density provides both better protection and better yield. Applying insecticide when damage occurs and increasing plant density appear to be suitable practices to manage flea beetles damages.



INSECTS ON CROPS IN MANITOBA IN 2021 – AN EXTENSION UPDATE

John Gavloski, Manitoba Agriculture and Resource Development, Carman, MB, Canada

Flea beetles (*Phyllotreta spp.*) in canola and grasshoppers, in many crops, were major insect concerns in 2021. There were reports of reseeded canola because of injury from flea beetles, and some reports of multiple applications of foliar insecticides. Late summer populations of flea beetles were also a concern in canola. Diamondback moth (*Plutella xylostella*) was a concern in canola in some regions from mid-July to mid-August. Alfalfa weevil (*Hypera postica*) was a concern in alfalfa fields in some regions in mid- and late-June. Aphids were abundant in small grains in some regions from late-June to late-July, although in some of these fields natural enemies such as lady beetles, lacewing larvae and hover fly larvae were also abundant. Lygus bugs were controlled in some fields of canola, sunflowers, alfalfa seed, and strawberries. Lygus damage was also an issue in a shipment of dry beans to Europe. Western corn rootworm (*Diabrotica virgifera virgifera*) and cannabis aphid (*Phorodon cannabis*) were found in Manitoba for the first time. The known range of the cabbage seedpod weevil (*Ceutorhynchus obstrictus*) and pea leaf weevil (*Sitona lineatus*) in Manitoba expanded considerably, based on surveys and submitted samples. Annual summaries of insect pests in crops in Manitoba are posted at: <http://www.gov.mb.ca/agriculture/crops/insects/index.html>



Western corn rootworm

BEES AND INDIGENOUS SOVEREIGNTY: UNDERSTANDING INTERSECTIONS OF SCIENTIFIC AND INDIGENOUS KNOWLEDGES

Phoenix Nakagawa¹ and Kyle Bobiwash², ¹University of Manitoba, Department of Soil Science, Winnipeg, MB, Canada, ²University of Manitoba, Department of Entomology, Winnipeg, MB, Canada

We will be discussing the intersection of Indigenous and scientific knowledge and the false dichotomy within practices between these knowledges, but rather the implementation and values of practices is where they differ. We acknowledge the oft-cited binary of incommensurable existential differences between scientific ways of knowing and Indigenous worldviews making integration of knowledge from these ideologies difficult. However, we hold the position that there may be more similarities than normally understood, and that the binary may actually be more solve-able than is commonly acknowledged. It is quite possible that certain western cultural artefacts entrenched within science are accepted in traditional Indigenous knowledge and vice versa. In our discussion, we hope to identify the contrast between method/idea and methodology/ideology and how these differences cause conflict between scientific and Indigenous knowledge. Our key points about knowledge dissemination among scientific and Indigenous communities, and how these affect the utilization of method and methodology, include: knowledge ranking with bias; integration, inclusion, and incorporation as forms of neo-colonialism; and whose ethics we use in our research. Finally, we discuss positionality and intersectionality in institutions representing science and within Indigenous communities, querying how positionality determines data ‘purity’. Overall, we hope to begin a discussion on ethics, bias, and social status among scientists, setting the stage for decolonization, coordinating research, action, and solidarity with Indigenous communities worldwide. Our hope is to build space for multiple knowledge systems to interact and discuss issues for greater understanding of the physical-biological world and our position within it.

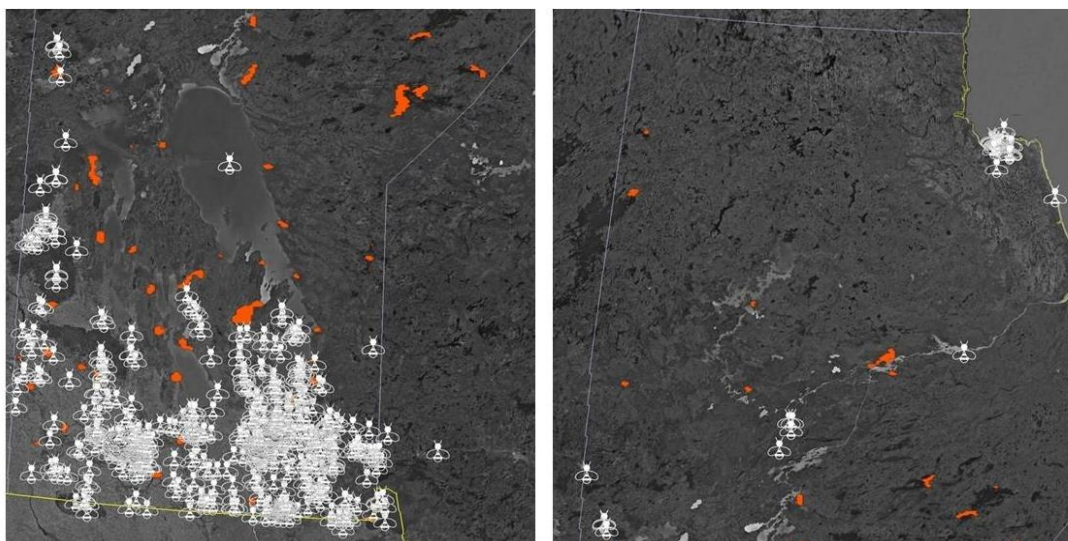


Figure showing geographical biases in biodiversity sampling surveys between southern (left) vs northern (right) Manitoba.

NETWORKS IN THE GRID: PLANT – POLLINATOR INTERACTIONS IN A POWERLINE EASEMENT CORRIDOR OF MANITOBA, CANADA

Massimo Martini and Kyle Bobiwash, University of Manitoba, Department of Entomology, Winnipeg, MB, Canada

Powerline easement corridors occupy a vast, ever-increasing area with a high ecological potential. In landscapes lacking sufficient quality early successional habitats, these rights-of-way could provide the full range of pollinator environmental requirements and act as refuges for native insects and wildflowers. However, the effects of these corridors on insect communities and the ecological functions they provide are poorly studied. To understand how powerlines in Manitoba can benefit pollinators, my project involved sampling pollination networks within a powerline easement along a 2.5° latitudinal gradient. My objectives were to determine the insect pollinator biodiversity within the corridor and evaluate the effects of local vegetation management strategies on the pollination community and network robustness. From June to August 2020, I sampled bees, flies, and wasps in 15 sites along the corridor, describing the architecture of the pollination networks by the frequency and patterns of interactions among the insects and flowering plants. Here, I discuss on the work completed for this project and the results obtained.



USING FLORAL ENHANCEMENTS TO SUPPORT BENEFICIAL INSECTS ON CROPS FIELDS

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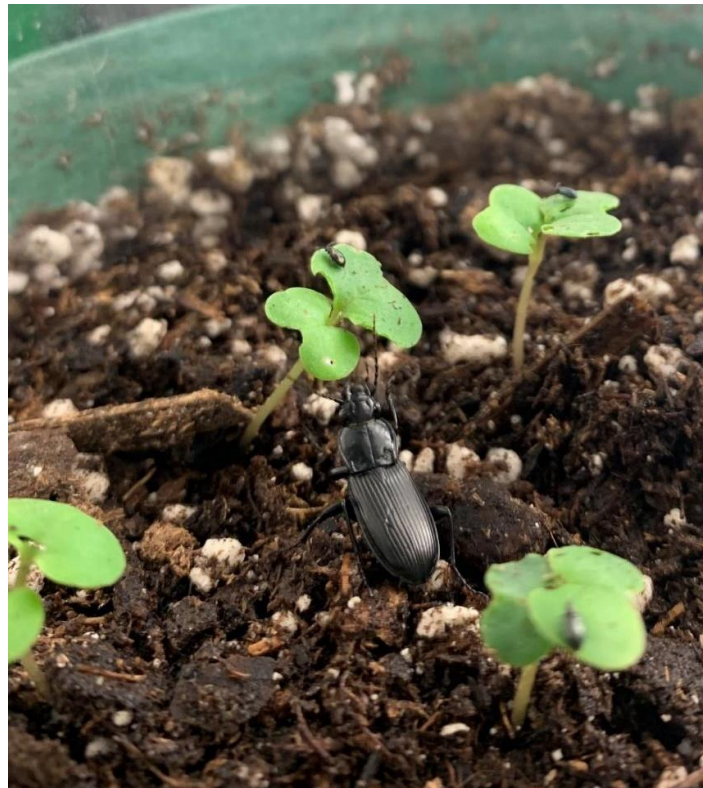
Beneficial insects such as bees, syrphid flies, and ground beetles provide valuable ecosystem services to agriculture including pollination and biological control of pests. However, in areas with intense agriculture, populations of these beneficial insects have often declined. Providing the necessary food and shelter resources for these beneficial insects through the use of floral strips has proven effective in other areas of the world. Although, this practice has not been adequately studied in areas with rotational crops, such as Manitoba. In the summer of 2019, we installed fifteen floral strips at multiple farms across Manitoba and used multiple collection techniques to monitor abundances of beneficial insects at strip, control, and semi-natural sites. Shortly after the strips were established, we found significantly more bees collected from floral strips than control sites using both pan traps (2.29 ± 6.34 against 0.6 ± 6.0 GLMM, $p < 0.001$) and targeted netting (2.79 ± 8.42 against 1.30 ± 7.87 GLMM, $p = 0.007$). Abundances of syrphids and beetles did not significantly differ between strip and control sites. Abundances of bees and syrphids did not differ between control and natural sites. Although, abundances of carabids were significantly lower at semi-natural sites than control sites (45.45 ± 14.68 against 46.5 ± 14.3 GLMM, $p = 0.006$). Our results provide support that floral strips may benefit some insect groups on farms with inconsistent crop rotations. These data will be used as a baseline when comparing future years of the study.



POTENTIAL OF CARABIDAE AND LYCOSIDAE PREDATORS TO CONSUME FLEA BEETLES AND REDUCE CANOLA DAMAGE

Shayla Storozuk, Maxime Damien, and Alejandro Costamagna, University of Manitoba, Department of Entomology, Winnipeg, MB, Canada

The crucifer flea beetle, *Phyllotreta cruciferae* (Goeze) (Coleoptera: Chrysomelidae), and the striped flea beetle, *Phyllotreta striolata* (Fabricius) (Coleoptera: Chrysomelidae), are invasive pests to canola crops, *Brassica napus*, (L.) (Brassicaceae) in North America. Generalist predators may be an important factor in flea beetle mortality, but their impact on flea beetles is seldom studied. Determining potential ground predators that consume flea beetles and decrease their damage is a critical step to further our understanding in natural control methods in canola fields. We determined the effectiveness of *Pterostichus melanarius*, *Harpalus amputatus* (Carabidae) and *Pardosa spp.* (Lycosidae) in a realistic laboratory study using microcosms. Each microcosm contained either three or six canola plants in the cotyledon stage with six flea beetles and one predator. A total of 12 trials took place over 12 weeks that consisted of 150 predators and 40 predator-free controls that were kept at 16 h light at 22°C and 8 h dark at 18°C for 48 hours. The proportion of live flea beetles was measured, the cotyledon defoliation was visually assessed, and stem damage was measured to estimate the consumed area. We found that two predators tested reduced flea beetle survivorship and the prevalence of damage to the stems in the microcosms. No interaction was observed between predator and plant density. Canola was found to sustain less flea beetle damage on the cotyledons and stems with a higher plant density.



UNDERSTANDING THE NOVEL RESPONSE TO THE RESISTANCE GENE, SM1 BY THE ORANGE WHEAT BLOSSOM MIDGE, *SITODIPLOSION MOSELLANA* (GÉHIN) (DIPTERA: CECIDOMYIIDAE)

Bridget A. White¹, Chaminda D. S. Weeraddana¹, Sheila Wolfe², Curt A. McCartney³, Ian Wise¹, Tyler Wist⁴ and Alejandro C. Costamagna¹, ¹University of Manitoba, Department of Entomology, Winnipeg, MB, Canada, ²Agriculture and Agri-Food Canada, Morden Research and Development Centre, Winnipeg, MB, Canada, ³University of Manitoba, Department of Plant Science, Winnipeg, MB, Canada, ⁴Agriculture and Agri-Food Canada, Saskatoon Research and Development Centre, Saskatoon, SK, Canada

The destructive pest wheat midge, *Sitodiplosis mosellana* (Géhin) (Diptera: Cecidomyiidae) is found across all of the major spring wheat growing areas in Canada, causing significant yield loss through larval feeding on the developing seed. Antibiotic host plant resistance is a key part of wheat midge management through the gene Sm1. In previous work, the winter wheat variety, MAC-274, has shown no damage despite multiple eggs being laid on the plant, suggesting strong resistance against wheat midge. MAC-274 spikes were exposed to wheat midge adults in cages under controlled laboratory conditions, alongside Unity and Shaw, varieties containing Sm1 with known responses to wheat midge damage, as well as a susceptible control, Roblin. Egg densities showed no significant oviposition preference between the varieties, also confirming that eggs are being laid on MAC-274. Within six days of oviposition, first instar larvae were found in all varieties, demonstrating that the eggs are indeed hatching on these winter wheat varieties. Preliminary data suggests that compared to the susceptible variety, the first instars do not develop into second instars in the same period of time in Shaw and MAC-274. Further tests will focus on determining if the larvae develop into second instars and when the larvae die on MAC-274. In addition, these varieties were tested under field conditions at two different locations in Manitoba for the field season in 2021. Spike dissections to quantify seed damage are ongoing.

DOWN THE BEE-BURROW: UNEXPECTED DIVERSITY IN THE *LASIOGLOSSUM GEMMATUM* SPECIES COMPLEX (HALICTIDAE: HALICTINI)

Joel Gardner and Jason Gibbs, University of Manitoba, Department of Entomology, Winnipeg, MB, Canada

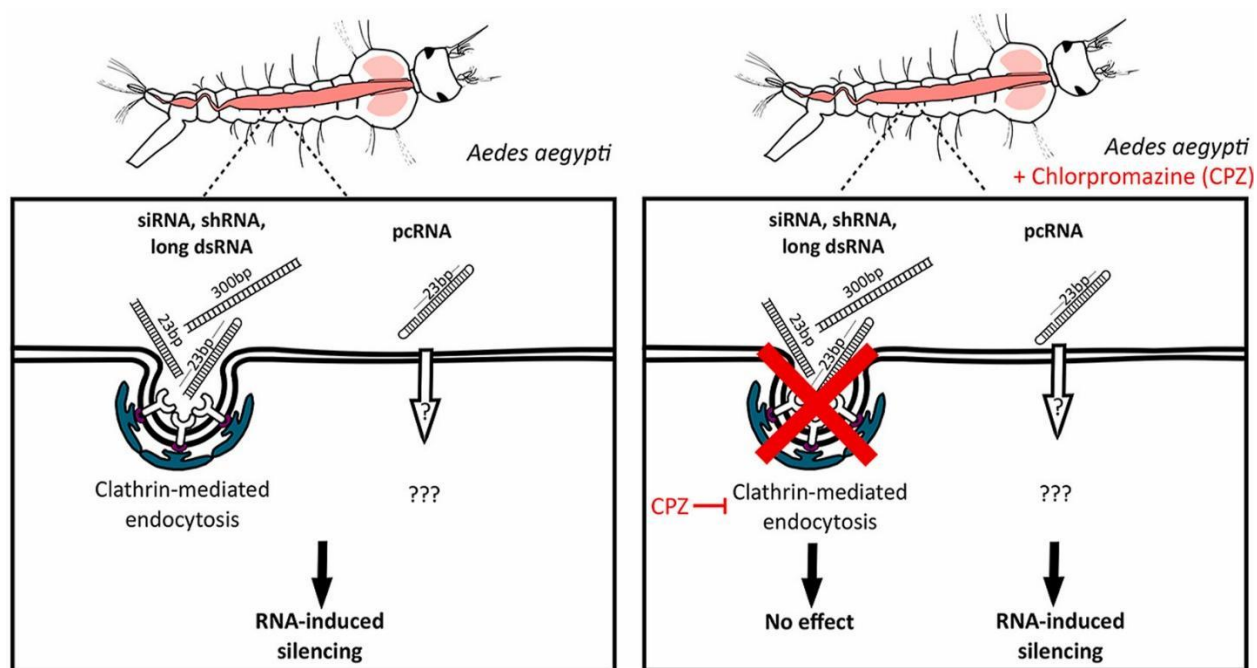
Within the “nightmare taxon” *Lasioglossum* (*Dialictus*), the *L. gemmatum* species complex is a refreshingly distinctive lineage characterized by an enlarged tegula. Historically, identifying species in this group was a simple matter of geography and metasoma colour. Under this system, only three names were commonly used: *L. tegulare*, *L. tegulariforme*, and *L. hunteri*. But recent work paints a much more complicated picture. A previous revision of *L. tegulare* revealed that it actually included four “cryptic” species, and ongoing work in the western Nearctic region is revealing even higher diversity in both *L. tegulariforme* and *L. hunteri*. There are up to 23 western species, including 10 new ones.



A NOVEL STRUCTURED RNA FOR IMPROVED RNA INTERFERENCE IN INSECTS

Daniel Heschuk, Roohollah Abbasi, Brandon Kim, Japujee Matharu, Kousha Kamal, and Steve Whyard, University of Manitoba, Department of Biological Sciences, Winnipeg, MB, Canada

RNA-interference (RNAi) is a sequence-specific method of inducing gene-knockdown in eukaryotic organisms. The mediating molecules, double-stranded RNAs (dsRNAs), have low persistence in the environment and negligible off-target effects, making RNAi an attractive technology for species-specific insect-control applications. However, before RNAi is readily adopted for insect control, there are several challenges it must overcome. One of these challenges is efficient cellular uptake and processing of dsRNA. In most insects studied, clathrin-mediated endocytosis (CME) was the primary uptake pathway for dsRNA molecules, and consequently, impairments in this pathway have been found to be the primary mechanism of both natural and developed resistance. Using CME-inhibitors such as chlorpromazine in the mosquito, *Aedes aegypti*, we confirmed that clathrin-mediated endocytosis was the pathway responsible for cellular uptake of dsRNA for three commonly used structures of dsRNA. However, a newly designed dsRNA structure termed ‘paperclip RNA’ (pcRNA) was found to enter cells independently of CME and induce a strong RNAi-response. Furthermore, pcRNAs demonstrated improved stability when incubated with insect gut extracts compared to traditional dsRNA structures. These new molecules may prove more effective than conventional dsRNAs in pest-control applications where RNAi efficiency is low or where resistance may arise.



LONG-TERM TERPENE RESPONSE TO MOUNTAIN PINE BEETLE ATTACK IN LODGEPOLE AND JACK PINES

Antonia E. Musso¹, Coleen Fortier¹, Dezene P.W. Huber², Allan L. Carroll³, and Maya L. Evenden¹, ¹University of Alberta, Department of Biological Science, Edmonton, AB, Canada, ²University of Northern British Columbia, Prince George, BC, Canada, ³University of British Columbia, Department of Forest and Conservation Science, Vancouver, BC, Canada

Insect herbivores must contend with constitutive and induced plant defences. The mountain pine beetle (*Dendroctonus ponderosae* Hopkins; MPB) has expanded its range east of the Rocky Mountains into the boreal forest in Alberta and is encountering evolutionarily naïve lodgepole and jack pines. Previous studies have examined terpene profiles prior to (constitutive) and just after (induced) mass attack but the terpene profile of trees post-overwintering is unknown. We manipulated mass attack densities in lodgepole and jack pines in the field and measured individual and total terpene amounts and diversity in phloem pre-attack, post-attack, and post-overwintering. Total terpenes as well as many individual terpenes increased at the post-attack stage but were only significantly higher post-overwintering in both lodgepole and jack pines. Chemical diversity was not different at the different stages of attack, but individual trees had distinct chemical communities. Lodgepole pines had greater amounts of total constitutive terpenes compared to jack pine, but jack pine had higher induced terpenes compared to lodgepole pine. Since phloem terpene content is increased post-overwintering, trees that survive minor attacks or are “strip attacked” could be more toxic to MPB that try to colonize in the subsequent year.



ARTHROPODS CROSSING THE DOORSTEP: STORED PRODUCTS, MUSEUMS AND PRIVATE HOUSEHOLDS

Matthias Schöller, Biologische Beratung GmbH, Berlin, Germany

Numerous arthropods are regularly found in buildings, either for overwintering, as pests or as beneficials. This fauna is dynamic, with new species appearing and known species changing in frequency of encounters. Examples for insects feeding on wood or wool include the common furniture beetle *Anobium punctatum* and its parasitoid *Spathius exarator*, and the larder beetles *Trogoderma angustum* and *Anthrenus verbasci* and their parasitoid *Laelius pedatus*. *Laelius pedatus* is originating from North America and became established in Europe. The common clothes moth *Tineola bisselliella* is known in Central Europe from buildings only. A new species record for Germany was its parasitoid *Baryscapus tineivorus* which is of Holarctic distribution. *Baryscapus tineivorus* is now commercially available and released in historic houses, museum collections and private households. It was shown to establish after release. Most stored product pests are multiplying inside buildings only in temperate regions. Parasitoids of both stored product moths and beetles are commercially available in Europe. Approximately 350,000 private households yearly are releasing egg parasitoids of the genus *Trichogramma* to control e.g. the Indian meal moth *Plodia interpunctella*, which became the most well-known system of biological control in the public. As the indoor fauna is typically composed by many thermophilous species, the occurrence of new species inside buildings can be expected with climate change.



Spathius exarator

GENERATION OF MOSQUITO RISK MAPS FOR URBAN LANDSCAPES USING MACHINE LEARNING ALGORITHMS

Martine Balcaen, and Richard Westwood, University of Winnipeg, Department of Biology, Winnipeg, MB, Canada

Successful suppression of mosquito populations is challenging in urban areas due to the ubiquity of cryptic habitats and high, multi-scale spatial heterogeneity. Machine learning algorithms can be trained on remotely sensed and GIS-based data to identify areas where mosquito populations are likely to be densest. Knowledge of landscape-level patterns in mosquito distribution allows for high-risk areas to be prioritized by large-scale control practitioners. In this study, mosquito population risk maps for Winnipeg were developed using data from municipal mosquito surveillance traps and remotely sensed landscape-level variables. Decision-making regarding the methods used and implications of the results are discussed.

FASCINATION WITH MANIPULATION: THE ECOLOGY, BEHAVIOUR AND EVOLUTION OF A PUPPETEER PARASITE IN ANTS

Cam Goater, University of Lethbridge, Department of Biological Sciences, Lethbridge, AB, Canada

The behaviours of ants infected with larvae of the lancet liver fluke, *Dicrocoelium dendriticum*, have captivated parasitologists and ecologists for over 60 years. Formicid ants that contain a single worm in the sub-esophageal ganglion are chauffeured from their nests onto flower petals, where they remain firmly attached with their mandibles. Attachment is thought to facilitate the transmission of fluke larvae to grazing mammals, within which fluke reproduction occurs. Infected ants remain attached to flower petals until ambient temperature exceeds 18-20°C, after which they detach and return to their nests. The fluke was introduced from Europe into parkland habitats in southern Alberta in approximately 1980, then emerged within local snail, ant, and ungulate hosts in the 1990s. Understanding the underlying causes and consequences of the bizarre ‘attach-detach-repeat’ sequence of behaviours is a focus of our ongoing research. One guiding premise is that determining the nature of the ‘on/off’ switch that characterizes the manipulation will help us better understand the widespread phenomenon of host manipulation by parasites. A second premise is that integrative approaches that include GIS technology, molecular ecology, behavioural ecology, and the imaging sciences can provide key insights into the nature of the manipulation and into the nature of parasite emergence into novel hosts.



Andy Hardy




A SWEET RELATIONSHIP: BEES AND CANOLA PRODUCTION IN CANADA

Shelley E. Hoover¹, Andony P. Melathopoulos², Riley Waytes³, Samuel Robinson⁴, Stephen F. Pernal⁵, George Adamidis⁶, and Ralph V. Cartar⁴, ¹University of Lethbridge, Department of Biological Sciences, Lethbridge, AB, Canada, ²Oregon State University, Department of Horticulture, Corvallis, Oregon, USA, ³LGL Ltd., Sidney, BC, Canada, ⁴University of Calgary, Department of Biological Sciences, Calgary, AB, Canada, ⁵Agriculture and Agri-Food Canada, Beaverlodge Research and Development Centre, Beaverlodge, AB, Canada, ⁶University of Patras, Department of Biology, Patras, Greece

Insect pollination is required for, or enhances, the seed set of many angiosperm plants, including approximately 75% of global crop species used for biofuel, human consumption, and animal feed. This is especially true of the calorie and vitamin-rich crop species. Modern canola production in Canada relies on hybrid seed, the production of which is dependent on pollination by the Western Honey Bee (*Apis mellifera*) and the Alfalfa leafcutting bee (*Megachile rotundata*), but the benefits of insect pollination to the commodity canola crop are less clear. We will discuss the pollination of both canola crops in Canada. Our results demonstrate that pollinator effectiveness is dependent on both the pollinator taxa, as well as their behaviour. We also demonstrate that in the Lethbridge region, self- and wind-pollination may be sufficient to enable full yield of commodity canola, however pollination causes plants to alter their functional characteristics, changing the total number of flowers, flower timing, root biomass, and whether pod production occurred on the main stem or branches. In a greenhouse trial, the addition of bumble bees resulted in equivalent or higher yields of commodity canola, suggesting that the benefit of pollinators to canola is context-dependent, and extends beyond simple measures of yield.



Pollination mechanism in each plot:

 = insect |  = wind |  = self-pollination

ACKNOWLEDGEMENTS

*The Entomological Society of Manitoba Wishes to
Thank the Following Sponsors for Their Generous
Support of the 76th Annual Meeting*

Orkin Canada Corporation

City of Winnipeg Insect Pest Control

Canadian Centre for Mosquito Management

Entomological Society of Manitoba Inc.

Minutes of the Entomological Society of Manitoba

77th Annual General Meeting

Saturday, 4 December 2021, 1:00 PM

Zoom

Present:

Jeff Marcus
Patricia MacKay
Robert Lamb
Neil Holiday
Alberto Civetta
Alejandro Costamagna
Bridget White
Chaminda Weeraddana
David Wade
Desiree Vanderwel
Jade Tanner
Joel Gardner
John Gavloski
Justis Henault
Kateryn Rochon
Kathy Cano
Kelsey Jones
Kyle Bobiwash
Margaret Friesen
Martine Balcaen

Paul Fields

Phoenix Nakagawa

Rob Currie

Robert Anderson

Robert Wrigely

Shayla Storozuk

Sheila Wolfe

Terry Galloway

Vincent Hervet

Sarah Semmler

Randy Gadawski

Regrets:

Jason Gibbs

Richard Westwood

Lavanya Ganesan

Jordan Bannerman

Ian Wise

1. Acceptance of Agenda
Accepted by consensus.
2. Acceptance of the Minutes of the last Annual Meeting (4 December 2020)
Accepted by consensus.
3. Business Arising from the Minutes
 - a. Survey Monkey
J. Marcus noted use of survey monkey for elections two important problems 1) Two individuals cannot vote sharing same device or internet connection. 2) Survey monkey tool can allow a single individual to vote multiple times using multiple networks. 3) Survey monkey now charging for review of entry over a certain number of entries.

Action Item: J. Marcus will continue to explore alternative options/platforms to address these issues before the next election.

4. Reports of the Executive
President – Jeffrey Marcus

Treasurer – Kathy Cano

J. Marcus noted ESM is running a deficit due to generosity. Going forward we will have to be more financially conscious to balance income with expenditures.

K. Rochon sought clarification of AGM revenue listed in proceedings.

D. Vanderwel noted the jump in expenses this year was due to the tie and awarding of two main scholarships.

K. Cano added other awards were also increased.

J. Marcus added increasing award amounts to reflect inflation is always something to consider every few years.

Regional Director(s) to the ESC – Jason Gibbs (Report not submitted)

J. Marcus shared that the director did not submit the report due to the UMFAs ongoing strike.

Editor of the Proceedings – Kelsey Jones/Jason Gibbs

J. Marcus and T. Galloway thanked K. Jones for stepping up to the role.

Membership – Sarah Semmler

J. Marcus thanked S. Semmler for all her hard work and contributions to ESM.

5. Reports of the Committees

Endowment Fund – Richard Westwood (R. Westwood not in attendance, K. Cano reporting)

R. Currie inquired if we are predicting annual increase of 950 from interest.

K. Cano clarified that yes, its similar to other years. Roughly around the 900\$ area.

Scientific Program – Vincent Hervet

J. Marcus inquired on attendance.

V. Hervet provided that 70 people total registered.

J. Marcus noted peak attendance at once was 40.

V. Hervet was surprised this number wasn't higher.

S. Semmler noted this was likely due to work schedules.

J. Marcus shared that these numbers were higher than last year when in person attendance was only roughly 50 people.

R. Currie agreed the amount is comparable for past in person meeting.

V. Hervet provided suggestions for smoother chair selection namely earlier selection

J. Marcus explained the past president is responsible for speaking with people to lead the meeting and to find the correct individual for the meeting.

K. Rochon confirmed its usually done earlier but due to uncertainties of whether a meeting would take place and format lead to delays in appointing someone. Even with the short timeline K. Rochon noted V. Hervet pulled together an excellent meeting and students privately messaged her complimenting the delivery of the ESM AGM.

P. Mackay noted in the society previously the incoming president had the job of replacing all chairs right after the AGM and a binder was passed from hand to hand including date deadlines that included when speakers were to be chosen for the following AGM. This was helpful because the further away from the AGM the more inclined speakers will be to accept the invitations. Perhaps returning to this method would be beneficial.

V. Hervet agreed and noted that he believed this binder would be beneficial to locate.

T. Galloway added the past two scientific chairs were previously responsible for selecting a scientific support group.

R. Currie pointed out in relation to binder terms of reference were made available on previous version of website, perhaps due to new website it was lost.

K. Rochon noted it is still on the website.

J. Marcus shared that himself and J. Gibbs provided V. Herve support. He also added, moving back to in person meetings we will also move back to having a full conference committee.

S. Wolfe noted students also had a very short lead time to submit materials for the AGM and would benefit with more time in future.

R. Anderson made a suggestion of “Genetica: Technologies impact on the study of entomology” for next years conference theme.

J. Marcus explained the theme is generally selected by the Chair and committee and added it was a great suggestion.

V. Herve remarked that his duty as chair was a fun experience.

Newsletter – Kelsey Jones/Kateryn Rochon

J. Marcus noted he enjoyed reading what was together and thanked K Jones and K. Rochon for prompts to aide him in providing personal submissions to the newsletter.

Youth Encouragement/Public Education – Bridget White

J. Marcus noted that even under pandemic regulations we were able to do this out reach safely and thanked B. White for her contributions.

N. Holiday noted least three years have passed since ESM taken advantage of the money from ESC for public outreach. Recently this amount has been raised from 300 to 500 (that cannot be carried forward).

J. Marcus added that the funds can be used for transportations costs and incidental expenses related to outreach (food, gas, etc.).

S. Storozuk noted she had applied for funds to go towards supplies for the insect colonies it is under review from ESC.

Social – Lavanya Ganeson

Scholarship and Awards – Desiree Vanderwel (Report not submitted)

ESM student achievement award – Katherine Morgan

ESM student service award – Shayla Storozuk

ESM graduate student scholarship – Joel Gardner

Orkin Award – TBA, selection process delayed due to U of M faculty strike.

Fundraising – Ian Wise

S. Semmler noted I. Wise sent his regrets and to refer to report.

K.Cano pointed out some discrepancies in donations, \$850 is the total donations as some donors that normally contribute did not this year.

Archives and Web Page – Jordan Bannerman

Common Names – Jason Gibbs (Report not submitted)

6. Election Results – **Scrutineer:** John Gavloski
Motion: R. Currie moved to destroy ballots, K. Rochon seconded..... carried.
7. New Business
 - a. Awards announcement – student oral presentation

V. Hervet noted the poster competition was not held so funds were moved to select three presentation winners, 1st – Antonia Musso, 2nd – Michael Killewald, 3rd – Bridget White
 - b. Acknowledging the retirement of Kathy Cano

J. Marcus congratulated and presented K. Cano with a digital card signed with well wishes to recognise her hard work and life service.
8. Moment of Silence for Deceased Members

David Rosenberg: Aug 24, 1943 – June 25, 2021
9. Transfer of Office

J. Marcus shared that it has been a pleasure to serve this office this past year and thanked everyone for all the support and contributions that helped move things forward.

J Marcus thanked K. Rochon who will be serving as our president in the incoming year. He looks forward to assisting her in her term as president.

K. Rochon thanked everyone’s service that are stepping down and everyone for stepping up to fill these roles.
10. Other Business

No other business.
11. Adjournment
Accepted by consensus.

APPENDIX A

Agenda of the Entomological Society of Manitoba

77th Annual General Meeting

Saturday, 4 December 2021, 1:00 PM

Zoom

1. Acceptance of Agenda
2. Acceptance of the Minutes of the last Annual Meeting (4 December 2020)
3. Business Arising from the Minutes
4. Reports of the Executive
 - President** – Jeffrey Marcus
 - Treasurer** – Kathy Cano
 - Regional Director(s) to the ESC** – Jason Gibbs
 - Editor of the Proceedings** – Kelsey Jones/Jason Gibbs
 - Membership** – Sarah Semmler
5. Reports of the Committees
 - Endowment Fund** – Richard Westwood
 - Scientific Program** – Vincent Hervet
 - Newsletter** – Kelsey Jones/Kateryn Rochon
 - Youth Encouragement/Public Education** – Bridget White
 - Social** – Lavanya Ganeson
 - Scholarship and Awards** – Desiree Vanderwel
 - Fundraising** – Ian Wise
 - Archives and Web Page** – Jordan Bannerman
 - Common Names** – Jason Gibbs
6. Election Results – **Scrutineer**: John Gavloski

7. New Business
Acknowledging the retirement of Kathy Cano
8. Moment of Silence for Deceased Members
David Rosenberg: Aug 24, 1943 – June 25, 2021
9. Transfer of Office
10. Other Business
11. Adjournment

APPENDIX B

President's Report to the Membership

Annual Business Meeting – 3/4 December 2021

There were five meetings of the Executive Committee of the Entomological Society of Manitoba in 2020/21:

First Executive Meeting –26 February 2021 – Virtual Meeting using Zoom

- There was a discussion of strategies for implementing equity, diversity and inclusion within the ESM beyond the statement that the Executive voted to post on the ESM website. Making a financial contributions to EntoPOC was discussed as a possibility.
- Because there was no physical program to the 2020 ESM Meeting, the meeting sponsors were not listed, printed and distributed to conference attendees. It was decided to post a list of meeting sponsors on the ESM website.
- There was a discussion of the desirability of nominating and approving additional new Honorary Member of ESM. It was decided to call for nominations from the membership.
- A discussion of the need to recruit a new editor of the peer-reviewed Proceedings of the Entomological Society of Manitoba because Terry Galloway expressed a wish to begin phasing himself out of that role as part of his retirement.
- There was also discussion of succession planning for the role of ESM Secretary, as Sarah Semmler has announced her intention not to stand for re-election when her current term as Secretary ends in late 2021.

The Executive later met in camera in March 2021 to discuss nominations and letters of support for the selection of Honorary Members of the ESM.

Second Executive Meeting –8 April 2021 – Virtual Meeting using Zoom

- It was publicly announced that Dr. Terry Galloway has been nominated and ratified as an Honorary Member of ESM. His name has been added to the list of honorees.
- A discussion of succession planning for the editor of the peer-reviewed Proceedings of the Entomological Society of Manitoba because Terry Galloway expressed a wish to begin phasing himself out of that role as part of his retirement.

Third Executive Meeting –16 July 2021 – Virtual Meeting using Zoom

- Kelsey Jones was welcomed as the new editor of the Proceedings of the ESM.
- The Executive voted to participate in a study of Perceptions of Canadian Researchers focused on organizations with membership interested in environmental research being conducted by a grad student from Dalhousie University (IRB Approved). A survey was sent to the ESM membership and members were encouraged to complete the survey.

- The format of the ESM annual meeting 2021 was discussed. The board concluded that it will need to be a virtual meeting (as it was in 2020). A process to recruit a scientific chair for the annual meeting was initiated.

Fourth Executive Meeting –5 October 2021 – Virtual Meeting using Zoom

- A decision was made to financially support Equity, Diveristy, and Inclusion by making a \$100 contribution to EntoPOC, a group committed to making Entomology more welcoming and accessible to people of colour.
- The executive voted and approved posting a list of the living Lifetime and Honorary ESM members to the ESM website as a way of recognizing recipients of these high honours from our organization.
- Preparations for the upcoming ESM elections were discussed.
- Vincent Hervet was welcomed as the Scientific Chair for the ESM annual meeting 2021, which will be held in a virtual format.
- Other items discussed were archiving records from the ESM Secretary and developing a fundraising strategy for sponsors of the annual meeting. It was decided that since the ESM meeting will be virtual, fundraising should be directed towards supporting student awards and scholarships.

Fifth Executive Meeting –5 November 2021 – Virtual Meeting using Zoom

- This was a special meeting primarily called to discuss planning of the AGM and symposium for the ESM Annual Meeting.
- Vincent Hervet is serving as the Meeting Chair for the 77th Annual Meeting of ESM, organizing a symposium of invited speakers under the theme of “Insects in a Human World”. Assembly of the roster of symposium speakers was still in progress. Keynote speaker will be Gail Anderson (University of British Columbia) who will be giving a presentation entitled “Miscarriages of Justice Resolved by Forensic Entomology”. All presentations (invited and submitted) will be presented virtually. We sincerely thank Vincent Hervet for his work organizing the Annual Meeting.
- Other matters discussed included completion of posting the list of Lifetime and Honorary ESM members to the ESM website, making arrangements for housing old (>7 years) paper documents from the ESM Treasurer in the ESM archive, and a discussion of the pros and cons of continuing to use Survey Monkey as a tool for conducting ESM elections.

I would like to sincerely thank all the members of the executive board, the ESM publication editors, and the Committee Chairs for their generous service to ESM. It is a real inspiration to work with such a dedicated group of people whose contributions are essential for the continuing work of our organization. I look forward to continuing to work with them as Past-President.

Jeffery Marcus

APPENDIX C

Treasurer's Report & Financial Statements

YEAR ENDING AUGUST 31, 2021

NOTE: These Financial statements have not been audited. The accounts, bank statements and receipts were provided by the treasurer.

Treasurer: Kathy Cano

Date: December 4, 2021

	2021	2020	2019
Current Assets			
Cash	22,046.89	15,827.20	16,304
GIC's	40,000.00	48,000.00	46,000
TOTAL	62,046.89	63,827.20	62,304
LIABILITIES			
Current	NIL	NIL	NIL
NET ASSETS			
Unrestricted net assets	22,046.89	15,827.20	16,304
Internally restricted	40,000.00	48,000.00	46,000
	62,046.89	63,827.20	62,304
REVENUES			
Annual Meeting	0	765	1233
Donations	850.00	1875	1175
ESC	0	0	0
Interest income	920.23	924.50	925
Membership fees	1385	1340	1420

Miscellaneous	0	0	0
Proceedings	0	0	0
Youth encouragement & Public Education	0	0	0
Total	3255.23	4904.50	

EXPENDITURES

Awards and Scholarships	5000	1550	1550
Donations	0	0	0
General	64.83	0	74
Meetings:	0	0	
ESC	0	0	
ESM	0	1408.80	2191
Newsletter	0	0	0
Proceedings	0	0	0
Social Committee	0	0	0
Youth Encouragement & Public Education	0	0	0
Bank Fees	61.02	46.51	23
Investments		2000	
TOTAL	5125.85	5005.31	

EXCESS / (DEFICIENCY) OF REVENUES OVER EXPENDITURES	(1870.62)	(100.81)	926
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APPENDIX D

Report of the *Proceedings* Editors

Volume 76 (2020) of the Proceedings of the Entomological Society of Manitoba was produced exclusively in electronic format. It was sent to the Secretary (Sarah Semmler) to be distributed to the membership and to the Webmaster (Jordan Bannerman) to be posted to the website. Volume 76 is 80 pages in length. Volume 76 includes a tribute to David Rosenberg authored by his friends and colleagues to commemorate his passing. The volume also contains a Scientific Paper authored by Terry Galloway titled “Lice (Phthiraptera: Trichodectidae), fleas (Siphonaptera: Pulicidae, Ceratophyllidae) and ticks (Ixodida: Ixodidae) infesting American badger, *Taxidea taxus* (Mammalia: Mustelidae), in Manitoba, Canada.” Terry Galloway and Jillian Detwiler contributed an image of a chewing louse from an American badger to be the first ever cover photo of the Proceedings of the Entomological Society of Manitoba. Abstracts from the papers presented at the 2020 Virtual Annual Meeting of the Entomological Society of Manitoba are also included in the 76th Proceedings. The abstracts are accompanied by amazing images of study specimens and field sites submitted by the presenters. Annual Meeting Minutes and Committee Reports from the 76th Annual Business Meeting can be found at the end of the volume. Thanks to Sarah Semmler for providing committee reports, and to Jason Gibbs for providing the abstracts for this issue.

Terry Galloway has decided to step down from his role as Editor of the Proceedings. Terry published his first volume of the Proceedings in 2001 (Volume 57). He has since published 20 issues of the Proceedings over the last 20 years. Terry currently holds the record for the longest term as editor of the Proceedings in its history. The society would like to thank Terry for his hard work and dedication to the ESM throughout his career!

Throughout 2021 Terry has been passing over his editorial knowledge to Kelsey Jones.

Beginning in 2022, Kelsey and Jason Gibbs will be co-editors of the proceedings. All future Scientific Note and Scientific Paper submissions should be emailed to kelsey.jones@agr.gc.ca or jason.gibbs@umanitoba.ca. In 2022, the Proceedings will be coming out with an official “Instructions for Authors” document to aid in the formatting and submission process. This document will be accessible on the Entomological Society of Manitoba website.

We encourage everyone to consider submitting Scientific Notes and full Scientific Papers. The Proceedings is a terrific place to publish new distribution records and faunal lists for insects and related arthropods in Manitoba, as well as the results of a wide variety of entomological study. We already have promises from several people to submit a number of very interesting papers, which we hope will appear in the 2021 Proceedings. All submitted manuscripts are peer-reviewed; all published papers are available as PDF reprints on the website. Issues of the Proceedings are fully accessible using on-line search engines. There are no page charges to authors for published manuscripts, and with our electronic format, colour images can be included in manuscripts. In theory, there are no practical limits to manuscript length. All issues of the Proceedings are freely available to entomologists around the world. If you have something of

relevance to entomology in Manitoba, we encourage you to consider submitting it to the Proceedings.

Respectfully,

Kelsey Jones & Terry Galloway

Proceedings Co-Editors

APPENDIX E

Report of the Endowment Fund Board

A summary of investments and projected interest income for the fiscal year is attached (Table 1). Interest generated by the Endowment Fund provides a basis for funding the Society activities. The Endowment Fund principal is \$50,000.

GIC 00920196133-0002 will mature on December 2, 2021 and be reinvested at 5 years for a minimum rate of 2.18% or higher. GIC 00920196133-0008 was reinvested for 1 year at 0.15% and GIC 00920196133-0010 matured in 2021 and was reinvested at 5 years at 2.18%.

Richard Westwood

Kathy Cano, Treasurer

Endowment Fund Guaranteed Investment Certificates

Table 1: Account information as of November 30, 2021.

Certificate No.	Principal	Interest Rate	Term	Maturity Date (Purchase Date)	Anticipated Interest
00920196133-0002	\$10000.00	1.73 %	5 yrs	December 2, 2021 (December 2, 2016)	\$865.00
00920196133-0008	\$1000.00	0.15 %	1 yr	October 30, 2021 (October 30, 2022)	\$15.00
00920196133-0001	\$9000.00	2.25 %	5 yrs	November 10, 2022 (November 10, 2017)	\$1012.00
00920196133-0006	\$10000.00	2.0 %	5 yrs	November 19, 2024 (November 17, 2019)	\$1000.00
00920196133-0007	\$10000.00	2.25 %	5 yrs	December 13, 2024 (December 12, 2019)	\$1125.00
00920196133-0010	\$10000.00	2.18 %	5 yrs	November 30, 2026 (November 30, 2021)	\$1090.00
Total	\$50000.00				

APPENDIX F

Report of the ESM Newsletter Committee

The Newsletter committee published three issues of the 47th Volume of the Newsletter in 2021. This year the Newsletter received submissions from multiple new authors and has seen the return of many dedicated authors. We would like to thank John Gavloski, Robert Wrigley and Todd Lawton for their continuous contributions to the Newsletter. We rely on the contributions of members to be able to produce these fantastic issues of the Newsletter. We encourage all of the membership to contribute to the newsletter through articles, announcements and pictures. If anyone is interested in submitting an article to the newsletter, please do not hesitate to contact Kelsey Jones (kelsey.jones@agr.gc.ca).

Kelsey Jones & Kateryn Rochon

Newsletter Co-Editors

APPENDIX G

Youth Encouragement and Public Outreach Committee

December 2020 – November 2021

This year, the YEPOC was involved in 5 outreach events (see table below). Due to the covid-19 global pandemic, the outreach programs have continued to be limited this past year. The pandemic has impacted the amount of outreach available since most in-person school activities and summer events could not happen. However, there were two virtual outreach events, with one led by Shayla Storozuk and the second by Bridget White. The first being a presentation on insect adaptations for Chief Peguis Middle School, with the classes being between the ages of 11-12 and approximately 55 children attended. The second presentation was primarily about spiders, with differences between them and insects being a key feature. This was for 6-8-year-olds attending École Riverview School. There were four classes that attended this presentation, with a total audience of approximately 75 children. Events were all requested through email to the committee chairperson (Bridget White).

In addition to the virtual presentations, John Gavloski was able to present in-person three times in August at the Carman Day Camp, TLC Daycare and Wee Care Daycare. John has a colony of Madagascar hissing cockroaches that he took to the presentations that students get to hold, have cockroach races, etc. He also used pinned insects for demonstrations and PowerPoint presentations for indoor events. Both the daycare presentations in 2021 were outdoor events, where kids were sweeping and collecting insects, in addition to the pinned insects and hissing cockroaches. The Carman Day Camp was an indoor event.

Bridget White

Date	Presenter	Event	Audience Size	Ages
February 12, 2021	Shayla Storozuk	Chief Peguis Middle School	55	11-12
August 10, 2021	John Gavloski	Carman Day Camp	12	5-12
August 12, 2021	John Gavloski	TLC Daycare, Carman	15	3-8
August 19, 2021	John Gavloski	Wee Care Daycare, Carman	30	3-12
November 3, 2021	Bridget White and Denice Geverink	École Riverview School	75	6-8

APPENDIX H

Report of the Fundraising Committee

The Entomological Society of Manitoba has requested donations this year from ten potential sponsors. The sponsors include Orkin Canada Corporation, Poulin's Pest Control, the City of Winnipeg Insect Pest Control, Bayer Cropscience Canada, Gilles Lambert Pest Control, North/South Consultants, Cano Pest Control, Canola Council of Canada, Metro Pest Control and the Canadian Centre for Mosquito Management. Letters of request were sent once the date for the ESM Annual Meeting was announced. Donations last year totaled \$1175. Early indications show promise that total donations in 2021 should exceed those from last year.

Ian Wise

APPENDIX I

ESM Website/Archivist Report

In the past year I have managed the ESM website and updated it based on various requests from the Executive committee. The most notable update is that a list of honorary and lifetime members can now be found on the committees page (<https://home.cc.umanitoba.ca/~fieldspg/committees.html>).

No new notable additions have been added to the archives, though I will soon be adding the Societies financial records from the past number of years that are currently being stored by Kathy Cano.

Jordan Bannerman

ESM Webmaster and Archivist

APPENDIX J

Election Report

Elections closed November 10, 2021 for the Entomological Society of Manitoba office of President-Elect. The Executive Board approved a new policy allowing the Member-at-large the choice to serve for a second term. This gives a greater opportunity for involvement and gaining valuable experience as part of a committee. Joel Gardner accepted a second term, so there was no election for this position in 2021. There were 79 ballots issues, 51 ballots returned, and there were no spoiled ballots.

The successful candidate for President-Elect is Alberto Civetta.

This was the fourth year using an electronic voting process. All votes were done through Survey Monkey again this year. Responses are anonymous. The source of the vote is not visible or collected. Survey Monkey is also set to only allow one vote per respondent.

We thank all candidates for their willingness to participate in the election. Formal announcement and commencement of terms will be at and after the ESM Annual Business Meeting, respectively.

John Gavloski, Chair

Scrutineer Committee



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