

# IDENTIFICATION OF CHRYSOPIDAE IN CANADA, WITH BIONOMIC NOTES (NEUROPTERA)

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## Abstract

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Chrysopidae in Canada comprise 24 species in 9 genera and 2 subfamilies. Additional southern species are mentioned, 1 as a new combination, and other nomenclatorial changes are reviewed in relation to the Canadian fauna. Generic diagnosis of males employs sternum VIII + IX, the arcessus, gonapsis, pseudopenis, and tignum. Generic diagnosis of females is based on the dorsal furrow, ectoprocts, spermatheca, subgenitale, and a non-genitalic trait, the innermost gradate crossvein in the wings. The ecological implications and inherent difficulties in taxonomy are discussed for coloration in Chrysopidae, to develop a practical key to differentiate 26 species using color and other non-genitalic traits. A checklist summarizes maps of the geographic distribution in Canada and notes species in Alaska, based on specimens examined. Patterns of distribution for the Canadian chrysopid fauna are either Holarctic for 1 species or indigenously Nearctic, with eastern, western, or boreal foci. Disjunctions are apparent for species with a more southern, transcontinental distribution, which enter Canada primarily in Ontario and British Columbia. Life-history and bionomic notes are limited to 6 species in Canada, for which synonymies and figures are based on specimens examined. Most data originate from studies performed in Ontario. There are 5 species of parasites from 2 chrysopids. Hosts include 11 species of insects and mites, with 2 cases of hyperpredation. Three insecticides account for the more recent scarcity of chrysopids in the Niagara region. Conclusions relate the following: variable color in the 1 Holarctic species to post-glacial mingling in the northwest; gaps in temporal and spatial distribution to extinctions in progress; and renewed interest in Chrysopidae to earlier research on this group in Canada.

## Résumé

Les Chrysopides du Canada comptent 24 espèces, représentant 9 genres et 2 sous-familles. D'autres espèces vivant plus au sud sont également signalées et on propose, ici, une nouvelle combinaison en rapport avec des changements de nomenclature en cours. La diagnose générique du mâle utilise les sternites VIII + IX, ainsi que les pièces génitales: arcessus, gonapsis, pseudopénis et tignum; celle de la femelle: la ligne dorsale, les ectoproctes, la spermathèque, la plaque sous-génitale et la série des nervures scalariformes alaires internes. Les conséquences écologiques de la coloration eidonomique, et les difficultés taxonomiques qu'elles entraînent, se trouvent indiquées dans la clé d'identification pratique de 26 espèces, clé basée sur les couleurs et autres caractères non sexuels. Une liste de contrôle résume les cartes de répartition géographique des spécimens examinés pour chaque espèce du Canada, avec quelques remarques sur les autres formes mises en évidence dans l'état de l'Alaska. D'une manière générale, la répartition de cette faune se conforme, pour 1 seule espèce, à une formule Holarctique, et pour le reste à une formule Néarctique autochtone, avec pour centre l'est, l'ouest ou la région boréale de l'Amérique du nord. Les espèces qui se trouvent plus vers le sud, montrent une formule transcontinentale, propre aux États-Unis d'Amérique et semblent avoir une répartition discontinue (quelques localités dans la province de la Colombie britannique et dans la province de l'Ontario). Les considérations biologiques et bionomiques ne concernent que 6 espèces canadiennes, pour lesquelles on indique les synonymies tirées de la littérature; quant aux figures, elle sont toutes fondées sur les spécimens étudiés. Dans la plupart des cas, les données proviennent de la province de l'Ontario avec 5 espèces spongieuses sur 2 espèces chrysopes. Des hôtes abritent 11 espèces des insectes (dont il y a 2 cas de hyperprédisme). L'utilisation de 3 insecticides fait comprendre la rareté récente des chrysopes appartenant à la région du Niagara. Enfin, la variabilité chromatique de l'espèce Holarctique

fait penser que les races du nord-ouest se sont mêlées après l'époque glaciaire — et des trous dans la répartition spatio-temporelle laissent supposer qu'on se trouve en présence d'un phénomène d'extinction. Néanmoins, l'étude actuelle des Névrotères, montre avec assez d'évidence tout l'intérêt et toute l'importance des recherches anciennes menées sur les chrysopes du Canada.

### Introduction

Chrysopidae in Canada were last analyzed more than 50 years ago (Smith 1932). Though relatively few in number, they still tend to be treated as a family-level group in ecological work, or to be lumped together as "*Chrysopa* species", preventing much information from a biological perspective from accumulating. Today, little is known about the bionomics of these insects at the species level other than that they generally are beneficial as predators. In reality, adults of some chrysopids ingest pollen (Adams and Garland 1981; Adams 1983), and adults of other entire genera are almost exclusively nectar feeders (Putman 1963a; Séméria 1977). To obtain nutrients not otherwise present in their diet, symbiotic yeasts are necessary (New 1975). However, the larvae are universally predatory. Indeed, their searching and attacking behavior and their known capacity for consuming large numbers of aphids justly earn the family its popular reputation.

The previous study of Canadian Chrysopidae stimulated more collecting activity, which eventually added more names to the list of endemic species. Thus, the known geographic distribution of many species was extended considerably, reflecting, it is thought, a growing awareness of and interest in naturally occurring beneficial insects generally, instead of recent range extensions. Also, early systematists erected an array of varietal and form names that, in the case of green lacewings, are only now being reduced to manageable levels (Adams 1982a). Gradually, too, the species concept has undergone an evolution of its own, making seasonal and regional variation essential aspects of any biosystematic study. Consequently, the earlier account of Chrysopidae in Canada, however useful in its day, is now cumbersome and quite misleading.

To appreciate these insects better, and to use them more effectively in forest, orchard, vineyard, and other agroecosystems, information that is known about the species of Chrysopidae in the restricted Canadian fauna is summarized here. The accompanying identification aids and bionomic notes have immediate relevance to Canada and the adjacent United States of America, including Alaska.

### List of Chrysopidae in Canada

The 1961 edition of the International Code of Zoological Nomenclature revised the use of varietal and form naming, such that the Canadian fauna might now be considered to consist of 24 species in 9 genera, representing 2 subfamilies (Garland 1984). The arrangement here is, for convenience, alphabetical.

**CHRYSOPINAE:** *Ceraeochrysa lineaticornis* (Fitch), *C. placita* (Banks); *Chrysopa chi* Fitch, *C. coloradensis* Banks, *C. excepta* Banks, *C. nigricornis* Burmeister, *C. oculata* Say, *C. pleuralis* Banks, *C. quadripunctata* Burmeister; *Chrysoperla carnea* (Stephens), *C. harrisii* (Fitch), *C. rufilabris* (Burmeister); *Chrysopiella brevisetosa* Adams and Garland; *Eremochrysa canadensis* (Banks), *E. fraterna* (Banks), *E. punctinervis* (McLachlan); *Mallada macleodi* Adams and Garland, *M. perfectus* (Banks); *Meleoma dolichartha* (Navás), *M. emuncta* (Fitch), *M. schwarzi* (Banks), *M. signoretti* Fitch; *Nineta gravida* (Banks).

**NOTHOCHRYSINAE:** *Nothochrysa californica* Banks.

The occurrence of *Chrysoperla comanche* (Banks) **Comb. Nov.**, in Canada, is unlikely, though the species does extend northward in Arizona, and possibly into Colorado and Utah, in the western United States. Similarly, *Chrysopa incompleta* Banks has not yet been found in eastern Canada, and *Chrysopiella sabulosa* Banks remains to be found

in the northwestern Great Plains beyond the southernmost part of Montana. Also, an enigmatic form of *C. oculata*, with entirely black gradates in the adult forewing, is known from southwestern Virginia and probably occurs in much of the eastern United States, but it has never been recognized among field-collected specimens from any region in Canada.<sup>1</sup>

The controversial *Chrysopa downesi* Smith (*nec* Banks *auctt.*) has been synonymized under the morphospecies complex presently known as *Chrysoperla carnea* (Garland 1984), after examination of the type-specimens, most of which were collected from under bark during the winter in the southern interior of British Columbia. The type-locality has been corrected to Vernon, BC, to conform with the label of the holotype female, whereas the original description states Kelowna, BC (Smith 1932), from which there are 7 paratypes. Smith inadvertently showed how poorly conceived his species was when he incorrectly determined 2 specimens from the Niagara region of southern Ontario as *C. downesi* (Putman 1932a). Though they are dark green, with the elongated wings characteristic of the type-specimens of *C. downesi* from BC, they are *Chrysoperla harrisii*, which is structurally quite distinct from the *C. carnea* complex. Another confusing taxon, for which the type evidently has been lost, *Chrysopa intacta* Navás, is being synonymized under *Ceraeochrysa placita*, with designation of a neotype (Garland 1985). Other recent nomenclatorial changes that affect the Canadian list of Chrysopidae include the synonymy of *Chrysopa assimilis* Banks under *C. oculata*, and that of *Chrysopa crotchii* Banks under *C. nigricornis* (Garland 1984). These changes similarly affect species lists for the Pacific Northwest of the United States.

### Taxonomic Characters in Canadian Chrysopidae

**Non-genitalic traits.** Chrysopidae are usually green, which is the basis for their commonly being called "green lacewings", though some species in this fauna are brownish. Much of the early work on this group emphasized coloration. However, color is no longer considered suitable as a criterion to define species, though it might be used as a practical aid to identification.

More recently, other non-genitalic traits have gained wide acceptance. Glandular microtholi, for instance, generally cover the surface of the sternoabdominal cuticle in males of *Chrysopa* species (*sensu stricto*). They are prominent in the Palaearctic type-species, *Chrysopa perla* (L.), and in the Canadian fauna they are abundant in *C. chi*, *C. oculata*, and *C. pleuralis*, but not so obvious in *C. coloradensis*, *C. excepta*, *C. nigricornis*, or *C. quadripunctata*, being sparse in many species. Other glandular structures have been observed on the pronotum in a Neotropical subgenus of *Chrysopa*, which also has microtholi (Adams 1982a).

Some *Meleoma* males have a modified frons, but not all species of that Nearctic and northern Neotropical genus are so modified (Adams 1969), such as the North American *M. schwarzi* in this treatment. *Meleoma* females have subtle frontal differences, too, characterization of which is difficult and subjective. Both sexes of *M. schwarzi*, however, have longitudinal striae on the lateral aspect of the anterior abdominal segments, plus a row of raised pegs on the hind femora (Adams 1962), distinguishing that species from others in the Canadian fauna (Garland 1979).

Another non-genitalic trait exists in males of some genera, which have enlarged spiracular atria. In *Ceraeochrysa*, however, the condition is variable and too subjective to use taxonomically (Adams 1982b). That genus also has a dorsal furrow, extending anteriorly from the anal sclerite to, and between, the ectoprocts. This non-genitalic trait might have phylogenetic significance, for it appears in other genus-level groups both in the Western

<sup>1</sup>The male genitalia are distinctive (P.A. Adams *in litt.* 28.XI.1984) and so is the larva, making this an undescribed sibling species, which has been suspected for some time. In this study, specimens were reared from Radford, Virginia, during a visit with R.L. Hoffman, August 1984.

Hemisphere (Adams 1982a, 1982b) and in the Ethiopian region (Tjeder 1966). A membranous furrow also separates the ectoprocts from the 9th tergum in both sexes of *Nothochrysa californica*, complementing other non-genitalic traits that distinguish the species from all Chrysopinae in the Canadian fauna: a jugum at the base of the forewing; a longitudinal, pronotal furrow; simple marginal veins in the forewing; and concave pretarsal claws.

The shape of the pretarsal claws, as another non-genitalic trait, is smoothly concave in *N. californica*, for which the term "entire" seems appropriate. In contrast, the pretarsal claws in all other genera in the Canadian fauna display some degree of ventral excision on their ental aspect. Thus, *Chrysopiella brevisetosa* and the 3 species of *Eremochrysa* have only a very shallow, obtuse excision. *Nineta* evidently has a variable excision, more pronounced in the Palearctic type-species, *N. flava* (Scopoli), than in the Nearctic *N. gravida*. An even deeper acute cleft, which creates the appearance of a swollen base and an apical hook, best describes the pretarsal claws in other genera, as represented in the Canadian fauna, though the behavioral and ecological implications of this trait remain obscure.

**Genitalic traits.** Chrysopid genitalia present several taxonomic characters that, alone, are sufficient to distinguish between the genera, especially in a restricted fauna such as the present one. Yet, historically important studies of Nearctic chrysopids (Banks 1903; Smith 1934; Parfin 1952; Bickley and MacLeod 1956; Throne 1971) and the now-outdated Canadian analysis (Smith 1932) do not take advantage of genitalic traits, which are the focus of more recent study (Bram and Bickley 1963). Thus, the predominantly North and Central American *Meleoma* finally has been settled as a genus on the strength of a distinctive set of genitalic traits, mostly in the male (Adams 1962, 1969; Tauber 1969). Analysis of the southern African fauna (Tjeder 1966) similarly used genitalic traits to establish subgenera and to restrict the definition of *Chrysopa*. The process continues, with new genera and subgenera being added (Adams 1978, 1982a, 1982b), despite difficulty interpreting the phylogeny of genitalic and non-genitalic traits in this group (Hölzel 1970). That accounts for delay in popularization of more recent nomenclatorial changes, especially in regional listings (Barnard 1978; Dorokhova 1979; New 1980). Nevertheless, in this treatment the former subgenus *Chrysoperla* is elevated, and both *Mallada* and *Nineta* are restored to full generic status, primarily on the basis of genitalic traits.

Specifically, the abdomen of the male chrysopid consists of 9 apparent sternal elements (Acker 1960), of which the terminal 8th and 9th have undergone varying degrees of fusion in the course of generic evolution. In this analysis, *N. californica* has a weakly sclerotized zone between sterna VIII and IX, suggesting the ancestral or plesiomorphic condition, now that there are nothochrysin fossils that differ but little from recent species (Adams 1967; Hölzel 1970). Thus, for taxonomic purposes *N. californica* is described as having an "unmodified" sternum VIII + IX. The Palearctic *Nineta flava* retains a membranous intersegmental zone and, in North America, *N. gravida* males presumably are similar to the type-species of the genus, *N. flava*, though none were available for study in this analysis, and the type, a male, lacks an abdomen. The intersegmental region in *Chrysopiella*, *Eremochrysa*, and *Meleoma* is discernible though it is not membranous, resulting in a fused sternum VIII + IX, which is thought of as a derived apomorphic condition. Complete fusion is found in the Canadian representatives of *Ceraeochrysa*, *Chrysopa* (*sensu stricto*), *Chrysoperla*, and *Mallada*. Again, in genera with the caudal margin of sternum VIII + IX uniformly rounded, the term "unmodified" is used in this context, too. Conversely, the "modified" condition, in which the 9th sternal component is produced caudad, as in *Eremochrysa* and *Nineta* in this treatment, is discussed here as a "simple process". In *Chrysopiella brevisetosa*, the detail of the caudal margin of the 9th

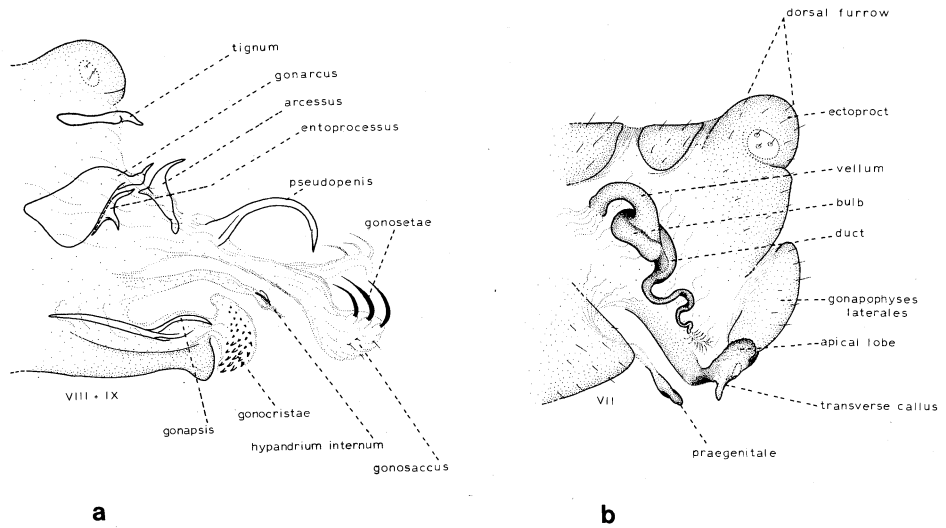


FIG. 1. Diagram of terminalia in a generalized chrysopid. (a) Male, everted in a lateral aspect. (b) Female, showing internal detail in lateral aspect.

sternal component differs, forming a pair of divergent "lateral processes" which are directed dorsad, which might not describe the condition in a broader survey of that genus.

In the female chrysopid, the abdominal venter has only 8 apparent sternal elements, the last constituting the subgenitale which clasps the gonapophyses laterales by means of a sclerotized apical lobe (Acker 1960; Hwang and Bickley 1961). In the present analysis, *Ceraeochrysa placita* is unusual by its possession of a praegenitale, which is suspended freely in the membrane at the proximal base of the subgenitale, and is reminiscent of certain genera in the South African fauna (Tjeder 1966). Further modification of the subgenitale, particularly by reduction to form a stalked condition, is typical of *Chrysopiella* and *Eremochrysa* in the Canadian fauna. Otherwise, genera in this analysis have a broad membranous zone of contact between the subgenitale and sternum VII, referred to here as "normal".

The dorsal furrow has already been mentioned. An associated trait which also is not sexually limited affects the ectoprocts, being either "free" or "fused" in relation to the 9th tergum.

### Generic Characterization for Chrysopidae in Canada

**Males.** (Fig. 1a; Table 1). The hypothetical, generalized male chrysopid has a variety of sclerotized structures associated with its hind body wall. In this group the hind body wall is membranous, with the anus dorsally and a ventrally situated gonopore. During preparation of terminalia, the position of the gonopore often is revealed when the hypandrium internum is extruded through its orifice. Several sclerites in the hind body wall, together with the taxonomic characters already mentioned, are critical for generic characterization in male green lacewings, which is possible in the much-restricted Canadian fauna.

**Gonarcus.** The large, horseshoe-shaped sclerite in the hind body wall, present in all Neuroptera-Planipennia and thought to be a remnant, or derivative, of the 10th sternum (Acker 1960). It is expanded laterally, undoubtedly for muscle attachment, and often has protuberances on its dorsal arch. The primary value of the gonarcus is as a landmark to describe the relative position of other sclerites in the hind body wall.

Table 1. Key to the genera of Chrysopidae in Canada: Males

1.	Tignum present .....	2
—	Tignum absent .....	3
2.	Gonapsis present.	
	(a) Arcessus normal .....	<i>Mallada</i>
	(b) Arcessus compound .....	<i>Meleoma</i>
—	Gonapsis absent .....	<i>Chrysoperla</i>
3.	Gonapsis present.	
	(a) Gonapsis median; sternum VIII + IX unmodified .....	<i>Ceraeochrysa</i>
	(b) Gonapsis asymmetric; sternum VIII + IX modified.	
	(i) As a simple process .....	<i>Eremochrysa</i>
	(ii) As a pair of lateral processes .....	<i>Chrysopiella</i>
—	Gonapsis absent .....	4
4.	Arcessus normal.	
	(a) Sternum VIII + IX unmodified .....	<i>Nothochrysa</i>
	(b) Sternum VIII + IX modified.	
	(i) As a simple process .....	<i>Nineta</i>
—	Arcessus replaced by pseudopenis .....	<i>Chrysopa</i>

**Tignum.** The transverse sclerite, below the anus and dorsal to the gonarcus, sometimes very narrow or greatly reduced, or as a small disc in the membrane. In *Chrysoperla*, the tignum is well developed and has a prominent, median, caudad-directed acumen. *Mallada* and *Meleoma* both have a tignum, though it is much reduced in some species in this treatment. Other genera lack the tignum, but *Chrysopa nigricornis* is unusual in having a small disc in the location where the tignum might occur that has been described as an acumen (Adams 1982a).

**Arcessus.** The "normal" condition consists of a median process contiguous to the dorsal arch of the gonarcus, with its down-curved apex directed caudad, seen in all genera here excepting *Chrysopa (sensu stricto)*. In *Meleoma*, a "compound" structure replaces the normal arcessus, with an auxiliary up-curved median process, for which the homology and naming still have not been resolved (Adams 1982a). *Ceraeochrysa* displays a variable condition, essentially having the normal arcessus in *C. lineaticornis*, with a pair of dorso-lateral projections and terminating caudally as a median hook, with a pair of lateral digits. This is typical for the genus (Adams 1982b). In contrast, the arcessus in *C. placita* consists of an elongate sclerotized strap, adherent to the dorsum of the membranous gonosaccus. Variation in the arcessus makes it a useful species-level character (Adams and Garland 1981, 1982), though the discrepancy outlined here in *Ceraeochrysa* would make a broader survey of the species in that mainly Neotropical genus of considerable interest.

**Gonosaccus.** The membranous zone distal to the gonarcus, and limited laterally by the wings of that sclerite, possibly being an eversible endophallus containing the gonopore (Matsuda 1976). In a more rudimentary state, as in *N. californica*, the gonosaccus stretches between the lateral wings of the gonarcus, beneath the arcessus but continuous with the ental aspect of that structure. In its more familiar configuration, the gonosaccus is a tongue-like or sac-like pouch directed caudad. In the living insect this is thought to be inflatable. *Chrysopa (sensu stricto)* has a bilobed gonosaccus and, on its dorsal aspect, there is an isolated, median, down-curved pseudopenis, which may have been derived from the arcessus (Hwang and Bickley 1961; Adams 1969). Other structures that are distributed over the gonosaccus include gonosetae on its dorsal aspect, spinellae on its ventral aspect, and gonocristae proximoventrally. The last-mentioned structures, however variable between genera, are best considered as species-level characters.

**Pseudopenis.** The down-curved, caudad-directed sclerite isolated in the sagittomedial aspect of the membranous dorsum of the gonosaccus, which is present in this analysis

only in *Chrysopa (sensu stricto)*. There are minute setae on its proximoental aspect, extending distad for about half the length (Bram and Bickley 1963), more readily apparent in some species than in others though there may be regional differences in the setae.

**Gonosetae.** The setae on the dorsal aspect of the membranous gonosaccus. The gonosetae are small, sparse, and non-tuberculate in *N. californica*, suggestive of a rudimentary state in this species in the Canadian fauna. They are similarly small and sparse in the 2 species of *Mallada* in this analysis, absent in *C. placita*, and only minutely tuberculate, and erect, in the majority of genera represented in Canada. However, the gonosetae in *Chrysopa (sensu stricto)*, in contrast, are robust, enormously tuberculate, and recurved.

**Spinellae.** The rosette-shaped structures with a centrally located secretory pore (Adams 1983) on the membranous surface of the ventral aspect of the gonosaccus. Spinellae are found in *Chrysoperla harrisii* and *C. rufilabris* in the Canadian fauna.

**Gonocristae.** The fields of imbricated, denticulate, scale-like setae on the ventrolateral aspect of the membranous gonosaccus, and as minute setae on the hypovalva region along the caudal margin of the abdominal sternum VIII + IX. They are best seen in *Chrysopa (sensu stricto)*, in which species-specific patterns are found. Gonocristae also exist in *Meleoma*, and they are present or absent in *Ceraeochrysa* (Adams 1982b). Specifically, in this analysis they are found in *C. lineaticornis*, but not *C. placita*.

**Entoproessus.** The dorsolateral flanges on the gonarcus.

**Gonapsis.** The sagittomedial sclerite embedded in the membrane of the hypovalva, closely apposed to the caudal margin of sternum VIII + IX. It varies between genera, being either elongate in *Ceraeochrysa* (Adams 1982b), for which it is described here as "median", or "asymmetric", such as in *Chrysopiella* and *Eremochrysa* in this analysis. In both *Mallada* and *Meleoma*, the gonapsis is median, with lateral wings and a caudad-directed process. The lateral wings are ornately denticulate in *Meleoma*.

In summary, all genera in the Canadian fauna have an arcessus, an exception being *Chrysopa (sensu stricto)*, in which the pseudopenis undoubtedly assumes its function. *Meleoma* has an auxiliary process, associated with the arcessus, and a tignum, which also is present in *Chrysoperla* and *Mallada*. Both *Mallada* and *Meleoma* have a gonapsis, also found in 3 other genera that lack the tignum. Thus, combinations of these genitalic sclerites and a consideration of supplementary non-genitalic traits, such as the structural composition of sternum VIII + IX, permit differentiation of males in each of the 9 genera shown here to be present in the Canadian chrysopid fauna. These distinctions have application to the contiguous territory of the United States, including Alaska, and their relevance only diminishes as Nearctic representatives of largely Neotropical genera, not included here, are encountered. The females, similarly, lend themselves to generic diagnosis.

**Females** (Fig. 1b; Table 2). The female chrysopid has only a limited number of genitalic structures, not sufficient to differentiate genera without recourse to other, non-genitalic, traits. The ectoprocts and the dorsal furrow have generic significance, and are not sexually limited. Another non-genitalic trait, involving the configuration of the innermost gradate crossvein in the wings, finds application in the diagnosis of genera, particularly for females. That gradate meets the pseudomedia in *Chrysoperla* whereas it is confluent with a branch of the radial sector in *Mallada* (Adams and Garland 1982). Specific details of the female genitalic structures are added below.

**Spermatheca.** The darkly tanned, sclerotized internal apparatus connecting the common oviduct to the bursa copulatrix (Tjeder 1966; Philippe 1972), and comprising a bulb and a proximal duct (Hwang and Bickley 1961). In essence, the spermatheca is a tube for sperm transfer, with nutritive gland cells associated with canaliculate ductules (Huebner 1980).

Table 2. Key to the genera of Chrysopidae in Canada: Females

1.	Ectoprocts free .....	<i>Nothochrysa</i>
—	Ectoprocts fused to tergum .....	2
2.	Dorsal furrow present .....	<i>Ceraeochrysa</i>
—	Dorsal furrow absent .....	3
3.	Subgenitale stalked.	
	(a) Apical lobe with ectal cavity .....	<i>Eremochrysa</i>
	(b) Apical lobe without cavity .....	<i>Chrysopiella</i>
—	Subgenitale normal .....	4
4.	Subgenitale sclerotized proximally .....	<i>Chrysopa</i>
—	Subgenitale membranous proximally .....	5
5.	Spermathecal bulb with shallow ventral impression .....	<i>Nineta</i>
—	Spermathecal bulb with conical ventral impression .....	6
6.	Apical lobe with ectal cavity .....	<i>Meleoma</i>
—	Apical lobe without cavity.	
	(a) Innermost gradate crossvein on radial sector .....	<i>Mallada</i>
	(b) Innermost gradate crossvein on pseudomedia .....	<i>Chrysoperla</i>

**Bulb.** The coiled, rounded or spherical body of the spermatheca, with a vellum on its dorsal aspect and, ventrally, an impression. The ventral impression is shallow and irregular in *Nineta* (Tjeder 1966; Hölzel 1970) whereas *N. californica* in this analysis has a concave impression, and other genera in the Canadian fauna have a deep, regular, conical ventral impression. The bulb, when rounded, is described as a pill-box in appearance, as is the case with all genera in the Canadian fauna except *Ceraeochrysa*, in which it typically is elongate and contorted (Adams 1982b). *Ceraeochrysa placita*, however, has the pill-box shape, complicating the use of the shape of the bulb in generic diagnosis in this analysis.

**Vellum.** The sclerotized, sheath-like collar on the dorsal aspect of the spermathecal bulb, which is attached to the membranous velum (pl. vela) of the bursa copulatrix and to other supporting membranes. It is a short, erect flange in *N. californica*. *Mallada macleodi*, in contrast, has a tubular vellum that extends in a curve beyond the edge of the spermathecal bulb. Again, in the Canadian fauna, differences are apparent between the 2 representative species of *Ceraeochrysa*: *C. lineaticornis* has an elongate, contorted spermathecal bulb, typical of that genus (Adams 1982b); *C. placita* has the pill-box-shaped spermatheca with an erect dorsal vellum, emphasizing the likelihood that the generic affinity of that species may not yet be fully resolved. Generally, the vellum is generically constant, though it is difficult to describe objectively.

**Praegenitale.** The sclerotized flap subtended in the intersegmental region between sterna VII and VIII. In this analysis, it occurs only in *Ceraeochrysa placita*, in which it is undifferentiated apart from the presence of an asymmetric seta. Function is unknown, and its presence in congeneric species is uncertain.

**Subgenitale.** The female sternum VIII, consisting of a sclerotized apical lobe and a membranous proximal region, which is the more "normal" condition, though sclerotization evidently increases proximal to the apical lobe as the female matures, at least in *Ceraeochrysa* (Adams 1982b). *Chrysopa (sensu stricto)*, however, displays species-specific patterns of sclerotization proximal to, and confluent with, the apical lobe, which is generically constant. *Chrysopiella* and *Eremochrysa* have the proximal region much reduced, giving rise to a "stalked" condition of the subgenitale.

**Apical lobe.** The sclerotized, distal part of the subgenitale, with a median notch and swollen lateral clasps.



**Transverse callus.** The acuminate, or broadly protrudent, proximal region of the apical lobe, sclerotized, and directed ventrad.

**Ectal cavity.** The rounded, pocket-like invagination on the ventral aspect of the apical lobe, in *Eremochrysa* and *Meleoma* in this analysis, showing species-specific variation. Function unknown.

In summary, all genera in the Canadian fauna have the pill-box type of spermathecal body, except *Ceraeochrysa*, in which it is tubularly expanded. *Ceraeochrysa placita*, however, is atypical in that and in other respects. The spermatheca usually has a conical, ventral impression. *Nineta* and *Nothochrysa*, as represented in this analysis, have only a shallow concavity, and *Nothochrysa* is distinguished on the basis of non-genitalic traits. A praegenitale is present in the deviant *C. placita*, but it is not diagnostic of that genus. The subgenitale is stalked in *Chrysopiella* and *Eremochrysa*. *Chrysopa (sensu stricto)*, in contrast, has a broadly membranous subgenitale, as in other genera, but it also has proximal sclerotization, also seen in *C. lineaticornis*, but not in the congeneric *C. placita*. An ectal cavity occurs on the apical lobe in *Eremochrysa* and *Meleoma*, separating *Eremochrysa* from *Chrysopiella* and making *Meleoma* distinct from all other genera. For the convenience of an objective couplet in the key to the genera, both *Chrysoperla* and *Mallada* are differentiated from each other by the alignment of the innermost gradate in the wings. Thus, as with males, the generic diagnosis of females combines genitalic and non-genitalic traits for the 9 genera of chrysopids in the restricted Canadian fauna, similarly with application to contiguous parts of the United States.

### Significance of Coloration in Chrysopidae

**Ecological implications.** The bodies of most Chrysopidae in Canada are green, but *Nothochrysa californica* and the species of *Eremochrysa* in this analysis are brownish. These color differences, however, do not imply phylogenetic affinity, and there is little evidence for ecological or behavioral similarity. Reasons for this body coloration are unknown. Similarly, head and antennal marks make many chrysopine species resemble each other. The patterns are repeated in different genera, suggesting behavioral convergence.

Seasonal factors further complicate coloration, in addition to regional influences of climate and food. Now that insect diapause and voltinism are better understood, widespread species, such as *Chrysoperla carnea*, have been the focus of phenology research (Canard *in* New 1975). Indeed, there has long been confusion over the specific identity of specimens collected in December and January from the southern interior of British Columbia, which were darkly colored. They were intended for release in New Zealand and, though subsequently given a specific name (Smith 1932, as *Chrysopa downesi* Smith), that "species" is now considered to be a seasonal form of the complex *C. carnea* (Garland 1984). In this insect, there is evidence for seasonally limited, pre-ovipositional flight behavior (Duelli 1980a, 1980b), complementing courtship studies and sonication behavior (Henry 1979, as *Chrysopa downesi* Banks [*sic*]). This ubiquitous species evidently has 2 autosomal loci that regulate its phenology (Tauber and Tauber 1979), providing a stratagem for assortative mating that ought not to be confused for reproductive isolation, as laboratory stocks quite readily interbreed (C.A. Tauber *in litt.* 18.IV.1980). This emphasizes the need for understanding the bionomics of local populations, and underlines the importance of seasonal coloration to the species concept itself.

**Taxonomic considerations.** The head markings in chrysopids, such as *Chrysopa oculata* especially, are variable. Historically, the species was given varietal and regional names, however descriptive, primarily on the basis of variation in coloration of the head. For illustration, and relevant to the Canadian fauna, *Chrysopa oculata carei* Smith (1932) was based on a series of type-specimens from a number of localities in southern British Columbia. The description emphasized marks, or rather their absence, on the vertex of

the head. That character subsequently was shown to be infrasubspecific (Bickley 1952), such that the name *carei* no longer represents a valid taxonomic category (Stoll *et al.* 1961), and is unavailable. In general, head markings vary tremendously, even within local populations of *C. oculata* (Fig. 2), *C. nigricornis*, and *C. chi*.

In specimens in collections, head markings frequently are concealed by dust, or by scales from other insects that had been collected using the same container. Light traps, especially, yield specimens with scales and debris plastered over the head and body. But even routine field collecting employs the same vial without time being taken to clean it, and lepidopteran scales accumulate, eventually covering insects that are placed in the same container to be sorted later. In attempts to remove this debris from green lacewings, antennae are all too readily lost. However trivial this may seem, experts themselves have misidentified chrysopid specimens on account of the presence of scales, or other debris, obscuring critical aspects of head and body coloration.

If the insect had been active in nature, or has been immersed in a preserving fluid, certain colors often become faded. A good example is *Chrysopa quadripunctata* in this analysis, for which some specimens no longer have the pattern of orange marks on the head and thorax, or abdomen, evidently lost as a result of bleaching. The direct rays of the sun are known to have that effect on pinned specimens<sup>2</sup>, as do killing agents, such as cyanide. Similarly, the procedure to prepare terminalia, involving digestion with potassium hydroxide, non-selectively removes detail from most cuticular patterns, as does alcohol in wet storage. In addition, the temperature and humidity in storage cabinets and the prolonged use of dichloride to deter museum pests affect body lipids that, in turn, alter coloration. These are important points to remember when working with specimens in university and other institutional collections, some of which may have been subjected to a combination of these various factors, and many of which are very old. The oldest, definitely dated specimen in this analysis of Canadian chrysopids was collected in July 1875 (*leg. H.H. Lyman*, Lyman Entomological Museum and Research Laboratory, McGill University), being a specimen of *Chrysopa oculata* from Montreal, which does not appear to have altered in coloration.<sup>3</sup>

Finally, the glare from lights when a specimen is being identified can obscure the contrast in coloration, especially of the gradate series of crossveins in the forewing (FW) and hindwing (HW). Differences in coloration of the gradates are most readily seen by shielding the specimen from direct lighting while, at the same time, rotating it during examination. Specifically, in the Canadian fauna, *Meleoma signoretti* has brown gradates, *Chrysoperla rufilabris* has black gradates, and *Chrysopa chi*, *C. coloradensis*, *C. pleuralis*, and *C. quadripunctata* all have blackish gradates. Also, the bases of longitudinal veins (FW) are blackened in *Meleoma schwarzi* (Garland 1979). The venation in *Mallada* is amber-brown.

The entire venation (FW, HW) is faintly margined with amber in the 2 species of *Mallada* in this analysis. Similarly, *C. placita* has faintly margined veins. Broader, dark brown margination occurs in *Eremochrysa canadensis*. Blackish infuscation is variable in *C. lineaticornis*, extending along the 2 series of gradate crossveins (FW) and over the subcostal crossveins beneath the pterostigmata (FW) in a recently caught specimen from the Isle de Montréal. This infuscation, however, is thought to be subject to fading, and might be related to the humidity that prevails during development of the immature stages.

<sup>2</sup>Either as a result of ultraviolet rays or, which is quite likely, due to the bleaching effect of ozone generated by ultraviolet light. For this reason, specimens collected by "black lamp" should be so labelled.

<sup>3</sup>A recently captured specimen of what appears to be the same species has been seen which, however, lacks the frontal mask (Penticton (West Bench), BC, 29.VI.1985, S.G. Cannings in Spencer Entomological Museum, UBC). More detailed examination emphasizes the difficulty that superficial characters present, as this specimen is a small male of *C. nigricornis*.

Also on the longitudinal veins (FW), colorless spots alternate with dark zones in *Eremochrysa punctinervis*, distinguishing that species from the similar *E. fraterna*. Venational spotting, however, is not as objective a trait as might be desired and, in this analysis of the Canadian fauna, there is reason to doubt if the 2 species actually coexist in British Columbia, where the recorded ranges suspiciously overlap. Indeed, it is thought that differences in venational spotting might just as easily arise as a consequence of climatic influences during development. Revision of the genus probably will be necessary to establish the validity of *E. fraterna*. In the meantime, *E. punctinervis* is the coloration most frequent in collections, and it would be the senior name in the event of eventual synonymy.

In summary, this analysis of the Canadian fauna emphasizes that, though head markings and other phenotypic coloration vary greatly, the number of species is sufficiently few that color can be used, along with other traits, to identify them (Table 3), with application to the contiguous United States of America.

### Geographic Distribution of Chrysopidae in Canada

**Relationship to Other Faunas.** The only truly Holarctic species in this analysis is *Chrysoperla carnea*, which occurs in the United Kingdom (Barnard 1978) and eastward in the Palearctic region to Siberia (Dorokhova 1979), as well as in North America, where it was known formerly as *Chrysopa plorabunda* Fitch (Tjeder 1960). In Canada, the range of this widespread species extends far beyond "treeline" in the District of Mackenzie, Northwest Territories, and it is also present in central and western Alaska. Specimens have also been examined from Sable Island, which is located 150 miles east of Halifax, Nova Scotia (Howden 1970), in the Atlantic Ocean. Considering this, its flight behavior (Duelli 1980a, 1980b) and its occurrence at high altitudes (Glick 1939, as *C. plorabunda*; Bowden 1979), the movement of this species across Bering Strait, which is much narrower than the seas between Sable Island and the mainland, seems quite plausible.

There are other species almost equally widely distributed in North America, such as *Chrysopa chi*, *C. nigricornis*, and *C. oculata* in the present analysis. These species, and others like them, occur throughout much of Canada, and *C. chi* and *C. oculata* have been examined from localities in Alaska. Unmistakably, these species are transcontinental in their geographic distribution. Other, similarly widespread species enter Canada, but only in more hospitable parts of Nova Scotia, southwestern Quebec, and extreme southern Ontario, or on the coast and in the southern interior of British Columbia. Yet other species appear to have even more restricted distributions in Canada, and it is thought that, essentially, they represent pioneering populations of those species whose northern limits fluctuate in response to climatic variation and the availability of food resources (concept in Scudder 1979).

Certain species, as yet unrecorded quite so far north, might enter the extreme southern limits of Canada during periods of warmer regional climate. *Chrysopa incompleta*, for instance, as an eastern woodland species recorded in lists for Maryland (Bram and Bickley 1963), Massachusetts (Bickley and MacLeod 1956), and southern Wisconsin (Throne 1971), might periodically enter southern Ontario. In the west, *Chrysopiella sabulosa* has been examined from southern Montana, so it, too, might enter Canada occasionally.

There are several additional species for which Canadian distribution records are based upon a few isolated specimens, most of which are very old. The 2 examples discussed here are western. *Nineta gravida* was last collected in Canada in 1908, at Departure Bay on Vancouver Island (leg. *unknown*, Canadian National Collection, Ottawa, per J.E.H. Martin). More recently, however, a specimen was collected at Bellingham, Washington, in 1962 (leg. *J.F.G. Clarke*, United States National Museum, Washington, DC, per O.S. Flint), revealing that the species still exists in the Pacific Northwest, and that it might be anticipated in Canada again. The other insect is the transcontinental *Chrysopa quadripunctata*. As it has always been associated with oak trees (Smith 1922), this species can

Table 3. Practical key to the species of Canadian Chrysopidae

1.	Body brown.	
	(a) Forewing with jugum; hindwing with 2 series of gradate crossveins; pretarsal claws entire	<i>Nothochrysa californica</i>
	(b) Forewing with jugum; hindwing with 1 series of gradate crossveins; pretarsal claws excized	4
—	Body green	2
2.	Forewing with 1 series of gradate crossveins.	
	(a) Antennal scape with lateral band continuous distally with middorsal scape spot	<i>Chrysopiella brevisetosa</i>
	(b) Antennal scape with lateral mark broadly continuous on ventral aspect; <i>western USA only</i>	<i>Chrysopiella sabulosa</i>
—	Forewing with 2 series of gradate crossveins.	
	(a) Radial sectors forming opposing curves between inner and outer gradate crossveins	10
	(b) Radial sectors forming regular curves between inner and outer gradate crossveins	3
3.	Head and antennal scape and pedicel marks as follows:	
	(a) Genae and/or clypeus; pedicel only	5
	(b) Genae and/or clypeus; scape and pedicel unmarked	6
	(c) Frons and/or vertex; scape and pedicel both	7
	(d) Frons and/or vertex; pedicel only	8
	(e) Frons and/or vertex; scape and pedicel unmarked	9
	(f) Head unmarked; scape and pedicel both	<i>Ceraeochrysa lineaticornis</i>
—	Head and antennal scape and pedicel unmarked	10
4.	Antennal scape suffused with brown dorsally; setae of frons long and dense, pronounced in male	<i>Eremochrysa canadensis</i>
—	Antennal scape with brown lateral band; setae of frons short and sparse.	
	(a) Venation interrupted with regular pale zones	<i>Eremochrysa punctinervis</i>
	(b) Venation without regular spotting	<i>Eremochrysa fraterna</i>
5.	Antennal scape elongate, straight-sided; genal mark continuous to eye; antennal flagellum pale	<i>Meleoma emuncta</i>
—	Antennal scape short, convexly rounded; genal mark reduced or absent, not continuous to eye; antennal flagellum darkened proximally, variable or pale in western populations	<i>Chrysopa nigricornis</i>
6.	Gradate crossveins black.	
	(a) Postgena reddish-orange; genal mark defined, dark; thorax and abdomen with dorsolateral reddish-orange spotting, variable	<i>Chrysopa quadripunctata</i>
	(b) Postgena unmarked; genal mark suffused, reddish; thorax and abdomen entirely green without orange spotting	<i>Chrysoperla rufilabris</i>
—	Gradate crossveins amber or brownish.	
	(a) Innermost gradate crossvein on radial sector.	
	(i) Labrum with uninterrupted black margin; a western species	<i>Mallada perfectus</i>
	(ii) Labrum with black margin interrupted medially; an eastern species, mid-western in USA	<i>Mallada macleodi</i>
	(b) Innermost gradate crossvein on pseudomedia.	
	(i) Antennal scape elongate, straight-sided	<i>Meleoma dolichartha</i>
	(ii) Antennal scape convexly rounded	11
7.	Gradate crossveins differentiated from rest of venation, black; thoracic pleurites outlined in black; antennal scape with basal spot only	<i>Chrysopa pleuralis</i>
—	Gradate crossveins undifferentiated from rest of venation; thorax unmarked; antennal scape with well-defined lateral band	<i>Chrysopa excepta</i>
8.	Gradate crossveins differentiated from rest of venation, black; pronotum darkly marked.	
	(a) Pronotum with longitudinal dark bands laterally; frontal mark forming black margin around antennal socket; antennal flagellum darkened proximally; a western species	<i>Chrysopa coloradensis</i>
	(b) Pronotum with symmetrical dorsolateral spots; frontal mark forming an inter-antennal mask, not confined to antennal socket; antennal flagellum pale proximally.	

Table 3. (Concluded)

i) Inter-antennal mark in form of an "X", or an irregular "Y" with a variable sub-antennal spot; widespread . . . . .	<i>Chrysopa chi</i>
(ii) Inter-antennal mark in form of a frontal mask; eastern USA only [includes the unnamed species, cf. footnote 1] . . . . .	<i>Chrysopa incompleta</i>
— Gradate crossveins undifferentiated from rest of venation, or darkened at extremities only; pronotum only faintly spotted . . . . .	<i>Chrysopa oculata</i>
9. Genae with continuous dark band to eye; labrum with black laterally; forewing subcosta and rest of longitudinal venation darkened basad; frontal mask not reaching eye socket; abdominal sterna with striae, and meta-thoracic leg with femoral pegs . . . . .	<i>Meleoma schwarzi</i>
— Genae and labrum unmarked; forewing subcosta and rest of venation undifferentiated, pale green; frontal mask reaching eye socket; abdominal sterna without striae, and metafemoral pegs absent . . . . .	<i>Nineta gravida</i>
10. Gradate crossveins differentiated from rest of venation, dark brown; venation without margination, green; radial sectors forming regular curves between inner and outer gradate crossveins; costal cells in basal half of forewing forming rectangles wider than high; frons in male deeply invaginated; antennal flagellum darkened proximally, variable . . . . .	<i>Meleoma signoretti</i>
— Gradate crossveins undifferentiated from rest of venation, amber with brownish margination; radial sectors forming opposing curves between inner and outer gradate crossveins; costal cells in basal half of forewing forming rectangles higher than wide; frons not sexually differentiated in male; antennal flagellum pale proximally . . . . .	<i>Ceraeochrysa placita</i> *
11. Inner series of gradate crossveins in forewing approximately 11, always more than 6; genal mark suffused and reddish; an eastern species . . . . .	<i>Chrysoperla harrisii</i>
— Inner series of gradate crossveins in forewing approximately 5, rarely more than 6; genal mark well-defined, dark, or suffused and reddish in northwestern populations; widespread . . . . .	<i>Chrysoperla carnea</i>

\*The type-specimen from Colorado has black clypeal smudges; seen at the Museum of Comparative Zoology, Cambridge, Massachusetts. Other specimens examined here (New Hampshire, Oregon, Utah, USA; Ontario, Québec, Canada) lack markings on the vertex, frons, genae, and clypeus entirely, making this species most resemble females of *Meleoma signoretti*, with which it is here contrasted.

be expected on Vancouver Island, where it was last collected in 1888 (*leg. G.W. Taylor*, Canadian National Collection, Ottawa, *per* J.E.H. Martin). Otherwise this species has an apparently disjunct range in the Canadian part of its North American distribution, appearing in Saskatchewan, where it was first found only in 1977 along the Qu'appelle River east of Regina (*leg. R. Hooper*, Saskatchewan Museum of Natural History, Regina, *per* R. Hooper). It also has been recorded in southern Minnesota (Parfin 1952), so it should occur in Manitoba where stands of native oak still flourish. Its absence from that part of its apparent range, and the disappearance of both this species and *N. gravida* from previously occupied habitats on the west coast of Canada, suggest gradual extinctions in progress.

The possibility of a truly disjunct distribution cannot be identified with certainty for any of the species represented in this analysis of the Canadian chrysopid fauna. *Eremochrysa*, for instance, includes several species names which, together, comprise a transcontinental complex considered here as *E. canadensis*. A revision of this entire genus seems desirable, as mentioned above. Similarly, *Meleoma signoretti*, though apparently disjunct (Tauber 1969), occurs along the Manitoba escarpment and in the Rocky Mountain House District of Alberta. Further collecting in the Prairie Provinces is expected to demonstrate a transcontinental, boreal pattern of distribution for this species. An unusual north-south disjunction for *Chrysoperla comanche* (Bickley and MacLeod 1956, as *Chrysopa sperryae* Banks; *cf.* Adams 1957), and an east-west disjunction in *Chrysoperla harrisii* (Smith 1932, as *Chrysopa harrisii*; Bickley and MacLeod 1956, *idem*), have been resolved here. Only the Fort Yukon, Alaska, record could not be traced (W.E. Bickley in *litt.*

22.XII.1980). The other questionable specimens have been examined, from several localities in British Columbia, and they are all considered here to be *Chrysoperla carnea*. Thus, *C. comanche* is entirely southern, and *C. harrisii* reaches its most westerly limit of distribution in Manitoba [in Canada].

The foregoing illustrates that the Canadian chrysopid fauna includes an Holarctic transcontinental species, and other species, which are either eastern Nearctic, western Nearctic, or more widespread, transcontinental components in the context of a broader analysis. Some species, of course, extend appreciably beyond Canada and the United States of America, entering the Neotropical Region.

### Checklist of Chrysopidae of Canada

The geographic distribution of species in Canada, and those transcontinental species known also from Alaska, is summarized below. For convenience the arrangement of species is alphabetical, and the Canadian provinces are listed from west to east, using standard abbreviations. Anticipated additions are queried: (?).

*Ceraeochrysa lineaticornis* (Fitch)

Sask., (?Man.), Ont., Que., NB, NS, (?PEI).

*Ceraeochrysa placita* (Banks)

(?BC), Ont., Que.

*Chrysopa chi* Fitch

Alaska, transcontinental in Canada (including Yukon, District of Mackenzie, and insular Nfld.).

*Chrysopa coloradensis* Banks

BC (coastal and interior).

*Chrysopa excepta* Banks

BC (interior), Alta., Sask.

*Chrysopa nigricornis* Burmeister

BC, Alta., Sask., Man., Ont., Que., NB, NS, (?PEI).

*Chrysopa oculata* Say

Alaska, transcontinental in Canada (including Yukon, District of Mackenzie, Isle d'Anticosti, Sable Island, and insular Nfld.).

*Chrysopa pleuralis* Banks

BC (interior), Alta.

*Chrysopa quadripunctata* Burmeister

BC (coastal), Sask., (?Man.), Ont., Que., NS, PEI.

*Chrysoperla carnea* (Stephens)

Alaska, transcontinental in Canada (including Yukon, District of Mackenzie, Sable Island, and insular Nfld.).

*Chrysoperla harrisii* (Fitch)

Man., Ont., Que., NS (including Sable Island).

*Chrysoperla rufilabris* (Burmeister)

Ont., Que., NS (including Sable Island).

*Chrysopiella brevisetosa* Adams and Garland

Alta.

*Eremochrysa canadensis* (Banks)

BC (interior), Ont., Que.

*Eremochrysa fraterna* (Banks)

BC (interior).

*Eremochrysa punctinervis* (McLachlan)

BC (interior).

*Mallada macleodi* Adams and Garland

Ont., (?Que.).

*Mallada perfectus* (Banks)

BC (interior).

*Meleoma dolicharthra* (Navás)

BC (coastal and interior).

*Meleoma emuncta* (Fitch)

BC, (?Alta.), (?Sask.), Man., Ont., Que., NB, NS, PEI, Nfld. (insular).

*Meleoma schwarzi* (Banks)

BC (interior).

*Meleoma signoretti* Fitch

BC, Alta., (?Sask.), Man., Ont., Que., (?NB), NS, (?PEI).

*Nineta gravida* (Banks)

BC (coastal).

*Nothochrysa californica* Banks

BC (coastal).

In the case of *Meleoma emuncta* from Saskatchewan, a doubtful record exists from Saskatoon (Smith 1932, as *Meleoma species near emuncta*). The specimen evidently is lost (Canadian National Collection, Ottawa, per J.E.H. Martin), so that record is queried here. Also, an ancient record of *Chrysopa quadripunctata* from St. Martin's Falls, Albany River, Hudson's Bay (Walker 1852), might have been misidentified (Hagen 1861). Regardless, there is no trace of this specimen (P.C. Barnard *in litt.* 23.IX.1980), and the site, in the vicinity of present-day Ogoki in north-central Ontario, is considered here beyond the anticipated range of the species, so that record is omitted entirely.

### Bionomic Notes Pertaining to Canadian Chrysopidae

Although only 6 of the species in this analysis have figured in any way in a biological investigation conducted in Canada, the available information relates importantly to their influence on pest-management considerations. As this is a subject of much current interest, this summary of bionomic notes pertaining to Canada may be helpful. The species are arranged alphabetically, again for convenience, and synonyms preface the discussion of the literature for each species.

*Chrysopa oculata* Say

(Fig. 2)

*Chrysopa albicornis*; Briand 1931: 123–126.

*Chrysopa chi*; Robinson 1952: 36.

*Chrysopa chlorophana*; Walker 1852: 259–260.

*Chrysopa euryptera*; Provancher 1869: 140.

*Chrysopa latipennis*; Walker 1852: 259.

*Chrysopa oculata*; Walker 1852: 260; Provancher 1869: 140; Briand 1931: 123–126; Steenburgh 1931: 64; Putman 1932a: 44–45; 1932b: 121–126; 1937: 29–37; Garlick 1955: 282, 326–327, 329; Wilde 1962: 847; 1963: 48; Watson and Wilde 1963: 435–438; Wilde and Watson 1963: 958–959; McMullen and Jong 1967a: 35–36; 1967b: 1293; Westigard *et al.* 1968: 740; McMullen 1971: 69; Hagley 1975: 34–35; Madsen and Morgan 1975: 13–14; New 1975: 131–132; Hagley 1979: 17.

*Chrysopa transmarina*; Provancher 1869: 140.

?*Hemerobius perla*; Gosse 1840: 197–198.

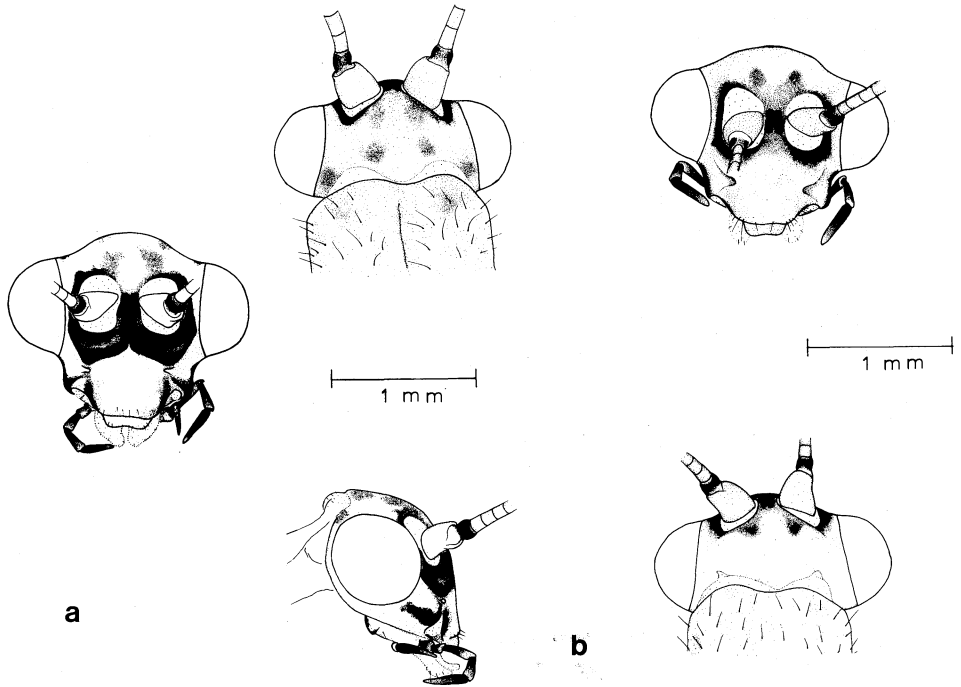


FIG. 2. *Chrysopa oculata*: head. (a) Female, British Columbia (based on a specimen collected by J.A. Garland, Penticton, BC, 7. VII. 1976 in Lyman Entomological Museum and Research Laboratory, McGill University). (b) Female, British Columbia (based on a specimen collected by J.A. Garland, Penticton, BC, 10. IX. 1976 in Lyman Entomological Museum and Research Laboratory, McGill University).

The adult of *C. oculata* emits a disagreeable odor when it is disturbed (Provancher 1869) and, on account of this and its widespread occurrence and abundance, is thought to have been the insect that Gosse encountered while farming near Compton, in the Eastern Townships of Lower Canada (Gosse 1840). Certainly, this insect was among the earliest of these naturally occurring, beneficial chrysopids ever to be recognized in Canada (Walker 1852) and, subsequently, it has proven to be useful as a predator.

For instance, during an outbreak of the Oriental fruit moth, *Grapholitha molesta* (Busck), in the Niagara Peninsula during the 1930's (Briand 1931), larvae of *C. oculata* ate the eggs of this moth (Steenburgh 1931). Commenting on that outbreak, Putman (1932*b*) noted that *C. oculata* preferred to rest and oviposit on low vegetation, thus explaining why its larvae were only rarely found on deciduous fruit trees where, presumably, they might have been of greater service to the orchardists. However, *C. oculata* eggs were also frequently found in orchards with weeds and cover crops (Putman 1932*a*). In subsequent studies, the larval feeding behavior and egg populations were assessed in Niagara orchards (Putman 1937). Among other sources of food, a larva of *C. oculata* has been seen sucking the egg of a clover mite (Garlick 1955), and adults have been examined in this analysis that were collected in association with tetranychid mites, on which they were thought to have been feeding (Robinson 1952).

Adults of *C. oculata* have been caught, on occasion, in bait traps (Garlick 1955), on sticky boards (Madsen and Morgan 1975), or in spider webbing in crotches of pear trees (Wilde 1963). The last-mentioned discovery of *C. oculata* in pear trees arouses curiosity about its potential as a natural-control agent of pear psylla, *Psylla pyricola* Förster (Wilde 1962; Watson and Wilde 1963; Wilde and Watson 1963; McMullen and Jong 1967*a*;



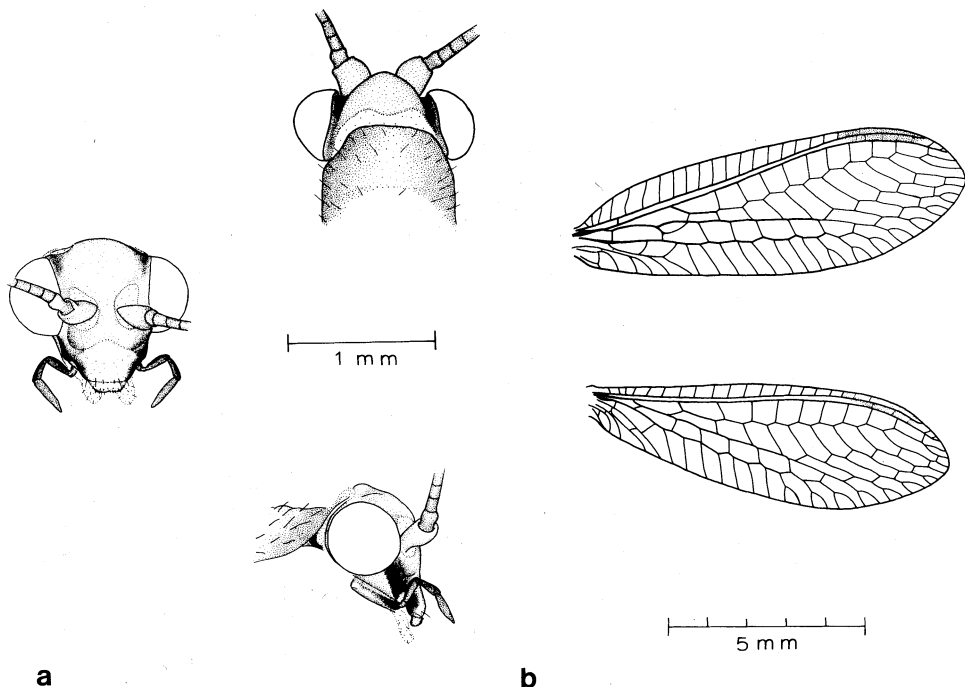


FIG. 3. *Chrysoperla carnea*: head and wings. (a) Male, Manitoba (based on a specimen collected by E.A.R. Liscombe, Carberry, Man., 22.VII.1948 in Department of Entomology, University of Manitoba). (b) Male, Manitoba (based on a specimen collected by P.W. Arnfield, Winnipeg, Man., 20.VIII.1980 in Department of Entomology, University of Manitoba).

1967b). Indeed, present evidence indicates that *C. oculata* is an effective predator against pear psylla (Westigard *et al.* 1968; McMullen 1971; New 1975), if not also against aphids on apple in Canadian orchards (Hagley 1975, 1979). More research on this insect seems warranted.

*Chrysopa oculata* is a host of *Tetrastichus chrysopae* (Crawford), a chalcidoid eulophid that has been recorded with as many as 22 progeny on the body of a single chrysopid larva (Watson and Wilde 1963). Also, at Tofield, near Edmonton, a specimen of the widespread proctotrupoid helorid, *Helorus anomalipes* Panzer, identification confirmed by L. Masner, Biosystematics Research Institute, Agriculture Canada, Ottawa, emerged from a cocoon of *C. oculata*, larval exuvium seen by C.A. Tauber, Cornell University. That species of helorid is well-known as a parasite of Chrysopidae (Townes 1977).

*Chrysoperla carnea* (Stephens)

(Fig. 3)

*Chrysopa carnea*; Wilde 1962: 847; Putman 1963a: 37; 1963b: 109; Wilde 1963: 48–49; Judd 1964: 990; Herne and Putman 1966: 937, 939; Putman and Herne 1966: 811–812; Judd 1967: 54; McMullen and Jong 1967a: 35–36; 1967b: 1293; McMullen 1971: 34; New 1975: 124, 129; Bucher and Bracken 1976: 26–30; Philogene and Chang 1979: 56; Burgess 1980: 745–746.

*Chrysopa downesi* Smith 1932: 594–595, 601; Bickley and MacLeod 1956: 193.

*Chrysopa harrisii*; Smith 1932: 595–596 (*partim*); Foster 1942: 22; Bickley and MacLeod 1956: 193.

*Chrysopa harrisii externa*; Smith 1932: 596; Robinson 1952: 36.

*Chrysopa plorabunda*; Putman 1932a: 44–45; 1932b: 121–126; Smith 1932: 584 (footnote 4), 593, 601; Ross and Putman 1934: 37; Putman 1937: 29–37; Garlick

1955: 281–282, 326–328; Putman 1955: 24; 1956: 520; Putman and Herne 1958: 668, 670–671; 1960: 200–201; Dustan 1961: 224.

*Chrysopa plorabunda californica*; Robinson 1952: 36.

In the 1920's, large numbers of overwintering adults of *C. carnea* were gathered from the Okanagan Valley of British Columbia in response to a request from R.J. Tillyard, who wanted to establish Chrysopidae in New Zealand (Dennys 1927; Smith 1932, also cited by Bickley and MacLeod 1956). About 2000 specimens were sent in 1925, and another 6000 in 1926. Presumably they arrived and were released, but there is nothing in New Zealand literature to suggest that *C. carnea* ever became established as a result of this program (Hudson 1950). Again, at a much later date, in a study of winter-active insects in forests near Vancouver, a specimen of *C. carnea* was collected sometime between November 1939 and March 1940 (Foster 1942). At other times, adults have been recorded among the captures in bait pails (Garlick 1955).

In general, this species is a nectar feeder as an adult (New 1975), making manipulation possible in agroecosystems. In laboratory studies in Canada, adults of *C. carnea* have been watched to learn about their feeding habits. Apparently they are most active at night, and they imbibe nectar from peach-leaf glands (Putman 1963*a*, 1963*b*). However, in nature the adult might be more a scavenger, which is inferred from the presence of insect cuticle and cestode oncospheres in the frass of 1 specimen (Putman and Herne 1966, also cited by New 1975; cf. abortive eggs in Sheldon and MacLeod 1974).

Like several other species in this account, *C. carnea* was important in the natural control of the Oriental fruit moth in the Niagara Peninsula during the 1930's (Putman 1932*a*, also cited by Dustan 1961; Ross and Putman 1934). The immatures of this species were present in every peach orchard examined (Putman 1932*a*). They were plentiful on tall weeds, as well as on young peach trees where they preyed upon fruit-moth eggs (Putman 1932*b*). Life history studies were initiated for this species during that period. Thus, for Niagara populations of *C. carnea* there is a certain amount of information about feeding behavior and development, voltinism, oviposition, and parasites (Putman 1937). Also, there is some early toxicological information. Sulfur was the only pesticide available during the period spanning the fruit-moth outbreak in the 1930's, and records show that it did not affect *C. carnea* adversely (Herne and Putman 1966). The more recent pesticides, such as DDT, eventually must have selected for tolerance in *C. carnea*, which became quite abundant in both sprayed and unsprayed orchards (Putman 1956, also cited by Putman and Herne 1958, by Herne and Putman 1966, and by New 1975). In contrast, sevin (carbaryl in Scott 1979) and parathion are devastating to chrysopid larvae, and these pesticides virtually have eliminated all Chrysopidae from Niagara orchards in recent times, though *C. carnea* appears to be least susceptible of several species to sevin (Putman and Herne 1960, also cited by Herne and Putman 1966, and by New 1975).

Other work with *C. carnea* in Canada shows that its larvae will feed non-selectively on several species of mites (Robinson 1952), including the European red mite, *Panonychus ulmi* (Koch) (Putman and Herne 1958, 1966). It also feeds on the eggs and young nymphs of pear psylla (Wilde 1962, also cited by McMullen and Jong 1967*a*, 1967*b*, and by McMullen 1971; Philogene and Chang 1979), on codling-moth eggs, *Laspeyresia pomonella* (L.) (Putman 1963*b*), on the early larval instars of the bertha armyworm, *Mamestra configurata* Walter (Bucher and Bracken 1976), and on the flea beetle, *Phyllotreta cruciferae* (G.) (Burgess 1980). The last was probably induced by stress due to a shortage of food. Though small, the adult flea beetle is not thought of as a preferred food for these larvae, on account of its very hard exoskeleton. To conclude, *C. carnea* also feeds on the Oriental fruit moth, as mentioned above, and it undoubtedly transfers to leafrollers or other small lepidopteran larvae, as well as to aphids.

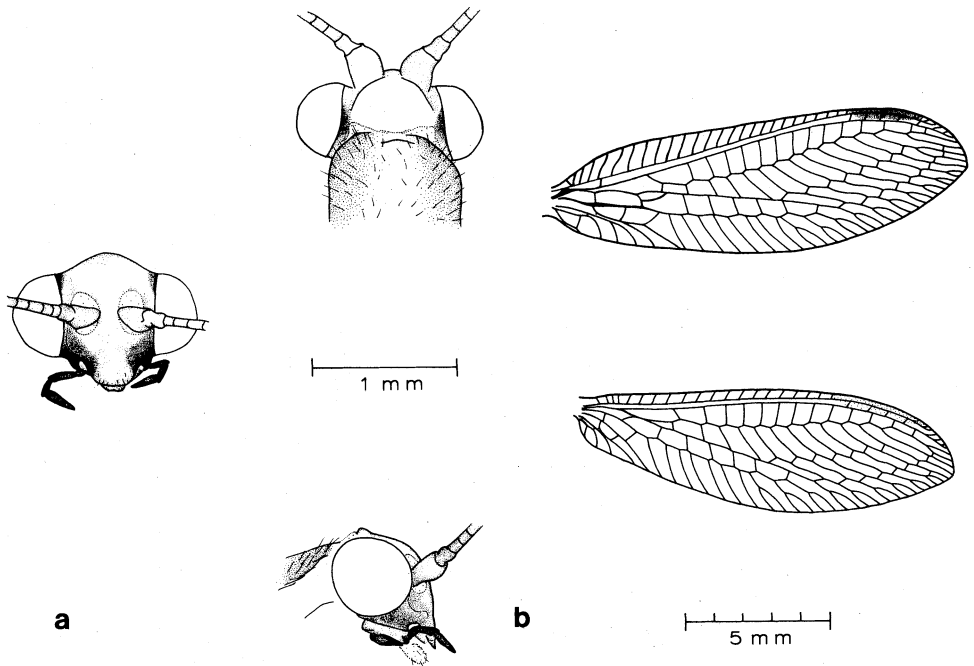


FIG. 4. *Chrysoperla harrisii*: head and wings. (a) Male, Quebec (based on a specimen collected by J. A. Garland, Ste-Anne-de-Bellevue, Que., 29.VIII.1978 in Lyman Entomological Museum and Research Laboratory, McGill University). (b) Female, Quebec (based on a specimen collected by A. T. Finnamore, Ste-Anne-de-Bellevue, Que., 4.VI.1976 in Lyman Entomological Museum and Research Laboratory, McGill University).

Hyperpredation by *C. carnea* larvae has been demonstrated, in which they have preyed upon eggs and larvae of other predators, such as the coccinellid beetle, *Stethorus punctillum* Weise (Putman 1955). In another instance, larvae attacked the nymphal stages of the anthocorid bug, *Anthocoris melanocerus* Reut. (Wilde 1963). Chrysopid larvae will also devour each other, a useful piece of information when trying to rear them in captivity. Both the larva and cocoon of *C. carnea* have been found in galls of the gelechiid moth, *Gnorimoschema gallaesolidaginis* Riley (Judd 1964, 1967).

*Chrysoperia harrisii* (Fitch)

(Fig. 4)

*Chrysopa downesi*; Putman 1932a: 121–126; Smith 1932: 584 (footnote 4).

?*Chrysopa downesi*; Putman 1937: 29–37.

*Chrysopa harrisii*; Judd 1949: 461–464; Garlick 1955: 282, 326, 328.

Investigations in the Niagara Peninsula during the 1930's mention *C. harrisii*, but it was never a commonly encountered species (Putman 1932a, also cited by Smith 1932). Nevertheless this species was reared and described (Putman 1937). Subsequently it is recorded as having been caught in bait pails in apple orchards near Vineland (Garlick 1955), though no voucher specimen appears to have been retained.

In addition to these studies, many cocoons of *C. harrisii* were collected and reared from Austrian pine on the McMaster University campus, Hamilton, and parasites were obtained (Judd 1949). They are the ichneumonid wasps *Dichrogaster crassa* (Provancher) and *Gelis tenellus* (Say), and the chalcidoid pteromalid *Pachyneuron altiscutum* Cook, identifications previously published confirmed here by M. Ivanochko and C.M. Yoshimoto, Biosystematics Research Institute, Agriculture Canada, Ottawa.

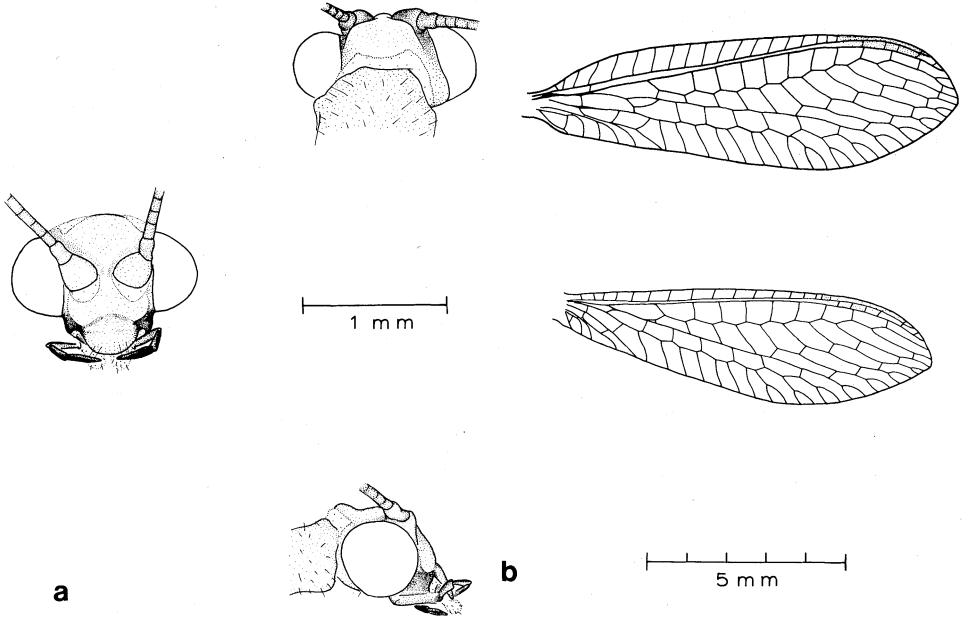


FIG. 5. *Chrysoperla rufilabris*: head and wings. (a) Female, Ontario (based on a specimen collected by K.E. Schedl, Biscotasing, Ont., 16.IX.1931 in Canadian National Collection, Ottawa). (b) Female, Quebec (based on a specimen collected by J.A. Garland, Ste-Anne-de-Bellevue, Que., 7.IX.1978 in Lyman Entomological Museum and Research Laboratory, McGill University).

*Chrysoperla rufilabris* (Burmeister)

(Fig. 5)

*Chrysopa rufilabris*; Putman 1932a: 44–45; 1932b: 121–126; Ross 1932: 40–43; Ross and Putman 1934: 37; Putman 1937: 29–37; Garlick 1955: 281–282, 326–328; Putman 1955: 24; 1956: 520; Putman and Herne 1958: 668, 670–671; 1960: 200; Dustan 1961: 224; Putman 1963b: 37; Herne and Putman 1966: 937, 939; Putman and Herne 1966: 811–812; New 1975: 129.

As a species poorly represented in museum collections where Canadian specimens are located, *C. rufilabris* has figured significantly in biological and toxicological studies of chrysopids in Canada. During the outbreak of Oriental fruit moth in the Niagara Peninsula in the 1930's, this species was present in noticeably large numbers in peach orchards (Ross 1932; Putman 1932b; Ross and Putman 1934; Dustan 1961). Its eggs and larvae were frequent between Niagara and Grimsby (Putman 1932b), resulting in study of its life history and, to some extent, bionomics (Putman 1932a, 1932b, 1937). At a later date, but in apple orchards in the Niagara area, it was an important predator of codling-moth eggs (Putman 1963b). The larva of *C. rufilabris* was later shown to be a general predator in the orchards of eastern Canada, where it feeds on all stages of certain phytophagous mites, including the European red mite (Putman and Herne 1958, 1966). Again there is hyperpredation, in which the eggs and immatures of other predators are preyed upon, such as the coccinellid beetle, *Stethorus punctillum* (Putman 1955). Like its congeners, the adult of *C. rufilabris* feeds on honeydew and nectar, using the peach-leaf glands for this purpose (Putman 1963b; Putman and Herne 1966).

The relative abundance of this species in the fruit-growing region of the Niagara Peninsula drastically declined from the level attained during the 1930's. There is no doubt about its high susceptibility, particularly of the larvae, to pesticides such as DDT (Putman 1956; Putman and Herne 1958). In contrast, only sulfur was available during the earlier

era, which does not appear to have had detectable toxicity (Herne and Putman 1966). Other more recent pesticides, such as parathion and carbaryl, are deleterious to this insect (Putman and Herne 1960; Herne and Putman 1966; New 1975). Consequently, the best interpretation for the more recently recorded decline in adult abundance, in bait traps for instance (Garlick 1955), is that the species, along with other chrysopids, was virtually eliminated from Niagara orchards as a result of insensitive pest management (Herne and Putman 1966).

*Meleoma emuncta* (Fitch)

(Fig. 6)

*Chrysopa cockerelli*; Brown and Clark 1956: 682.

*Meleoma emuncta*; Putman 1937: 36–37; Garlick 1955: 326, 329; Grobler 1962: 40.

Adults of this species have been collected at baits (Garlick 1955), and at lights. Similarly, field study has shown that the larvae of *M. emuncta* are important predators of the eggs of woolly pine-needle aphid, *Schizolachnus pini-radiatae* (Davidson), in pine plantations in Kirkwood Township, Ontario (Grobler 1962). Also, *M. emuncta* has been listed as a probable predator of the balsam woolly aphid, *Adelges piceae* (Ratz.), in eastern Canada, though feeding was never actually observed (Brown and Clark 1956).

The immatures of this species were reared, and described, from the Niagara Peninsula during the Oriental-fruit-moth investigations (Putman 1937). The third-instar larva has a frontal spot, which will distinguish it from the third-instar larva of *M. signoretti* in the greater part of Canada.

*Meleoma signoretti* Fitch

(Fig. 7)

*Meleoma signoretti*; Putman 1932a: 121; Ross and Putman 1934: 37; Putman 1937: 29–37.

This species also was important in natural control of the Oriental fruit moth in the Niagara Peninsula during the 1930's (Ross and Putman 1934). Adults have been trapped in bait pails using molasses (Putman 1932a). Eggs and larvae were collected from peach leaves, facilitating insectary rearings and a study of development in relation to temperature (Putman 1937). The insect has been reared in this analysis, confirming absence of the frontal spot in this species (Putman 1937).

### Conclusions

Complexity in *Chrysoperla carnea*, particularly in the north-west in this analysis of the Canadian chrysopid fauna, might conceivably be the result of a relatively late Wisconsinan mingling of formerly separate, zoogeographically isolated siblings, whether of specific rank or, which is more probable, only infraspecifically differentiated. Regardless, as far as is known, all species represented here are indigenous. However, the changes that have taken place in historic times, since settlement as it is understood, have greatly diminished the available habitat for these insects. For instance, the rapid growth of urban centers during the present century with concomitant parks management and arrangements for abatement of biting flies, the widespread employment of pesticides in accordance with registered agricultural and forestry use-patterns, and disruptive events such as flooding for hydroelectric development or aerial spraying for public-health reasons, as was recently done in Manitoba, leave little doubt that the suitability of whole tracts of the former range of some chrysopid species is being much more drastically altered than is realized. Thus, it no longer seems acceptable to dismiss gaps in the geographic distribution of certain species, or to describe such deficiencies as artifacts due to inadequate or selective collecting. The chrysopid specimens examined here originated at many Canadian localities, and the list of collectors, both private and professionally engaged, is impressively long. Clearly, coverage extends throughout most of Canada, with understandable concentration

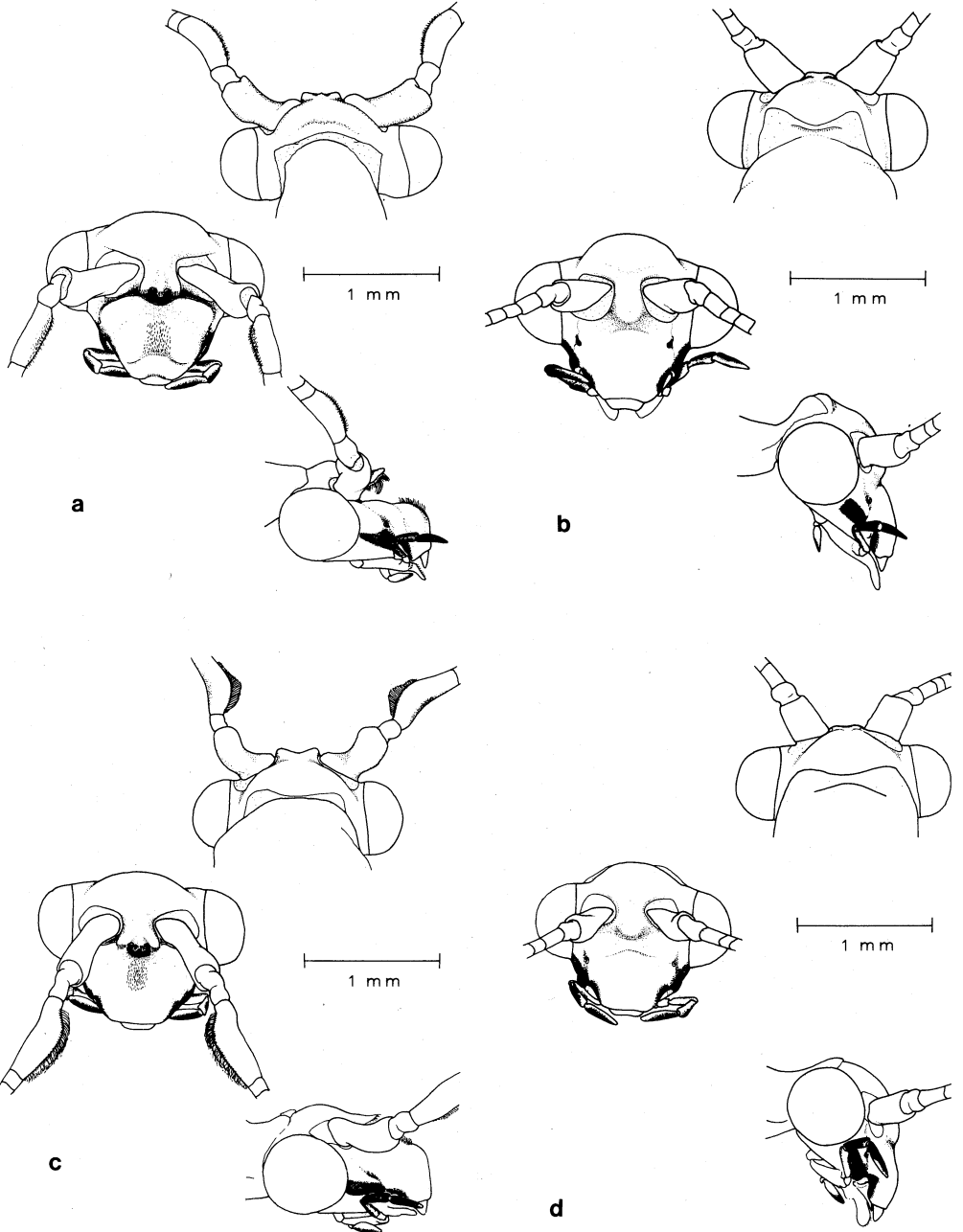


FIG. 6. *Meleoma emuncta*: head. (a) Male, Quebec (based on a specimen collected by A.F. Winn, Shawbridge, Que., 6.VIII.1930 in Lyman Entomological Museum and Research Laboratory, McGill University). (b) Female, Quebec (based on a specimen collected by S.D. Vickery, Notre-Dame du Laus (Lac Serpent), Que., 27.VII.1970 in Lyman Entomological Museum and Research Laboratory, McGill University). (c) Male, British Columbia (based on 4 specimens collected by J.A. Garland, Penticton, BC, 28.VII-10.VIII.1976 in Lyman Entomological Museum and Research Laboratory, McGill University). (d) Female, British Columbia (based on 12 specimens collected by J.A. Garland, Penticton, BC, 29.VII-16.IX.1976 in Lyman Entomological Museum and Research Laboratory, McGill University).

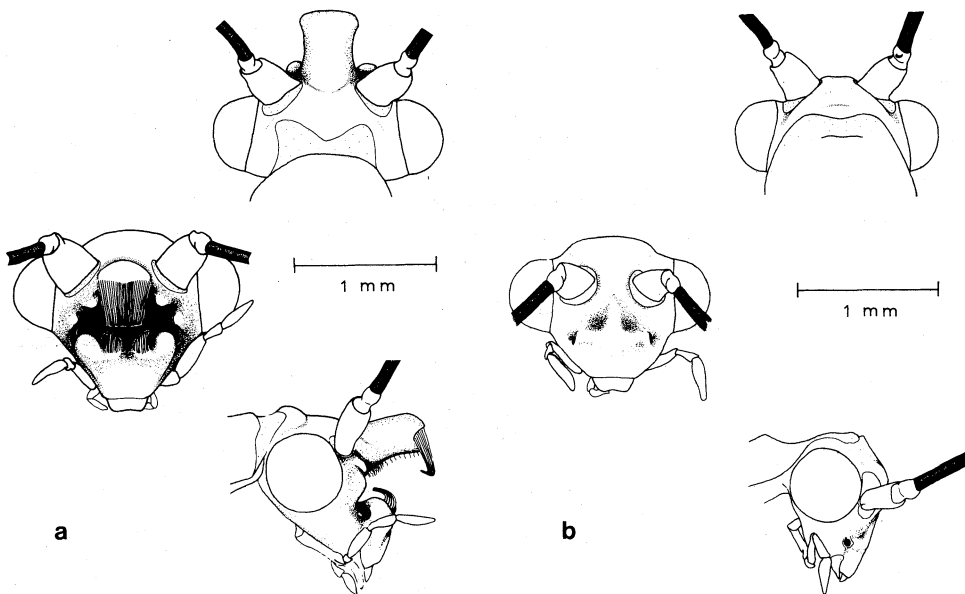


FIG. 7. *Meleoma signoretii*: head. (a) Male, Quebec (based on a specimen collected by J.A. Garland, Ste-Anne-de-Bellevue, Que., 6.VII.1979 in Lyman Entomological Museum and Research Laboratories, McGill University). (b) Female, Quebec (based on a specimen collected by J. Lovrity, Ste-Anne-de-Bellevue, Que., 26.VI.1965 in Lyman Entomological Museum and Research Laboratory, McGill University).

in and around major cities. In addition, the geographic-distribution patterns for some species, such as *Chrysopa chi*, *C. oculata*, and *Chrysoperla carnea*, are quite complete, at least across the southern portion of Canada, suggesting instead that the species differ in relative abundance, if not for more fundamental reasons. More collecting is needed to clarify the status of some species in specific regions. The checklist identifies deficiencies, but it also conceals much more detailed information now available (Garland 1981).

There is a parallel between the situation prevalent when most of the Canadian work on Chrysopidae was begun, and the present. An entomological problem existed but, unaccountably, it abated before more elaborate ecological studies could analyze factors involved. Specifically, in the 1930's the preeminence of the Oriental fruit moth in the Niagara fruit-growing region of Canada provided the impetus for original studies of the taxonomy and biology of Chrysopidae occurring in Canada. Therefore, it is in that context that, historically, the first truly comprehensive account of taxonomy of the Chrysopidae of Canada was prepared by the late R.C. Smith in 1932 (Knutson 1980), who responded to a need perceived by Canadian workers. At that time, there already was an integrated approach to pest-control practices in forest, orchard, vineyard, and other agroecosystems, though the choices were much more limited than they are today. In retrospect, the early Canadian experience with the fruit moth increased awareness of the chrysopid fauna, and of its potential. Without doubt this was done so that operational practices on individual farms might be modified to take advantage of these naturally occurring predators. That ideal is still paramount in the minds of all persons engaged professionally, at various levels and in many capacities, with forestry and the agricultural industry today, when the taxonomy and biology of endemic, beneficial insects are even better known. There are, regrettably, enormous gaps in that understanding in Canada, as made quite apparent by this summary of just 1 group, the Chrysopidae.

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### References

- Acker, T.S. 1960. The comparative morphology of the male terminalia of Neuroptera (Insecta). *Microentomology* **24**: 25-84.
- Adams, P.A. 1957. A synonym in the genus *Chrysopa* (Neuroptera: Chrysopidae). *Psyche Camb.* **63**: 45.
- 1962. A stridulatory structure in Chrysopidae (Neuroptera). *Pan-Pacif. Ent.* **38**: 178-180.
- 1967. A review of the Mesochrysinæ and the Nothochrysinæ (Neuroptera: Chrysopidae). *Bull. Mus. comp. Zool. Harv.* **135**: 215-238.
- 1969. New species and synonymy in the genus *Meleoma* (Neuroptera: Chrysopidae), with a discussion of genitalic homologies. *Postilla* 136. 18 pp.
- 1978. A new species of *Hypochrysa* and a new subgenus and species of *Mallada* (Neuroptera: Chrysopidae). *Pan-Pacif. Ent.* **54**: 292-296.
- 1982a. *Plesiochrysa*, a new subgenus of *Chrysopa* (Neuroptera). *Neuroptera Int.* **2**: 27-32.
- 1982b. *Ceraeochrysa*, a new genus of Chrysopinae (Neuroptera). *Neuroptera Int.* **2**: 69-75.
- 1983. A new subspecies of *Chrysoperla externa* (Hagen) from Cocos Island, Costa Rica (Neuroptera: Chrysopidae). *Bull. South. Calif. Acad. Sci.* **82**: 42-45.
- Adams, P.A., and J.A. Garland. 1981. A new species of *Chrysopiella* Banks from western North America (Neuroptera: Chrysopidae). *Can. Ent.* **113**: 1-4.
- 1982. A review of the genus *Mallada* in the United States and Canada, with a new species (Neuroptera: Chrysopidae). *Psyche Camb.* **89**: 239-248.
- Banks, N. 1903. A revision of the Nearctic Chrysopidae. *Trans. Am. ent. Soc.* **29**: 137-162, pl. II.
- Barnard, P.C. 1978. A check-list of the British Neuroptera with taxonomic notes. *Ent. Gaz.* **29**: 165-176.
- Bickley, W.E. 1952. Inheritance of some varietal characters in *Chrysopa oculata* Say (Neuroptera: Chrysopidae). *Psyche Camb.* **59**: 41-46.
- Bickley, W.E., and E.G. MacLeod. 1956. A synopsis of the Nearctic Chrysopidae with a key to the genera (Neuroptera). *Proc. ent. Soc. Wash.* **58**: 177-202.
- Bowden, J. 1979. Photoperiod, dormancy and the end of flight activity in *Chrysopa carnea* Stephens (Neuroptera: Chrysopidae). *Bull. ent. Res.* **69**: 317-330.
- Bram, R.A., and W.E. Bickley. 1963. The green lacewings of the genus *Chrysopa* in Maryland (Neuroptera: Chrysopidae). *Bull. Univ. Maryland agric. exp. Stn.* A-124. 18 pp.
- Briand, L.J. 1931. Notes on *Chrysopa oculata* Say and its relation to the Oriental peach moth (*Laspeyresia molesta* Busck) infestation in 1930. *Can. Ent.* **63**: 123-126.
- Brown, N.R., and R.C. Clark. 1956. Studies of predators of the balsam woolly aphid, *Adelges piceae* (Ratz.) (Homoptera: Adelgidae) II. An annotated list of the predators associated with the balsam woolly aphid in eastern Canada. *Can. Ent.* **88**: 678-683.
- Bucher, G.E., and G. Bracken. 1976. Chrysopid predation on bertha armyworm. *Man. Ent.* **10**: 26-30.
- Burgess, L. 1980. Predation on adults of the flea beetle *Phyllotreta cruciferae* by lacewing larvae (Neuroptera: Chrysopidae). *Can. Ent.* **112**: 745-746.
- Dennys, A.A. 1927. Some notes on the hibernating habits of insects in dry trees in the interior of B.C. *Proc. ent. Soc. Br. Columb.* **24**: 19-25.
- Dorokhova, G.I. 1979. The family Chrysopidae (Neuroptera) in the USSR. *Ent. Rev. Wash.* **58**: 55-59.
- Duelli, P. 1980a. Adaptive dispersal and appetitive flight in the green lacewing, *Chrysopa carnea*. *Ecol. Ent.* **5**: 213-220.
- 1980b. Preovipository migration flights in the green lacewing, *Chrysopa carnea* (Planipennia, Chrysopidae). *Behav. Ecol. Sociobiol.* **7**: 239-246.
- Dustan, G.G. 1961. The Oriental fruit moth, *Grapholitha molesta* (Busck) (Lepidoptera: Olethreutidae) in Ontario. *Proc. ent. Soc. Ont.* **91**(1960): 215-227.
- Foster, R.E. 1942. Insects active throughout the winter at Vancouver, B.C. Part I: introduction and lists of the Coleoptera and Neuroptera. *Proc. ent. Soc. Br. Columb.* **38**(1941): 19-23.
- Garland, J.A. 1979. *Meleoma schwarzi*: an addition to the Canadian fauna (Neuropteroida Planipennia: Chrysopidae). *Can. Ent.* **111**: 745-746.



- 1981[1982]. The Taxonomy of the Chrysopidae of Canada and Alaska (Insecta: Neuroptera). Ph.D. thesis, McGill University.
- 1984. Catalogue of Chrysopidae of Canada and Alaska. *Neuroptera Int.* 3: 93–94.
- 1985. Une synonymie nouvelle dans les Chrysopes Nord-américaines, avec désignation d'un néotype. *Neuroptera Int.* 4. In press.
- Garlick, W.G.P. 1955. Field studies of natural control of the codling moth, *Carpocapsa pomonella* (L.), and of the interrelated fauna in apple orchards in Ontario. *A. Rep. Ent. Lab. (Vineland Stm.) Canada Dep. Agric.* 2: 265–391.
- Glick, P.A. 1939. The distribution of insects, spiders, and mites in the air. *U.S. Dep. Agric. Tech. Bull.* 673.
- Gosse, P.H. 1840. The Canadian Naturalist. A series of conversations on the natural history of Lower Canada. Facs. Repr. (1971), Coles Publ. Co., Toronto. xii + 372 pp.
- Grobler, J.H. 1962. The life history and ecology of the woolly pine needle aphid, *Schizolachnus pini-radiatae* (Davidson) (Homoptera: Aphididae). *Can. Ent.* 94: 35–45.
- Hagen, H. 1861. Synopsis of the Neuroptera of North America, with a list of South American species. *Smithson. misc. Collns.* xx + 347 pp.
- Hagley, E.A.C. 1975. The arthropod fauna in unsprayed apple orchards in Ontario. II. Some predacious species. *Proc. ent. Soc. Ont.* 105(1974): 28–40.
- 1979. Integrated pest management — insecticides and natural predator populations on apple. *Proc. ent. Soc. Ont.* 109(1978): 9–21.
- Henry, C.S. 1979. The courtship call of *Chrysopa downesi* Banks [sic] (Neuroptera: Chrysopidae): its evolutionary significance. *Psyche Camb.* 86: 291–297.
- Herne, D.H.C., and W.L. Putman. 1966. Toxicity of some pesticides to predaceous arthropods in Ontario peach orchards. *Can. Ent.* 98: 936–942.
- Hölzel, H. 1970. Zur generischen Klassifikation der paläarktischen Chrysopinae. Eine neue Gattung und zwei neue Untergattungen der Chrysopidae (Planipennia). *Z. Arbgem. öst. Ent.* 22: 44–52.
- Howden, H.F. 1970. Coleoptera. In Fauna of Sable Island and its zoogeographic affinities — a compendium. *Natl. Mus. Can. Publ. Zool.* 4. 45 pp.
- Hudson, G.V. 1950. Fragments of New Zealand Entomology. Ferguson & Osborn, Ltd., Wellington. 188 pp.
- Huebner, E. 1980. Spermathecal ultrastructure of the insect *Rhodnius prolixus* Stål. *J. Morph.* 166: 1–25.
- Hwang, J.C., and W.E. Bickley. 1961. The reproductive system of *Chrysopa oculata* (Neuroptera: Chrysopidae). *Ann. ent. Soc. Am.* 54: 422–429.
- Judd, W.W. 1949. Emergence of the lacewing, *Chrysopa harrisii* Fitch (Neuroptera) and three hymenopterous parasites from the cocoon. *Ann. ent. Soc. Am.* 42: 461–464.
- 1964. Insects and spiders from goldenrod galls of *Gnorimoschema gallaesolidaginis* Riley (Gelechiidae). *Can. Ent.* 96: 987–990.
- 1967. Insects and other arthropods from year-old galls caused by *Gnorimoschema gallaesolidaginis* Riley (Lepidoptera: Gelechiidae) on goldenrod. *Can. J. Zool.* 45: 49–56.
- Knutson, H. 1980. Obituary. Roger Cletus Smith 1888–1980. *Bull. ent. Soc. Am.* 26: 415–416.
- McMullen, R.D. 1971. *Psylla pyricola* Förster, pear psylla (Hemiptera: Psyllidae). In Biological control programmes against insects and weeds in Canada, 1959–1968. *Commonw. Inst. biol. Contr. Tech. Commun.* 4. 266 pp.
- McMullen, R.D., and C. Jong. 1967a. New records and discussion of predators of the pear psylla, *Psylla pyricola* Förster, in British Columbia. *Proc. ent. Soc. Br. Columb.* 64: 35–40.
- 1967b. The influence of three insecticides on predation of the pear psylla, *Psylla pyricola*. *Can. Ent.* 99: 1292–1297.
- Madsen, B.J., and C.V.G. Morgan. 1975. Mites and insects collected from vineyards in the Okanagan and Similkameen Valleys, British Columbia. *J. ent. Soc. Br. Columb.* 72: 9–14.
- Matsuda, R. 1976. Morphology and evolution of the insect abdomen. Pergamon Press, New York, Toronto. viii + 534 pp.
- New, T.R. 1975. The biology of Chrysopidae and Hemerobiidae (Neuroptera), with reference to their usage as biocontrol agents: a review. *Trans. R. ent. Soc. Lond.* 127: 115–140.
- 1980. A revision of the Australian Chrysopidae (Insecta: Neuroptera). *Aust. J. Zool. Suppl.* 77. 143 pp.
- Parfin, S.I. 1952. The Megaloptera and Neuroptera of Minnesota. *Am. Midl. Nat.* 47: 421–434.
- Philippe, R. 1972. Les appareils génitaux mâle et femelle de *Chrysopa perla* (Neuroptera) étude anatomique, histologique et fonctionnelle. *Ann. Soc. ent. Fr. (S.N)* 8: 693–705.
- Philogene, B.J.R., and J.F. Chang. 1979. New records of parasitic chalcidoids of pear psylla (Homoptera: Psyllidae) in Ontario, with observations on the current world status of its parasitoids and predators. *Proc. ent. Soc. Ont.* 109(1978): 53–60.
- Provancher, L. 1869. Insectes utiles. Les Chrysopes. *Naturaliste Can.* 1: 138–140.
- Putman, W.L. 1932a. Chrysopids as a factor in the natural control of the Oriental fruit moth. *Can. Ent.* 64: 121–126.
- 1932b. Chrysopids as a factor in the natural control of the Oriental fruit moth. *A. Rep. ent. Soc. Ont.* 62(1931): 44–45.

- 1937. Biological notes on the Chrysopidae. *Can. J. Res. (D)* **15**: 29–37.
- 1955. Bionomics of *Stethorus punctillum* Weise (Coleoptera: Coccinellidae) in Ontario. *Can. Ent.* **87**: 9–33.
- 1956. Differences in susceptibility of two species of *Chrysopa* (Neuroptera: Chrysopidae) to DDT. *Can. Ent.* **88**: 520.
- 1963a. Nectar of peach-leaf glands as insect food. *Can. Ent.* **95**: 108–109.
- 1963b. The codling moth, *Carpocapsa pomonella* (L.) (Lepidoptera: Tortricidae): a review with special reference to Ontario. *Proc. ent. Soc. Ont.* **93**(1962): 22–60.
- Putman, W.L., and D.C. Herne. 1958. Natural control of phytophagous mites (Tetranychidae and Eriophyidae) in Ontario peach orchards. *Proc. Xth int. Congr. Ent.* (1956) **4**: 667–673.
- 1960. Effects of sevin on phytophagous mites and predators in an Ontario peach orchard. *Can. J. Pl. Sci.* **40**: 198–201.
- 1966. The role of predators and other biotic agents in regulating the population density of phytophagous mites in Ontario peach orchards. *Can. Ent.* **98**: 808–820.
- Robinson, A.G. 1952. Annotated list of predators of tetranychid mites in Manitoba. *Proc. ent. Soc. Ont.* **82**(1951): 33–37.
- Ross, W.A. 1932. History of the Oriental fruit moth infestation in the Niagara Peninsula. *A. Rep. ent. Soc. Ont.* **62**(1931): 40–43.
- Ross, W.A., and W.L. Putman. 1934. The economic insect fauna of Niagara peach orchards. *A. Rep. ent. Soc. Ont.* **64**(1933): 36–41.
- Scott, J.A. 1979. Compendium of pest control products registered in Canada. *Agric. Canada*. 1654 pp.
- Scudder, G.G.E. 1979. Present patterns in the fauna and flora of Canada. pp. 87–179 in H.V. Danks (Ed.), Canada and its insect fauna. *Mem. ent. Soc. Can.* **108**. 573 pp.
- Séméria, Y. 1977. Discussion de la validité taxonomique du sous-genre *Chrysoperla* Steinmann (Planipennia, Chrysopidae). *Nouv. Rev. Ent.* **7**: 235–238.
- Sheldon, J.K., and E.G. MacLeod. 1974. Studies in the biology of the Chrysopidae. V. The developmental and reproductive maturation rates of *Chrysopa carnea* (Neuroptera: Chrysopidae). *Ent. News* **85**: 159–169.
- Smith, R.C. 1922. The biology of the Chrysopidae. *Cornell Univ. agric. exp. Stn. Mem.* **58**: 1286–1372.
- 1932. The Chrysopidae (Neuroptera) of Canada. *Ann. ent. Soc. Am.* **25**: 579–601.
- 1934. Notes on the Neuroptera and Mecoptera of Kansas, with keys for the identification of species. *J. Kansas ent. Soc.* **7**: 120–145.
- Steenburgh, W.E. 1931. The biological control factors affecting the abundance of the Oriental peach moth (*Laspeyresia molesta* Busck) in Ontario during 1930. *A. Rep. ent. Soc. Ont.* **61**(1930): 57–65.
- Stoll, N.R., R.P. Dollfus, J. Forest, N.D. Riley, C.W. Sabrosky, C.W. Wright, and R.V. Melville. 1961. International Code of Zoological Nomenclature adopted by the XVth International Congress of Zoology. International Trust for Zoological Nomenclature, London. xvii + 176 pp.
- Tauber, C.A. 1969. Taxonomy and biology of the lacewing genus *Meleoma* (Neuroptera: Chrysopidae). *Univ. Calif. Publ. Ent.* **58**: 1–94.
- Tauber, M.J., and C.A. Tauber. 1979. Inheritance of photoperiodic responses controlling diapause. *Bull. ent. Soc. Am.* **25**: 125–128.
- Throne, A.L. 1971. The Neuroptera — suborder Planipennia of Wisconsin. Part I — Introduction and Chrysopidae. *Mich. Ent.* **4**: 65–78.
- Tjeder, B. 1960. Neuroptera from Newfoundland, Miquelon, and Labrador. *Opusc. ent.* **25**: 146–149.
- 1966. Neuroptera — Planipennia. The lacewings of southern Africa. 5. Family Chrysopidae. *S. Afr. Anim. Life* **12**: 228–534.
- Townes, H. 1977. A revision of the Heloridae (Hymenoptera). *Contr. Am. ent. Inst.* **15**(2). 9 pp.
- Walker, F. 1852. Catalogue of the Specimens of Neuropterous Insects in the Collection of the British Museum. Part II. 193–476. Newman, London. 476 pp.
- Watson, T.K., and W.H.A. Wilde. 1963. Laboratory and field observations of the pear psylla in British Columbia. *Can. Ent.* **95**: 435–438.
- Westgard, P.H., L.G. Gentner, and D.W. Berry. 1968. Present status of biological control of the pear psylla in southern Oregon. *J. econ. Ent.* **61**: 740–743.
- Wilde, W.H.A. 1962. Bionomics of the pear psylla, *Psylla pyricola* Foerster in pear orchards of the Kootenay Valley of British Columbia, 1960. *Can. Ent.* **94**: 845–849.
- 1963. Hyperpredators of the pear psylla, *Psylla pyricola* Foerster (Homoptera: Chermidae). *Proc. ent. Soc. Br. Columb.* **60**: 48–49.
- Wilde, W.H.A., and T.K. Watson. 1963. Bionomics of the pear psylla, *Psylla pyricola* Foerster, in the Okanagan Valley of British Columbia. *Can. J. Zool.* **41**: 953–961.

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**ERRATUM**

Vol. 117, 1985. pp. 737-762.

p. 745, l. 7: "*Ceraeochrysa placita*" should read "*Ceraeochrysa placita*".

p. 746, footnote 3: "29.VI.1985" should read "29.VI.1981".

p. 748, l.(b): "Forewing with jugum" should read "Forewing without jugum".

p. 755, l. 8: "*Chrysoperia*" should read "*Chrysoperla*".

# Bibliography of the Neuropterida

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