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Closely Related Species from the Same
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**The Nymph of *Rhithrogena impersonata* (Ephemera) and a New
Closely Related Species from the Same Locality in
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Early in the summer of 1951 a small collection of aquatic insects was submitted to the author by J. Goodwin of Toronto, taken from Sheldon Creek in Dufferin County, Ontario. Included were nymphs of two readily distinguishable species of *Rithrogena*, one having bright red gills and the other hyaline whitish gills. Those with hyaline whitish gills were more abundant and proved to be *R. impersonata* Mc.D. of which specimens from Baddeck, N.S. and Lachine, P.Q. are in the Canadian National Collection at Ottawa. I have records of this species in both nymphal and adult stages from the Credit River, Peel County, Ontario, where the association of nymph and adult was made, and in the nymphal stage from the Saugeen River in Grey County, Ontario. The nymphs with red gills proved to be those of a new species which, considering genitalic characters, is closely related to *R. impersonata*.

In 1952 several visits were made to the locality in the expectation of finding the subimagos emerging and the adults swarming. Adults were found swarming on June 1, 2, and 5, and on the last two visits the swarming was observed to extend from approximately 8-9.15 p.m. E.D.T. and was particularly noticed over a bridge spanning the river. The swarm was rather compact with little undulation of the individuals composing it and only occasionally dropping down to a level which made capture possible. A few individuals were observed emerging as subimagos from the rapids at 6.45 p.m. E.D.T. on the 2nd. Adults of both species were taken in the swarm on all occasions and the nymphs of both were found in the same location in the rapids, frequently intermingling on the same stones. The

ratio of adults in the swarm was approximately 40 of *R. impersonata* to 6 of the new species and the nymphs were present in about the same proportion.

In 1953 the locality was visited on June 14th, 18th, 19th, and 21st during the evening at the time of swarming. The swarming interval varied and on June 21st, a warm day, began at 8.55 p.m. E.D.T. and ended at 9.40 p.m. The collecting on these latter occasions was directed towards obtaining mating pairs of the two species of *Rhithrogena* which could be discerned briefly associated as they left the swarm. Two of the apparent pairs thus taken were a male *R. impersonata* with a female *Ephemerella excrucians* Walsh and a male *R. impersonata* with a female *Siphonurus rapidus* Mc. Dunnough. The remaining thirteen pairs obtained were in all cases a male with a female of the same species, twelve pairs of *R. impersonata* and one of the new species.

***Rhithrogena impersonata*, McD.**

Nymph: length 7 mm., caudal filaments 9 mm.

Head: subovate, wider than long; umber brown of variable intensity including pale mid-dorsal line on vertex, narrow pale area from front of eye to lateral border, pale line between lateral ocelli and passing anterior to eye. Antennae basally umber brown paling to whitish apically.

Thorax and wing pads: umber brown with pale median line. Femora with conspicuous pattern as shown in figure 7.

Abdomen: dorsally unicolorous umber brown, ventrally umber with darker pattern in the form of a pair of segmentally arranged submedian dark dots, anterior border of segments with dark laterally directed patches, lateral borders pale. In some individuals the venter is uniformly dark, in others almost unpigmented. Gills whitish hyaline with distinct but not blackish venation, gills of segment 1 convergent apically, with scalloped anterior border, folded and fused to or at least adhering to the venter by its dorsal surface (Fig. 5). Intermediate gills with median ear-like lobe. Caudal filaments dark brown basally, paler apically with distinct joints.

This species is dark unicolorous umber brown with conspicuous pattern on the femora, clear whitish hyaline gills with small median lobe as described for *R. doddsi* Mc. D.

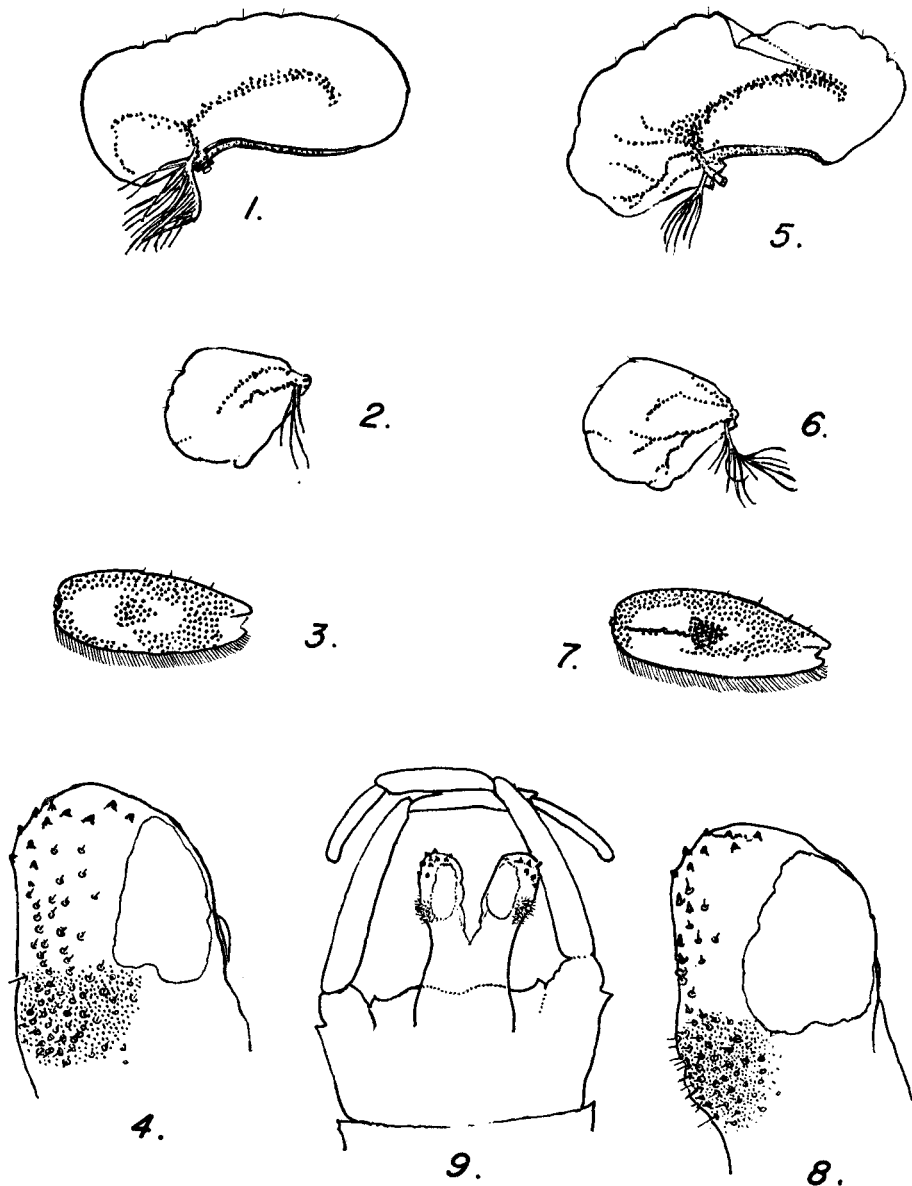
***Rhithrogena sanguinea*, new species**

Male imago (dried): length 8 mm., caudal filaments 17 mm., forewing 10 mm.

Head: eyes and area between ocelli dark brown tinged with purple; frons ochre yellow with red flush near eyes and at tip; antennae brown, paler apically.

Thorax: dorsum reddish brown with ruddy area anterior to scutellum, pale and yellowish laterally with distinctly ruddy area anterior to wing base and around base of meso- and metathoracic legs; femora red-brown, darker brown at the apex and yellowish at extreme base; scarcely discernible dark stroke basad of the middle; fore tibia smoky with dark brown apex, remaining tibiae brown basally; wings hyaline, slightly brownish-grey basally in some lights, venation brown.

Abdomen: dorsum dark brown, narrowly hyaline on anterior borders, posterior borders of anterior segments narrowly reddish, segments 8, 9 and 10 opaque and paler; venter smoky, opaque and buff-coloured on segments 8 and 9, faint markings in form of oblique stroke across antero-lateral angle and small submedian dark spots; forceps base ochre yellow, remainder smoky; caudal filaments with basal curvature characteristic of the group, dark smoky with segments indistinctly separated by darker lines; genitalia (Figs. 4 and 9) of the



1-3 *Rhithrogena sanguinea* n. sp., (1) gill 1, left, dorsal view, (2) gill 2, left, dorsal view, (3) femur of front right leg.

4 *R. sanguinea*, right penis lobe, dorsal view.

5-7 *Rhithrogena impersonata* Mc.D., (5) gill 1, left, dorsal view, (6) gill 2, left, dorsal view, (7) femur of front right leg.

8 *R. impersonata* Mc.D., right penis lobe, dorsal view.

9 *R. sanguinea*, male genitalia, dorsal view.

R. impersonata form lacking a basal spine on the penis lobe and with sparse short spines apically.

Female imago (dried): length 7 mm., caudal filaments 12 mm., forewing 10 mm.

Head: eyes grey; vertex and interocellar area umber brown; frons dark red ventrally, yellow patch medially and others ventral to lateral ocelli, bright red laterally extending dorsally along margin of eye; antennae brown, paler apically.

Thorax: dorsum brown, pale yellowish at sides in front and at base of wings; red on pleura in front of and ventral to wing bases; scutellum with pale areas; coxae yellowish with red patch; trochanters yellow basally, red distally; femora reddish brown, narrowly yellowish basally; tibiae paler reddish brown and tarsi piceous; wings hyaline with brown venation.

Abdomen: terga dark brown, venter paler; intersegmental folds reddish; caudal filaments pale basally, remainder piceous with darkened joints, no abrupt bending ventrad.

Female subimago, (dried): length 8 mm. caudal filaments 7 mm. wing 10 mm.

In this single individual the frons and the areas on the thorax which were reddish in the imago male are also reddish though somewhat duller; wings grey becoming paler greyish-yellow at tips and along posterior border of hind-wings; dark strokes of central area of femur scarcely discernible but apices of femora slightly darkened; caudal filaments smoky with indistinct joints.

Nymph (alcohol): length 7 mm., caudal filaments 9 mm.

Head: subovate and wider than long, reddish brown with pale area postero-laterad of eye, a pale streak extending in front of eye to lateral border, a faint median dark line on frons, red patch laterad of lateral ocellus; antenna brown, paler apically. In males the distance between the compound eyes is less than the diameter of an eye and in females greater.

Thorax: pale brown with paler mid-dorsal line, irregular patches at base of wing pads; femora pale basally, indistinct spot centrally and darker maculation extending to near apex as shown in Fig. 3; in most individuals femora entirely suffused with bright red.

Abdomen: dorsally reddish brown darker and more ruddy on posterior borders, ventrally without conspicuous marking, pale or with pale reddish brown suffusion intensifying posteriorly; gills bright carmine red (blood red in life) medially becoming paler and colourless laterally, gills of segments 1 and 7 convergent but gill 1 not folded, tracheae indistinct, small median lobe on intermediate gills as in *R. doddsi* and *R. impersonata*, tuft of gill filaments on gill 1 with about twelve filaments, that on gill 2 with 5 or 6 (Figs. 1 and 2); caudal filaments pale with darker brown base.

This nymph is pale reddish brown with carmine red gills and with median lobe on those of intermediate segments. The pattern on the femora, particularly the central spot, is relatively inconspicuous,

Holotype, male: Sheldon Creek, Dufferin County, Ontario, June 5, 1952.
F. P. Ide.

Allotype, female: Sheldon Creek, Dufferin County, Ontario, June 17, 1953.
F. P. Ide.

Paratypes: 5 male imagos, 1 female subimago. Sheldon Creek, Dufferin County, Ontario, June 1-5, 1952. F. P. Ide.

In living material of *R. sanguinea* some additional features are apparent. The eyes of the male imago are brown, the femora are flushed with bright red which is particularly intense along the borders, the central dark dash of the femora is obsolescent or wanting, the bases of the tibiae are greenish. The thorax

and abdomen are suffused with red pigment which is particularly conspicuous on the intersegmental folds of the abdomen. The maculation of the abdomen is variegated with pale geminate spots near the middle line in the posterior half, pale paramedial strokes in front of these converging on the middle line anteriorly; laterally, at the front, are two dark strokes separated from one another and from the lateral border by pale areas. The lateral flanges are reddish.

Living individuals of *R. impersonata* have a decidedly greenish tinge which is most noticeable in the areas which are red in *R. sanguinea* but this is lost in the dried specimens and probably also in specimens in alcohol. It seems probable that the red pigment of one species and the green of the other are related biochemical substances. It is possible that they have some significance in respiration. The distribution of the two pigments in a similar manner in parts of the body having thinner cuticle and the fact that the pigment carries through from the nymph and subimago to the imago suggests that it is a blood or muscle pigment rather than part of the external colour pattern.

R. impersonata and *R. sanguinea* can be readily separated from all other described species of *Rhithrogena* in the adult stage on characters of the genitalia. *R. jejuna* Eat. which has a wide distribution with records from Lachine on the St. Lawrence and Cascades on the Gatineau River in the Province of Quebec, from Smoky Falls on the Kapuskasing River in Northern Ontario, from Churchill on the Churchill River in Manitoba and from localities further west in Canada can be readily distinguished on genitalic characters from these two species, Needham et al (9). From *R. rubicunda* Traver, a species with ruddy colour, and from *R. amica* Traver they can be readily distinguished on genitalic characters as they lack the spatulate process on the penis, Traver (12). No satisfactory character, however, has been found in the genitalia for separating *R. sanguinea* from *R. impersonata*. There are more setae in the central part of the penis lobe in the one than in the other as shown in Figs. 4 and 8 but the difference in the figures is exaggerated owing to the slightly different aspects shown in the two cases. The two species can, however, be readily separated on other characters in all stages. The red colour of *R. sanguinea* is striking and together with the more variegated dorsal abdominal pattern and the obsolescent character of the femoral spots should make separation easy in the case of imagos and subimagos.

The nymph of *R. doddsi* McD. Needham (8) McDunnough (7) and Needham et al (9) has red gills and also the median lobe on the intermediate gills as has *R. sanguinea*. The genitalia of *R. sanguinea* and *R. impersonata* are, however quite different from those of *R. doddsi* which have conspicuous lateral spines basally. Dr. Traver has described several species of *Rhithrogena* from North Carolina, Traver (11 and 12), including *R. amica*, *R. rubicunda*, *R. sp. No. 2* known only in the nymphal and imago female stages and *R. sp. No. 3*, known only in the nymphal stages but suspected of being the nymph of *R. rubicunda*. The first two are similar in having a spatulate process on each penis lobe which is absent in both *R. impersonata* and *R. sanguinea*. *R. Sp. No. 2* has a faint lavender tint basally in the gills but the associated female imago has pale yellowish legs which possess the characteristic central femoral blotches which are obsolescent in *R. sanguinea* but present in *R. impersonata*. *R. Sp. No. 3* has deep purplish colour on the gills which differs in its distribution being confined to gills 2-6 rather than appearing, as does the red in *R. sanguinea* on all gills. Further, nymphs of this species are more contrastingly marked than are those of the latter. *R. fuscifrons* is known in the nymphal and female imago stages. In many details of structure of both nymph and female imago this species agrees with *R. imper-*

sonata and it may turn out to be this species. Daggy (2) has described *R. pellucida* from the Mississippi River at Minneapolis separating it from *R. impersonata* but leaving in abeyance its relation to *R. fuscifrons*. When male imagos are found the settling of the status of *R. fuscifrons* will be possible.

**Discussion of the Habitat and Distribution of *R. sanguinea*
n. sp. and *R. impersonata* McD.**

The section of Sheldon Creek at which these two species of *Rhithrogena* were collected is about 10 miles downstream from the highest source located in the Singhampton moraine near the brow of the Niagara escarpment at a point about two miles south-east of the village of Primrose in Dufferin County. The stream, in this section, is from ten to fifteen feet wide and flowing fairly rapidly with numerous alternating pools and riffles. At the point it is flowing eastward through a deep cedar clothed valley cut through the Banks moraine. The valley in which the upper sections of the creek flow is, according to Chapman and Putman (1), a spillway which carried a glacial river flowing southward along the border of the ice during the recession of the last ice sheet. Sheldon Creek is now a tributary of the Nottawasaga River flowing northward to Georgian Bay.

This location is the only place to date at which *R. sanguinea* has been found although most of the main watersheds of Southern Ontario have been methodically examined in recent years in connection with surveys made by the Ontario Department of Planning and Development. *R. impersonata* had been taken at the Forks of the Credit in Peel County and in the Saugeen River in Grey County in addition to Sheldon Creek. Both species have, therefore, a spotty distribution and while it is probable that additional localities will be found it is felt that, as far as Southern Ontario is concerned, these will be in other rivers associated with the Niagara escarpment.

From the investigations of geologists it can be demonstrated that there has been much modification in stream courses in the past and particularly during the recession of the Wisconsin ice sheet across this part of Ontario. From its source in the Singhampton moraine Sheldon Creek flows eastward into a prominent spillway which carried a large river originating near the village of Singhampton and flowing southward between this moraine and the Gibraltar moraine (Galt moraine of Taylor) Chapman and Putnam (1) and Taylor (10). The river followed the escarpment closely, passing the Forks of the Credit, in whose channel the Credit River now flows at this point, flowed over the top of the escarpment near Georgetown, and eventually discharged into glacial Lake Warren. It is probable that the upper parts of Sheldon Creek were tributary to this river and that there was thus continuity of the rapid water habitat between Sheldon Creek and the Credit River when past history is taken into account. Sheldon Creek now crosses this ancient channel from west to east, traverses the Gibraltar moraine and then crosses another spillway. This latter is the channel of another glacial river of later time which flowed southward past the Forks of the Credit and then followed the course of the present Credit River below the escarpment for some distance. This latter spillway would afford continuity of rapid water conditions between Sheldon Creek and the Forks of the Credit of more recent date than in the former case. From its intersection of this latter spillway Sheldon Creek now flows eastward through a gap in the Banks moraine, following again a glacial channel, and joins the Nottawasaga river flowing northward to Georgian Bay. If the above interpretation is correct this is a good illustration of river piracy with streams which originally flowed to the south now flowing north. Chapman and Putnam (1) mention that the present streams have captured the glacial spillways in a number of places.

The above relations may not be the explanation of the discontinuous distribution of these insects but with forms such as mayflies which have brief aerial existence and remain in close proximity to the place in the stream from which they emerge continuity of the aquatic habitat would seem to be more satisfactory than postulation of fortuitous distribution by wind or other agency. Especially would this be so in the case of species, like those under discussion, whose distribution is now restricted to local rapid water habitats in the rivers. It is quite probable that these insects were more widely distributed in the past. The changing courses of streams during and following the glacial recession has a significant bearing on this past history.

There are other elements of the stream fauna of this part of Ontario which show close affinities with those of parts of Michigan, Illinois, New York and the Laurentian and Appalachian highlands although this locality is now isolated from them. This phenomenon could be most satisfactorily explained on the basis of rivers flowing south in the past from the edge of the receding ice sheet up which elements of the fauna migrated and persisted to the present time in habitats which remained suitable. The existence of such rivers has been demonstrated but most of them appear to have emptied into large bodies of static water which would be effective barriers to the migration of rapid water forms from the south. From a study of the history of the great lakes and the history of their outlets and connections, Leverett and Taylor (5) possibilities of suitable rivers draining southward from this section of Ontario would seem to have been restricted either to the very early period of the removal of the ice sheet from Ontario, for example the time of early Lake Maumee, or to a much later period of glacial recession when the ice sheet had withdrawn from the face of the Niagara escarpment in the Niagara region but before the inception of Lake Iroquois in the Lake Ontario basin. This would correspond to the earliest stage of, or stage of transition to, Lake Algonquin the last of the glacial lakes in the region. The courses of the glacial rivers are incompletely known at the present time.

Relationship of *R. sanguinea* n. sp. and *R. impersonata* McD.

R. impersonata is, as far as present records show, restricted in Ontario to a few locations in the vicinity of the Niagara escarpment and *R. sanguinea* is apparently even more restricted having been found at only one place. The question arises as to whether the latter species has evolved in this habitat which it shares with *R. impersonata* and that a case of sympatric speciation is thus illustrated.

On criteria of the taxonomist these two species are closely related and yet readily distinguishable in both nymphal and adult stages. The most conspicuous difference in both stages is the red pigment of *R. sanguinea* which colours the gills and other parts of the nymph and is carried through into the subimago and imago, and the substitution in *R. impersonata* of a pale green pigment which is quite noticeable in the femora and basal part of the tibiae in the living specimens but not evident in dried ones. There are other differences notably in ground colour and in the maculation of the abdomen and in the degree of prominence of the femoral spots and also structural differences as for example those of the gills which have been noted. These differences are comparable in magnitude to the differences which are used in the separation of species in the mayflies and the description of *R. sanguinea* as a new species seems warranted. On genitalic characters alone, however, the two are almost indistinguishable and by this criterion would be considered to be closely related. On the basis of genitalia, also, these species would be considered to be more distantly related to other known members of the genus than they are to one another.

The nymphs of both species occurred in the same rapids in the stream and were frequently intermingled on the same stone. *R. sanguinea* was scarcer than *R. impersonata*. As far as could be determined, without extensive quantitative analysis, the nymphs of both coincided in their stage of development and when their emergence was checked in the summer of 1952 it was found that both emerged on the same days and at the same time in the evening. More continuous sampling might show, however, that this was a case of extensive overlapping. Swarming of adult males and matings were observed on seven evenings and on each occasion both species were combined in a restricted swarm.

In this case, therefore, it is certain that there is no spatial or significant temporal segregation of the two species. Between many species of stream inhabiting mayflies there is no geographical, even microgeographic, isolation but in these there is, except in one or two cases similar to the present one, a separation of the mating activity in any one habitat in a seasonal or diurnal manner, Ide (3). Mayr, (6), has commented on one of these cases, and is of the opinion that, when such closely related mayfly species occur together in the same place in the same stream, it is a result of a secondary moving into the same habitat after having been geographically isolated at an earlier period. The presence of two closely related species of mayflies in the same restricted locality in a stream is very usual and in some instances three species which are more closely related to one another than to other species are found. The example treated in the present paper is, however, a stronger argument for sympatric speciation than are others in which there is temporal separation. Even in the latter instances, however, the case for sympatric speciation is strong as they would appear to have been evolved by the seasonal separation into two species of an ancestral continuously varying population. The author (4) has interpreted one such case of this type as incipient speciation.

The case of these two species of *Rhithrogena* is not absolute proof of sympatric speciation since as Mayr has pointed out the divergence may have taken place under conditions of geographical isolation and the two species later moved into the same habitat. If, however, we admit of such a possibility one of these species has moved back into the same geographical position as the other and its physiological attributes are such as to allow it to coincide in season and mating activity with the other. This would be a remarkable coincidence and would be unusual between closely related forms, and wider geographical distribution of both species would be expected if such had taken place.

Of thirteen pairs of *Rhithrogena* taken from the swarm and being associated in the mating position twelve were of a male *R. impersonata* with a female *R. impersonata* one was of a male *R. sanguinea* with a female *R. sanguinea*. These findings, although meagre, support a view that the males of the two species become associated with their respective females in the swarm. It is probable that they attempt mating with individuals of the other species since, as mentioned above, attempts to mate with the opposite sex of species of other genera were observed. In these latter cases the mating is probably not completed and might not be in the former if such took place.

The critical period for isolation of these two species apparently is in the mating swarm and since they are in the same place at the same time, sexual selection, one concludes, is the effective isolating mechanism allowing them to coexist. The evidence here presented supports the view that speciation may take

place where there is no spatial (geographical or microgeographical) or temporal isolation involved and that isolation is probably in the nature of sexual selection with interspecific incompatibility.

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