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TWO NEW SPECIES OF NORTH AMERICAN *PROTOCALLIPHORA* HOUGH (DIPTERA: CALLIPHORIDAE) FROM BIRD NESTS

TERRY WHITWORTH

Whitworth Pest Solutions, Inc., 2533 Inter Avenue, Puyallup, WA 98372, U.S.A. (e-mail: wpctwbug@aol.com)

Abstract.—***Protocalliphora bennetti*, n. sp.**, and ***P. rugosa*, n. sp.** (Diptera: Calliphoridae) infesting bird nests are described from North America. *Protocalliphora bennetti* is primarily eastern but extends northwest to Alaska, British Columbia, and northern Idaho, and *P. rugosa* is western ranging from British Columbia south to Wyoming, Utah, and Oregon. Bird hosts of each species are listed. The puparia of these species are more readily identified than are adults. Adults of *P. bennetti* are intermediate between *P. sialia* and *P. shannoni,* while adults of *P. rugosa* are almost identical to *P. hirundo.* A key is presented to the males and puparia of *Protocalliphora* species with white calypteres and digitate surstyli.

Key Words: new species, *Protocalliphora,* Diptera, Calliphoridae, bird nests, North America

Members of the genus *Protocalliphora* Hough are commonly known as bird blow flies because of their habit of parasitizing nestling birds. The taxonomy of this genus in North America was poorly understood until Sabrosky et al. (1989) redescribed the 11 known species and described 15 new species. Sabrosky began studying *Protocalliphora* in 1950 and soon realized that, despite Hall's then recent revision (1948), much work was still needed. Bennett (1957) completed a doctoral dissertation on the eastern species of *Protocalliphora* while Whitworth completed a masters thesis (1971) and doctoral dissertation (1977) on western species. Both Bennett and Whitworth reared many *Protocalliphora* from bird nests thereby associating males, females, and immatures. This made it possible to clarify new species relationships.

I have tested the adult and puparial keys provided in Sabrosky et al. (1989) on numerous specimens submitted for identification. The key, which utilizes male, female, and puparial characters, is very reliable for specimens in good condition. The key to single males is usually reliable, but the key for single females is good for only the ten most distinctive species. The puparial keys have serious restraints because most puparial descriptions were based on specimens from a single area without accounting for geographical variation. Many of the characters used to distinguish species using puparia proved to be variable when specimens from different areas were studied.

Problems with existing puparial keys led to misidentifications in Dawson et al. (1999). A single puparium from a kestrel nest identified as *P. avium* Shannon and Dobroscky in that work, is now recognized as *P. sialia* Shannon and Dobroscky. Also, a series of two males, five females, and numerous puparia identified as *P. shannoni* Sabrosky et al. in Dawson et al. (1999) are now regarded as a new species described as

P. bennetti. Because of problems with the puparial keys, a study of *Protocalliphora* puparia was begun in 1997. The on-going study of puparia has revealed two previously undescribed species with distinctive puparia, but with adults that are almost indistinguishable from known species. These species are described here, with their distributions and hosts, and separated from related species.

Materials and Methods

Protocalliphora are rarely collected using conventional techniques and are mostly taken directly from bird nests. To collect adults, nests must be examined within 10–15 days after nestlings fledge; after that, only empty puparia will be found. As most bird nests are found after leaf drop in the fall or when birders are cleaning out nest boxes after the nesting season, the development of a good key to empty puparia will be of great value in expanding our knowledge of this genus.

Initially, local bird nests in western Washington State were collected. Subsequently, requests for bird nests were made via the Internet and ornithological publications, and nests were acquired from all over the lower United States, Canada, and Alaska. Since 1993, 3884 nests have been examined, mostly from bird nest boxes; 38.6% of these nests were infested with 17 species of *Protocalliphora.* A detailed key to North American *Protocalliphora* puparia is being developed and will be published in the near future.

Nests were examined for puparia by dissecting them on a large sheet of white paper. Most nests received for study were in sealed Ziploc® bags and, if infested, contained empty puparia. Some nests had emerged adults, and a few, collected right after nestlings fledged, had viable pupae from which adults were reared. Puparia were picked out of nest material, counted, and viable pupae were often sorted into individual vials so adults could be matched with their puparia.

Empty puparia were screened and sorted to species with a stereo microscope equipped with a brightfield/darkfield stand with zoom capabilities to 70×. For specimens that could not be positively identified with a stereo scope, species identification was verified by preparing slide mounts and viewing with a compound scope at up to 400×. Puparia were boiled for 1–5 minutes in a 10% potassium hydroxide solution to soften and clear the cuticle. After rinsing in distilled water, puparia were sectioned with small scissors. The dorsal, ventral, stigmatal, and prothoracic fringe areas were cut away (Figs. 1–3) and soaked in specimen clearing fluid for 1–3 days. Once sections were sufficiently clear, they were dehydrated in 95% then 100% ethanol and mounted in Euparol mounting medium. All slide-making materials were purchased from Bioquip® Products, Gardena, California. Slides were then dried in an oven at about 70°C for 1–2 weeks, until the medium hardened. It is very important that the medium is completely dry or specimens will drift when slides are placed on edge.

Most terminology regarding puparia and adults follow Sabrosky et al. (1989). However, measurements of the prothoracic fringe are total diameter, rather than a measurement of individual spines. Prothoracic spine lengths cannot be measured accurately in puparia, only in larvae. Also, cuticular spine lengths are based on the longest spines in an area, rather than the average spine length since average spine lengths tended to mask differences between species. All measurements have been performed on 25 specimens, unless indicated otherwise. Adult and puparial specimens collected from nests are identified by nest lot numbers. Individuals from a given lot may be distinguished by Lot #-1, -2, etc.

Protocalliphora (Protocalliphora) bennetti Whitworth, new species

(Figs. 1, 4)

Protocalliphora shannoni: Dawson et al. 1999 (misidentification).

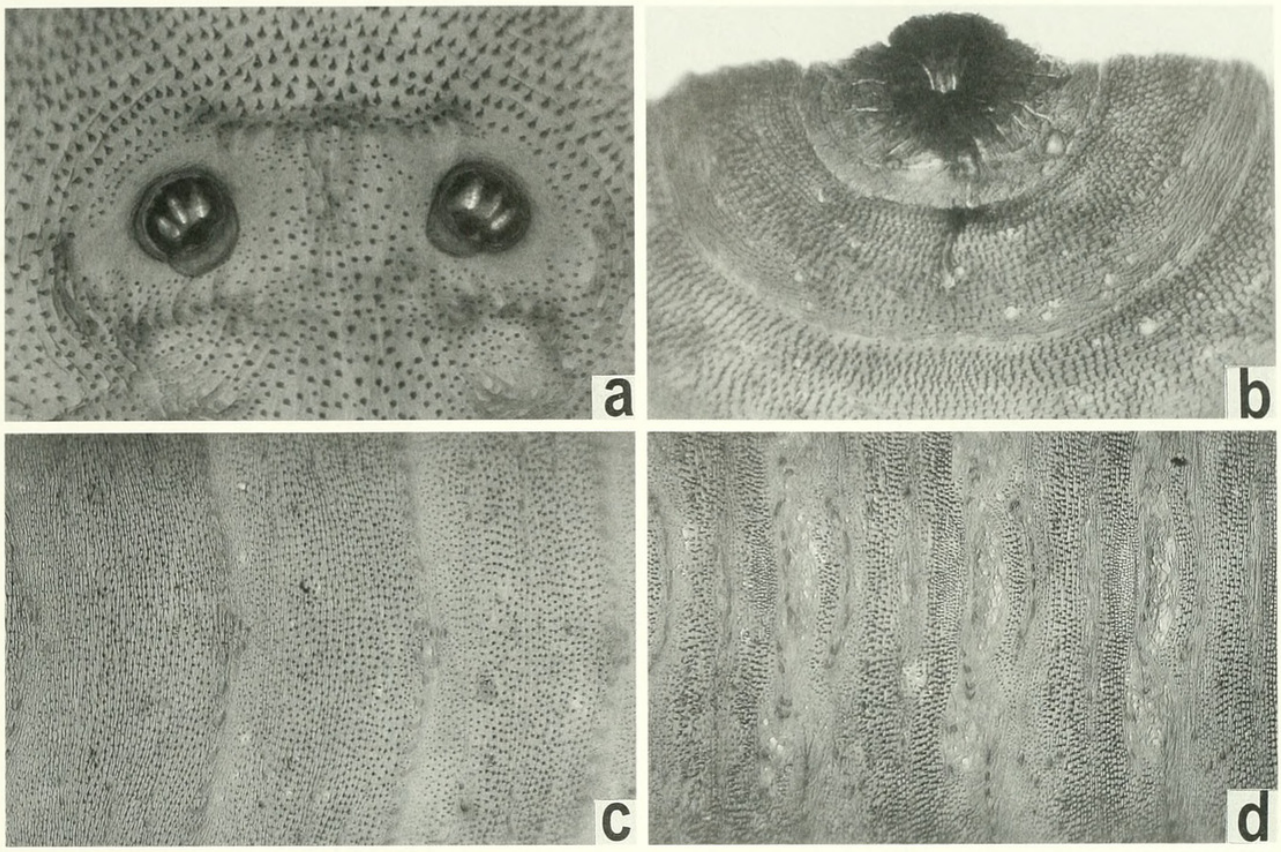
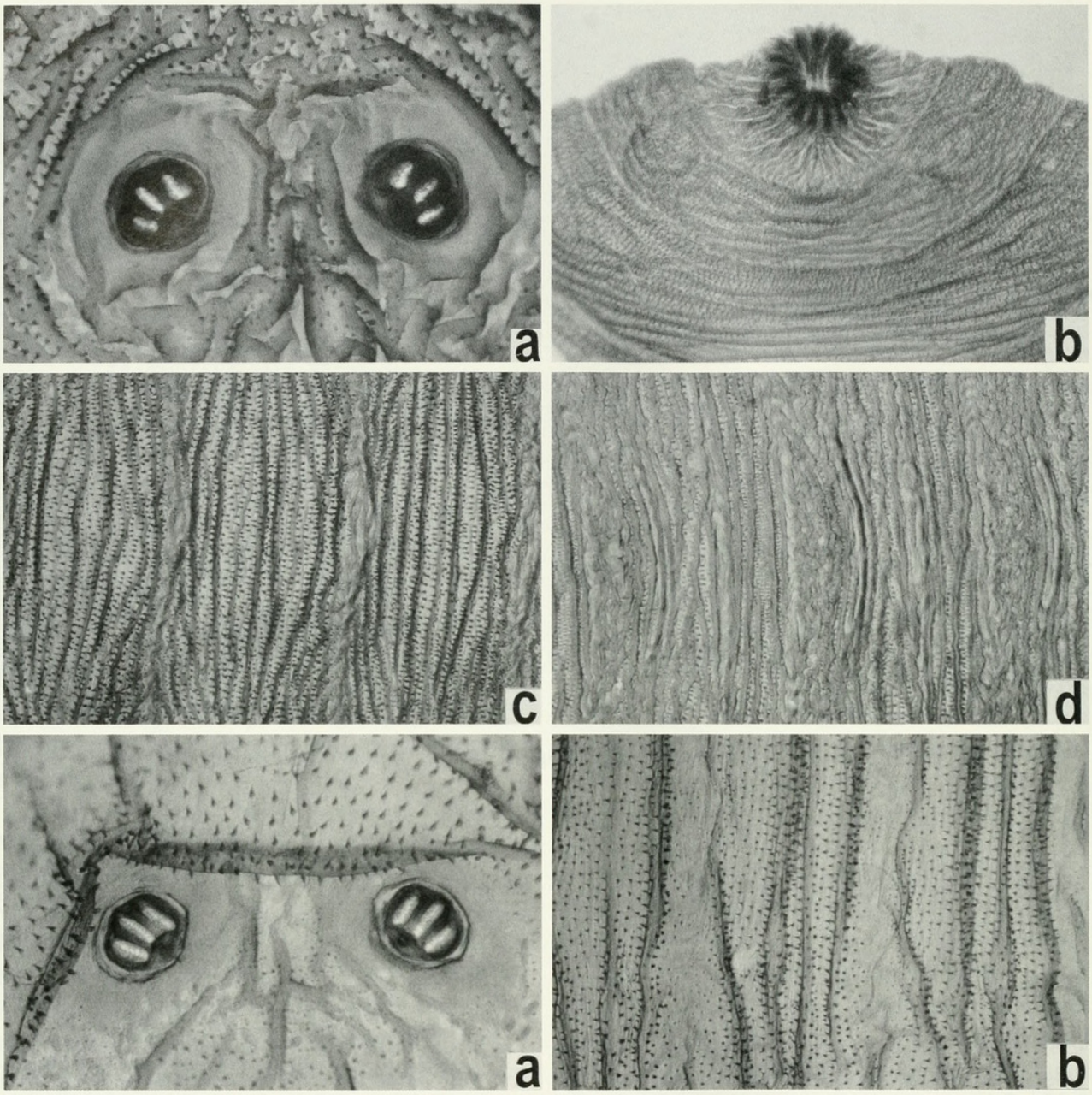


Fig. 1. Puparium of *Protocalliphora bennetti:* a, stigmatal view; b, prothoracic fringe; c, dorsum; d, venter.

Diagnosis.—Sexes concolorous, monochromatic, shining metallic blue to bluish purple, adults very similar to *P. sialia* frons width intermediate between *P. sialia* and *P. shannoni* (see Figs 4–6); surstyli digitate. Prothoracic fringe of puparia about 350μ, much shorter than *P. sialia,* dorsal cuticular folds faint compared to pronounced in *P. sialia.*

Male.—Head ground color black, parafrontal and parafacial silvery microtomentose, preocellar area triangular (Fig. 4) and polished shining to subshining black. Thorax shining metallic dark blue to bluish purple, dorsum thinly microtomentose, viewed from behind microtomentum with three shining undusted stripes, central stripe broad but stops short of anterior edge of pronotum, lateral stripes narrower, sometimes indistinct and extending to anterior edge of pronotum. Abdomen concolorous with thorax, with sparse white microtomentum when viewed from behind at a low angle. Calypter white with faintly yellow rims.

Frons narrow 0.075 times head width (0.065–0.08), some Alaska specimens to 0.09 and 1.10 times ocellar span (0.88–1.38); frons width about equal to 3rd antennal segment 1.04 (0.72–1.29); frontal vitta narrow above, widening below, at narrowest 3 to 4 times width of an adjacent parafrontal, parafrontal greatly narrowed above, silvery microtomentose ending below ocellar triangle, to a thin black line above; preocellar area with small, black, polished area varying from a tiny area just below median ocellus to a long polished streak (Fig. 4). Parafrontal with a few tiny hairs starting midway to 2 or 3 rows below and merging with numerous hairs on broader parafacial. Parafacial, at widest, 1.6 times 3rd antennal segment (1.13–1.80) and 1.64 times width of frons (1.26–2.17), 1.73 times width of ocellar span (1.39–2.08), and 0.79 times vibrissal interval (0.625–0.964), cheek height



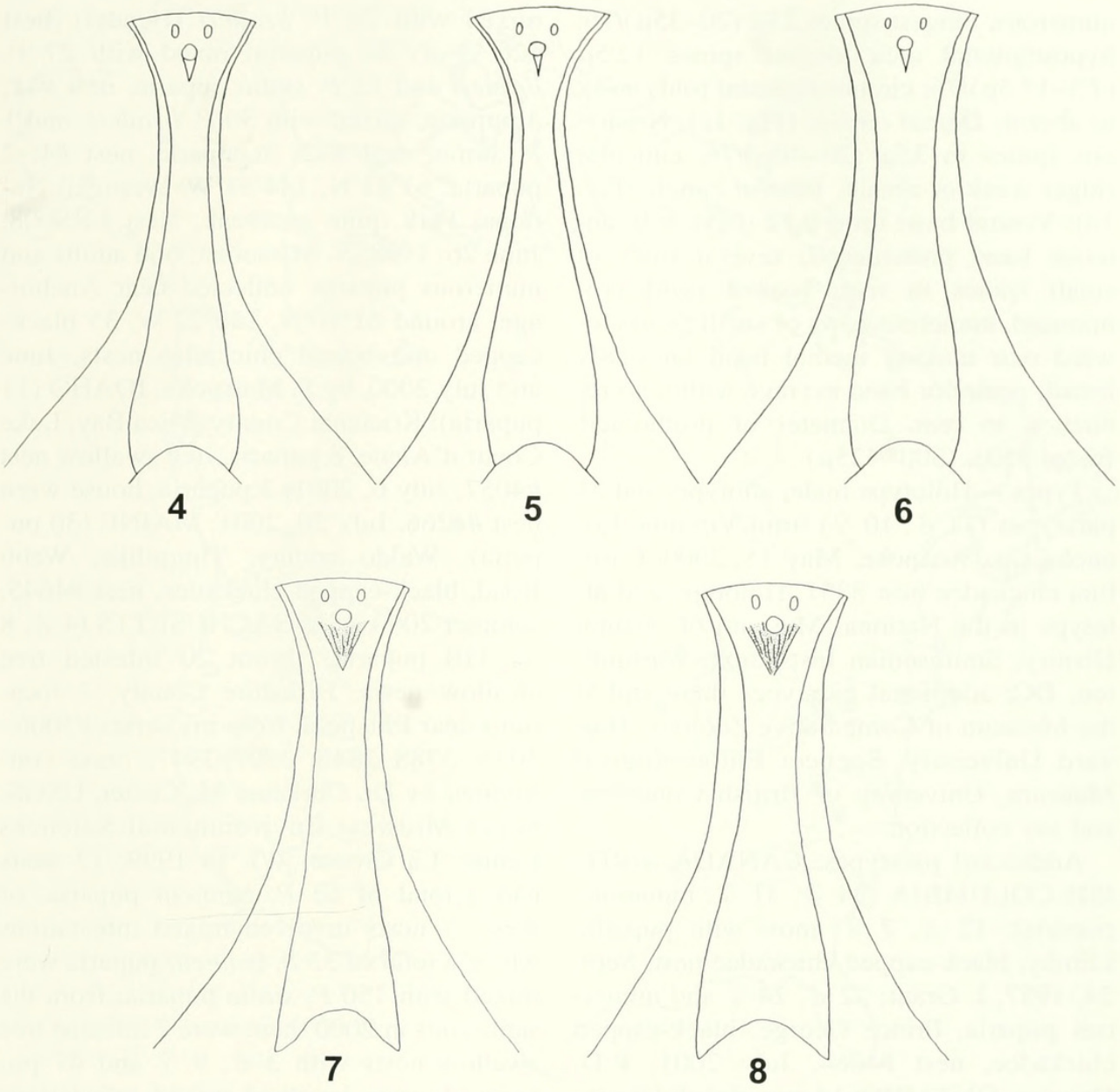
Figs. 2–3. Puparia. 2, *Protocalliphora rugosa* (top four figures): a, stigmatal view; b, prothoracic fringe; c, dorsum; d, venter. 3, *P. hirundo* (bottom two figures): a, stigmatal view; b, dorsum.

0.38 times maximum eye height (0.290–0.414).

Thorax without accessory notopleural bristles or hairs on tympanic membrane, only a few hairs occasionally on postalar wall. Foretibia normally with one median posterior bristle, although some specimens with 2 on one or both sides. In 23 specimens from type series, nest lot #3351, holotype with 2 posterior bristles on left tibia, two males with 2 posterior bristles on both sides, and 2 males with 2 posterior bristles on right side.

Terminalia with cerci distally acuminate, narrow and parallel, surstyli digitate and broadly rounded at distal end, aedeagus as usual in genus (Sabrosky et al. 1989).

Female.—Same color as male; head with microtomentum of parafrontal and parafacial light brown to golden brown, commonly with a spot of changeable reflection on upper surface of parafacial opposite lunule,



Figs. 4–8. Frons comparisons in adult male *Protocalliphora*. 4, *P. bennetti*. 5, *P. shannoni*. 6, *P. sialia*. 7, *P. rugosa*. 8, *P. hirundo*.

viewed from above spot dark brown against light brown, or from below golden on charcoal background. Preocellar area large, irregular polished black, usually contrasting with rest of frons. Frons at vertex 0.25 times width of head (0.24–0.28), to 0.30 in Alaska specimens, and 3.10 times ocellar span (2.78–3.67); frontal vitta parallel sided, with few or no bristles mesad of row of frontal bristles; parafacial relatively broad, width 0.51 times that of frons (0.482–0.596), 1.62 times ocellar span (1.47–1.82), and 0.81 times vibrissal interval (0.714–0.967); cheek height 0.37 times maximum eye length (0.321–0.414).

Puparium.—Length, 7.5 mm (6–8.5 mm); width 3.25 mm (2.6–4.0 mm); medium thick-walled, dull dark brown cuticle. *Posterior region* (Fig. 1a): Stigmatal plates 170μ (145–198μ)/76 in diameter; distance between buttons 503μ (400–600μ)/75; and across stigmatal plates 1007μ (820–1250μ)/75; stigmatal ratio 0.50 (0.41–0.60)/74. Upper mesostigmatal spines as tubercles, lower spines up to 15μ below, folds absent, plaques faint; hyperstigmatal spines

numerous, longest spines 27μ (20–35μ)/76; hypostigmatal area longest spines 12.5μ (7.5–17.5μ)/76; circumstigmatal folds weak to absent. *Dorsal cuticle* (Fig. 1c): Numerous spines to 35μ (30–40μ)/76, cuticular ridges weak or absent. *Ventral cuticle* (Fig. 1d): Ventral band ratio 0.72 (0.54–89); anterior band pronounced, several rows of small spines to rear; medial band pronounced, numerous rows of small spines toward rear making medial band unusually broad; posterior band average width, no reduction to rear. Diameter of prothoracic fringe 350μ (300–425μ).

Types.—Holotype male, allotype, and 21 paratypes (11 ♂, 10 ♀) from Virginia, Roanoke Co., Roanoke, May 15, 2000, Carolina chickadee nest 3351. Holotype and allotype in the National Museum of Natural History, Smithsonian Institution, Washington, DC; additional paratypes there and at the Museum of Comparative Zoology, Harvard University, Spencer Entomological Museum, University of British Columbia, and my collection.

Additional paratypes: CANADA, BRITISH COLUMBIA (34 ♂, 31 ♀, numerous puparia): 12 ♂, 7 ♀, most with puparia, Lumby, black-capped chickadee nest, Sept. 24, 1957, J. Grant; 22 ♂, 24 ♀ and numerous puparia, Prince George, black-capped chickadee, nest #4064, July 2001, R.D. Dawson. ONTARIO: 14 puparial slides prepared by G.F. Bennett, labeled 52-60W, which, according to Bennett's coding, is Algonquin Park, house wren, nest #60, summer 1952. Some slides were labeled *P. cooki,* the name was never published. There also was a reference to associated adults examined by Sabrosky, which were not located. SASKATCHEWAN (2 ♂, 5 ♀, 75 puparia): 1 ♂, 5 ♀, 15 puparia, Saskatoon area, tree swallow, nest #2546; 1 ♂ and 60 puparia, house wren, nest 2547, summer 1996, Russ Dawson.

UNITED STATES: ALASKA (688 adults, numerous puparia): Fairbanks, Creamers' Field, 4 tree swallow nests, July 1994, D.D. Roby; 7 ♂, 11 ♀, 44 puparia, mixed with 23 *P. braueri* (Hendel), nest #20; 4 ♂, 34 puparia mixed with 27 *P. braueri* and 12 *P. sialia* puparia, nest #41; 4 puparia, mixed with 30 *P. braueri,* and 1 *P. sialia,* nest #42; 5 puparia, nest #4; 2 puparia, 61°41′N, 144°51′W, Wrangell National Park, pine grosbeak, Nest LRS008, June 26, 1998, S. Matsuoka; 666 adults and numerous puparia, collected near Anchorage, around 61°10′N, 150°22′W, 35 black-capped and boreal chickadee nests, June and July 2000, by S. Matsuoka. IDAHO (11 puparia): Kootenai County, Mica Bay, Lake Coeur d'Alene, 8 puparia, tree swallow nest #4057, July 6, 2001; 3 puparia, house wren nest #4266, July 20, 2001. MAINE (30 puparia): Waldo county, Thorndike, Webb Road, black-capped chickadee, nest #4645, summer 2000. MASSACHUSETTS (4 ♂, 8 ♀, 110 puparia): From 20 infested tree swallow nests, Birkshire County, 3 locations near Pittsfield, from my series #3006–3033, 3788–3846, 3892–3947, nests contributed by Dr. Christine M. Custer, USGS, upper Midwest Environmental Sciences Center, La Crosse, WI. In 1999, 13 nests had a total of 63 *P. bennetti* puparia, of these, 7 nests involved mixed infestations where a total of 33 *P. bennetti* puparia were mixed with 150 *P. sialia* puparia; from the same sites in 2000 there were 7 infested tree swallow nests with 3 ♂, 9 ♀ and 47 puparia, 4 nests involved mixed infestations with *P. sialia.* MINNESOTA (10 puparia): Marshall County, Agassiz National Wildlife Refuge, 3 tree swallow nests #3042, #3052, and #3053, summer 1999, Dr. Christine Custer. NEW YORK (9 ♂, 12 ♀, 162 puparia): Cattaraugus County, Franklinville, July 15, 1999, 3 nests; 6 ♂, 10 puparia, starling nest #2744; 7 ♂ 11 ♀, 26 puparia, house wren nest #2748; 23 puparia mixed with 2 *P. sialia* puparia, house wren nest #2749; 12 puparia, Oswego County, Mexico, tree swallow nest #2765, summer 1999; Cattaraugus County, Franklinville, late July 2000, 6 nests; 16 puparia, house wren nest #2934; 5 ♂, 1 ♀, 12 puparia, tree swallow nest #4067; 1 ♂, 3 puparia, house wren nest

Fig. 9. Distribution of *Protocalliphora bennetti* (solid dots) and *P. rugosa* (circles).

#4070; 36 puparia, tree swallow nest #4071; 19 puparia mixed with 7 *P. sialia* puparia, tree swallow nest #4072; 5 puparia mixed with 70 *P. sialia* puparia, tree swallow nest #4073. VIRGINIA (8 ♂, 5 ♀, 20 puparia): Roanoke County, Salem, Carolina chickadee nest #3307, May 18, 2000; 23 puparia Roanoke County, Roanoke, house wren nest #3625, late June, 2000. WEST VIRGINIA (125 adults, numerous puparia, mixed with 20 adult *P. deceptor*): Marion County, Fairview, Carolina chickadee nest #3390, early June 2000. WISCONSIN (7 puparia): Rusk County, Sheldon, eastern bluebird nest #5560, August 2001. All specimens collected by author from nests contributed by Cornell Birdhouse Network contributors, Cornell University, unless stated otherwise.

Specimens examined.—101 ♂, 92 ♀, plus 688 adults from Alaska and 125 adults from West Virginia not counted by sex, also numerous puparia.

Distribution.—USA: Alaska, Idaho, Maine, Massachusetts, Minnesota, New York, Virginia, West Virginia, Wisconsin. Canada: British Columbia, Ontario, Saskatchewan (Fig. 9).

Basis for description of puparia.—Alaska slides - #20, 1–14 & 16, plus 21 slides from the Anchorage areas from material provided by S. Matsuoka. Massachusetts slides-#3013, 1–3. New York, #2744, 1–4; #2748, 1–4; #2749, 1–7; #2934, 1–3. Ontario slides-52-60w, 1–12. Saskatchewan slides-#2546, 1–3; #2547, A&D, 1–4. Collection data for these nest numbers can be found under type series information.

Hosts.—Eastern bluebird, Boreal, black-capped, Carolina chickadees, pine grosbeak, European starling, tree swallow, and house wren.

Ecology and biology.—This species seems to be the eastern counterpart of *P. parorum* Sabrosky, Bennett, and Whitworth, which is found in the west. Both species are frequently found in chickadee and house wren nests. *Protocalliphora bennetti,* like *P. parorum* is found in cavity nests of wrens and chickadees, but *P. bennetti* is also found in tree swallow nests, while *P. parorum* is not. In tree swallow nests, it is often, mixed with *P. sialia,* the unusual tree swallow parasite. This suggests that chickadees and wrens are the favored hosts while tree swallows are not. *Protocalliphora bennetti* extends west across Canada, and northwest from the East Coast to Alaska as does *P. avium.* To-date, I have found *P. parorum* as far north as southern British Columbia while northern Idaho appears to be the southern most range of *P. bennetti* in the west (Fig. 9).

Variation.—Male specimens from northeastern U.S. tend to have lower frons to head ratios (0.06–0.08). Specimens from British Columbia and Alaska tend to have higher ratios, 0.08–0.09, and occasionally to 0.10. Alaskan puparia tend to have higher ventral band ratios, an average of 0.81, versus an average of 0.69 for those from northeastern United States. Despite this variation, adults and puparia show many characters in common and appear to be the same species.

Etymology.—I am pleased to dedicate this species to the late Dr. Gordon F. Bennett of the Memorial University of Newfoundland who was a mentor and co-author. His early work inspired me, and his pioneering research on immature *Protocalliphora* laid the foundation for my current studies.

Protocalliphora (*Protocalliphora*) *rugosa* Whitworth, new species

(Figs. 2, 7)

Protocalliphora hirundo: Sabrosky et al. 1989, (in part). Specimens identified as *P. hirundo* from nests of purple martins, tree swallows, and violet-green swallows almost certainly are *P. rugosa.* Identification of Utah specimens has been verified. The photographs identified as *P. hirundo* in figures 53b and 53c of Sabrosky et al. 1989 appear to be *P. rugosa,* figures 53a and 53d appear to be *P. hirundo.*

Diagnosis.—Sexes concolorous monochromatic, shining metallic blue, adults very similar to *P. hirundo.* Parafrontal greatly narrowed above in males, much narrower than *P. hirundo* (Figs. 7, 8). Frons to head ratio slightly smaller in males 0.08 (0.07–0.09) vs 0.10 (0.09–0.11) in *P. hirundo.* Cuticular ridges of puparia prominent in stigmatal area, ridges on venter and dorsum closer together, usually smaller, and more regular than *P. hirundo* (Figs. 2, 3).

Male.—Head ground color black; parafrontal and parafacial silvery microtomentose when viewed from above; parafacial dark red or dark brown, color of parafacial extends through genal groove under eye. Thorax shining, metallic dark blue or bluish purple, dorsum faint gray microtomentose, when viewed from rear, with 3 broad, weak shining stripes. Abdomen concolorous with thorax. Calypteres opaque white, outer rims tinged with pale yellow.

Frons at narrowest 0.08 times head width (0.07–0.09) and slightly wider than ocellar span (1.19 ×; 1.0–1.40); preocellar area dull gray microtomentose elongate triangle. Lower parafrontal broad, narrowing greatly in prevertical area, microtomentose area

ending just short of ocellar triangle (Fig. 7). Parafacial 1.82 times width of 3rd antennal segment (1.5–2.25) and 1.42 times width of frons (1.17–2.00); 1.65 times ocellar span (1.36–2.22); and 0.85 times vibrissal interval (0.68–1.11); cheek not half maximum length of eye 0.42 (0.37–0.48).

Thorax without accessory notopleural bristles and without hairs on tympanic membrane, with only an occasional seta on postalar wall. Foretibia with only a single median posterior bristle.

Terminalia like *P. hirundo* (Sabrosky et al. 1989), cerci distally acuminate, parallel, surstyli relatively short and broad, broader at base, slightly curved inward to distal end, parallel-sided; aedeagus as usual in genus.

Female.—Same color as male, but head with parafrontal silvery tan with a yellow tinge when viewed from above. Most specimens with a changeable spot in parafacial opposite lunule; dorsum of thorax duller than in male with heavy gray microtomentose very similar to female *P. hirundo*. Abdomen as in male. Frons at vertex 0.28 times head width (0.26–0.30) and 3.62 times ocellar span (3.09–4.11), frontal vitta with a few scattered weak hairs; preocellar area with a dull black, or tan, triangular or rounded area; parafacial broad throughout but narrowing steadily to prevertical area above. Parafacial, 2.26 times width of 3rd antennal segment (1.67–2.86), 0.52 times width of frons (0.43–0.59), 1.89 times ocellar span (1.55–2.22), and almost equal to vibrissal interval (1.06 ×; 0.89–1.26); check 0.46 times maximum eye length (0.37–0.47).

Length of normal adults 9.5 mm (9–10 mm).

Puparium.—Length 8.5 mm (8–9 mm); width 3.5 mm (3–4 mm); thick-walled, dark brown cuticle. *Posterior region* (Fig. 2a): Stigmatal plates 195μ (158–213μ) in diameter; distance between buttons 534μ (420–740μ); and across stigmatal plates 1204μ (940–1460μ); stigmatal ratio 0.44 (0.39–0.53). Upper mesostigmatal spines as knoblike tubercles or short spines, lower spines to 15μ, folds moderate to pronounced; hyperstigmatal area longest spines 30μ (25–40μ)/54 folds pronounced; hypostigmatal area longest spines to 15μ (10–20μ)/54, pronounced irregular folds; circumstigmatal folds concentric, and moderate to pronounced. *Dorsal cuticle* (Fig. 2c): Dense spines to 35μ (30–40μ)/36; cuticular ridges pronounced, dense, and parallel, ridges broad, 35–50μ in width. *Ventral cuticle* (Fig. 2d): Ventral band ratio 0.72(0.54–0.85)/54, ratios difficult to measure because of ridges; anterior band and patch pronounced, medial band pronounced, posterior band reduced to a few rows of short spines. Diameter of prothoracic fringe 350μ (300–400μ).

Types.—Holotype male, allotype and 24 paratypes (12 ♂, 12 ♀), from Utah: Cache Co, Logan Canyon, July 18, 1970, tree swallow nest #358. Holotype and allotype in the National Museum of Natural History, Smithsonian Institution, additional paratypes there and in University of British Columbia, Spencer Entomological Museum, Utah State University, Washington State University, and Whitworth Collections.

Additional paratypes: CANADA, BRITISH COLUMBIA (9 ♂, 10 ♀, 31 puparia): 22 puparia, Osoyoos, tree swallow nest #3713, 7/1/2000; 9 ♂, 10 ♀, 6 puparia, Haney, bank swallow nest, July 25, 1955, Mrs. Boye (Spencer Museum); 3 puparia, near Kamloops, Lac du Bois, tree swallow, August 10, 1954, G.J. Spencer. IDAHO (2 puparia mixed with 13 *P. sialia* puparia): Athol, Bonner Co., tree swallow nest #4044, July 15, 2000. MONTANA (4 puparial slides): Ravalli County, "swallow species", no date, G.F. Bennett Collection. OREGON (4 ♀ and 138 puparia): Springfield area, Lane County; 3 puparia, violet-green swallow nest #3741, July 8, 2000; all the following from tree swallow nests; 9 puparia mixed with 2 *P. sialia* puparia, nest #4194, July 8, 2000; 19 puparia mixed with 4 *P. hirundo* puparia, nest #4202, July 13, 2000; 11 puparia mixed with 3 *P. sialia* puparia, nest #4203, July 10, 2000; 62 puparia nest

#4204, July 12, 2000; 1 adult ♀, 15 puparia mixed with 5 *P. sialia* puparia, nest #4205, July 15, 2000; 2 puparia mixed with 5 *P. sialia* puparia, nest #4501, July 8, 2000; 7 puparia, nest #4502, July 24, 2000; 9 puparia, nest #4506, July 26, 2000; 3 ♀, 3 puparia, nest #4508, June 6, 2000; 1 puparium mixed with 3 *P. braueri* puparia, nest #4511, June 15, 2000. UTAH (94 ♂ and 107 ♀, many puparia): Logan Canyon, Cache Co. tree swallow nests; 10 ♂, 11 ♀, nest #359, July 18, 1970; 2 ♂, 2 ♀, nest #497, August 7, 1970; 19 ♂, 13 ♀, nest #498, August 7, 1970; the following nests were collected July 17, 1971; 9 ♂, 17 ♀, nest #1196; 7 ♂, 5 ♀, nest #1197; 9 ♂, 7 ♀, nest #1198; 2 ♂, nest #1199; 5 ♂, 8 ♀, nest #1200; 3 ♂, 3 ♀, nest #1202; 2 ♀, purple martin nest #1215, July 23, 1971; 1 ♂, 1 ♀, tree swallow nest #1216, July 23, 1971; 11 ♂, 12 ♀, Monte Cristo, Rich Co., purple martin nest #519, August 10, 1970; 5 ♂, 4 ♀, mixed with *P. sialia,* Walton Canyon, Rich Co., cliff swallow nest #418; 1 ♂, 3 ♀, mixed with *P. halli* Sabrosky, Bennett, and Whitworth. Logan, Cache Co., barn swallow nest #1290, August 14, 1971; 7 ♂, 6 ♀, Box Elder Co., violet-green swallow nest August 2, 1966, collector Ken Capelle. WASHINGTON (19 ♂, 81 ♀, many puparia): Tacoma area, Pierce Co.; 3 ♂ mixed with 65 *P. braueri,* house sparrow nest #1955, July 6, 1978; 3 ♂, 4 ♀, tree swallow nest #1966 June 15, 1979; 8 males, 15 ♀, tree swallow nest #2025, June 23, 1990; 6 ♂, 12 ♀, purple martin nest #2164, July 30, 1990; 22 ♀, purple martin nest #2165, July 30, 1990; 15 ♀, purple martin nest #2229, August 5, 1991; 7 puparia, tree swallow nest #2384, August 15, 1993; 85 puparia, purple martin nest #2539, summer 1996; 1 puparium, tree swallow nest #2557, July 13, 1997; 2 ♂, 3 ♀, Snohomish, Snohomish Co., tree swallow nest #2566, August 1, 1997; 5 ♀, Bellingham, Whatcom Co., violet-green swallow nest #3751, July 10, 2000; 1 ♀, Bellingham, Whatcom Co., tree swallow nest #4166, August 2, 2000; 2 ♀, Bellingham, Whatcom Co., tree swallow nest #4171, July 30, 2000; 20 ♀, tree swallow, nest #4172, July 30, 2000. WYOMING (2 ♂, 3 ♀): Gros Ventre River, Jackson, violet-green swallow nest #448, 7/29/70.

Specimens examined.—145 ♂, 228 ♀, numerous puparia.

Distribution.—USA: Idaho, Montana, Oregon, Utah, Washington, Wyoming, Canada: British Columbia (Fig. 9).

Basis for description of puparia.—Utah slides - 359-2 & 3; 447; 519-A & C; 1198-1, 2, & 3; Washington slides - 2384, 1–2; 2539, 1–5, 7–10; 2557; 3751, 1–2; 4172, 1–2; Oregon slides - 3741, 1; 4194, 2; 4202, 1 & 3; 4204, 2; Idaho slides - 4044, 1–2. Collection data for these nest numbers can be found under type series information.

Hosts.—Purple martin, house sparrow, and many swallow species including: bank, barn, cliff, tree and violet-green.

Ecology and biology.—*Protocalliphora rugosa* was the primary species in the nests of purple martins in northwestern United States and also often found in tree and violet-green swallow nests. It rarely occurred in barn swallow, bank swallow, or cliff swallow nests where *P. halli, P. chrysorrhoea* (Meigen) and *P. hirundo* respectively were the primary parasites. Puparia were usually found wrapped in feathers like *P. sialia* and *P. parorum.* Adult specimens of *P. rugosa* reared from nests in Washington were disproportionately females. Three nests, lot numbers 2165, 2229, and 4172, produced 57 adults, all females, with no males. However, in Utah the sex of adults was about equally male and female (94 males, 107 females). Similar sex ratio distortion has been observed in other insects due to the presence of son-killing or male-killing bacteria like *Wolbachia,* which kills male hosts of diploid insects early in development. I have not observed this sex ratio distortion in other species of *Protocalliphora,* but *Wolbachia* has been found in all species of *Protocalliphora* examined to date (E. Baudry, personal communication) [information obtained in writing].

Etymology.—The specific name is derived from the Latin *rugosus,* which means wrinkled or folded and describes the heavy folds characteristic of the puparia of the species.

Key to Species

The following key will serve to separate males and associated puparia of closely related species with white calypteres and digitate surstyli.

1. Frons of male as wide or wider than breadth of 3rd antennal segment. Hyperstigmatal spines of puparia 25μ or more, posterior ventral spine bands not reduced to rear. 2
– Frons of male obviously narrower than breadth of 3rd antennal segment. Hyperstigmatal spines of puparia short, usually 20μ or less, posterior ventral spine bands significantly reduced to rear. . . . . *shannoni*
2. Preocellar area of male with polished black triangle or streak (Figs. 4–6). Dorsal cuticle of puparia with ridges weak or absent, or if pronounced, prothoracic fringe 500μ or more. . . 3
– Preocellar area of male with dull gray triangle or streak (Figs. 7, 8). Dorsal cuticle with pronounced ridges, diameter of prothoracic fringe 400μ or less. 4
3. Puparium with prothoracic fringe diameter of 500μ or more, dorsum heavily ridged, frons in male averaging about 1.4 times breadth of 3rd antennal segment (Fig. 6). . . . . *sialia*
– Puparium with prothoracic fringe about 375μ (Fig. 1b), dorsal ridges usually weak (Fig. 1c), frons in male about equal to the breadth of the 3rd antennal segment (Fig. 4). . . . *bennetti,* n. sp.
4. Stigmatal region of puparium with a few broad, irregular folds (Fig. 3a), dorsum with broad, irregular folds (Fig. 3b). Upper portion of parafrontal in male not significantly narrowed (Fig. 8). . . . . *hirundo*
– Stigmatal region of puparium with narrower, concentric folds (Fig. 2a), dorsum with narrow, regular folds (Fig. 2c). Upper portion of parafrontal in male narrows significantly (Fig. 7). . . . . *rugosa,* n. sp.

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Literature Cited

Bennett, G.F., 1957. Studies on the genus *Protocalliphora* (Diptera: Calliphoridae) University of Toronto, Canada, unpublished Ph.D. dissertation, 194 pp, 33 plates.

Dawson, R.D., T.L. Whitworth and G.R. Bortolotti, 1999. Bird blow flies, *Protocalliphora* (Diptera: Calliphoridae), in cavity nests of birds in the boreal forest of Saskatchewan. Canadian Field-Naturalist 113 (3): 503–506.

Hall, D.G., 1948. The Blowflies of North America. Thomas Say Foundation, Entomological Society of America, Lafayette, Indiana, 477 pp, 51 plates.

Sabrosky, C.W., G.F. Bennett, and T.L. Whitworth, 1989. Bird blow flies (*Protocalliphora*) in North America (Diptera: Calliphoridae), with notes on Palearctic species. Smithsonian Institution Press, Wash. D.C. 312 pp.

Whitworth, T.L., 1971. A study of the biology of the species of *Protocalliphora* in the northern Wasatch Range. unpublished M.S. Thesis, 58 pp. Utah State University, Logan, Utah.

———. 1977. Host and habitat preferences, life history, pathogenicity and population regulation in species of *Protocalliphora* Hough (Diptera: Calliphoridae). Utah State University, Logan, Utah, Dissertation Abstracts International, B, 37 (10): 4933-B.