

IDENTIFICATION KEYS TO THE LARVAE AND PUPAE OF NEW JERSEY BLACK FLIES (DIPTERA: SIMULIIDAE)¹

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ABSTRACT: Multichotomous identification keys are provided to the black fly larvae and pupae of New Jersey and neighboring states. Control of black flies is targeted at the aquatic immature stages, making proper identification of larvae and pupae vital for suppression purposes. The key includes 39 species known from NJ and an additional 25 species from surrounding states. A species confirmation table is also included to increase identification accuracy. Diagnostic images of simuliid pupae and larvae are also provided.

KEY WORDS: Simuliidae, Black Fly, New Jersey, identification key, species confirmation table, postgenal cleft, *Simulium jenningsi* species group

Black flies (Simuliidae) have become an increasing pest problem in New Jersey from late spring to early fall, having detrimental effects on livestock productivity, public health, quality of life, and tourism (Adler et al., 2004). Economic losses to these industries due to black flies have long been established in North America (Jamnback 1973, Laird et al., 1982, Gray et al., 1996). Though simuliid pests usually arise from an array of different causes (Cupp 1988), this steady increase in simuliid pests is apparently due to improved water quality resulting from the Federal Clean Water Act of 1972, particularly for large river-inhabiting species such as *Simulium jenningsi*. As immatures, black flies inhabit lotic environments which offer sufficient oxygen and water flow needed for carrying food particles to their filter feeding apparatuses. Control of pestiferous black flies is normally attained with lotic applications of pesticides targeted at the larval stage. The chief species of interest are those in the *Simulium jenningsi* species group, the only regional species group known to bite humans, although many other simuliid species are known to swarm about humans. This group's ranking as the dominant simuliid pest in NJ is augmented by their multiple generations per year. Of the 22 species in the *S. jenningsi* species group occurring in North America (Adler et al., 2004), 7 are known to occur in NJ. In addition, there are reports from field biologists who have witnessed species of the *Simulium tuberosum* species group biting humans in NJ.

The Pennsylvania simuliid key published by Adler and Kim (1986) is widely used in both PA and NJ, but does not include all NJ species. Although Crans and McCuiston (1970) previously published a comprehensive list of NJ black flies, they did not include a key, and the known species diversity of NJ's black flies has nearly doubled since their survey (Carle 2010). This increased diversity is aided by recolonization via predominating winds (Webster 1902), and itinerant frontal

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systems connected with atmospheric pressure variations (Wellington 1974). As new species of black flies enter NJ streams, updated keys are necessary for proper identification, especially in surveillance efforts. Since the immatures are the principal targets of black fly treatments, surveillance relies heavily on larval and pupal identification keys. For this reason, it is also important for black fly suppression programs to have identification aids that improve the accuracy and efficiency of identifications such as species confirmation tables provided herein. With the improvement in water quality, black fly species are continually expanding their ranges into urbanized areas; therefore, it is important to consider all regional species in a state key.

Species not yet found in New Jersey that are known to occur in surrounding states have been included in both the species confirmation table (Table 1) and the keys to the black fly larvae and pupae of NJ and vicinity. These species include: *Twinnia tibblesie* (PA); *Helodon vernalis* (DE); *Prosimulium approximatum* (MA), *P. fontanumatum* (PA), *P. saltus* (NY) and *P. transbrachium* (PA & VA), all from the *hirtipes* species group; *Ectemnia primaeva* (Eastern Coastal Plain); *Greniera abdita* (PA) and *G. longicornis* (DE). Regional species from the genus *Simulium* not yet known from NJ include: *Simulium pilosum* (PA); *S. rivuli* (PA); *S. craigi* (PA), *S. Loerchae* (PA), all from the *Simulium vernum* species group; *S. vittatum* (PA); *S. innoxium* (PA); *S. chlorum* (PA), *S. Jonesi* (DE), *S. nyssa* (PA), *S. podostemi* (PA), all from the *Simulium jenningsi* species group; *S. slosonae* (Eastern Coastal Plain); *S. conundrum* (AL to ME) from the *Simulium tuberosum* group; and *S. hematophilum* (PA).

KEY TO BLACK FLY LARVAE OF NEW JERSEY AND VICINITY

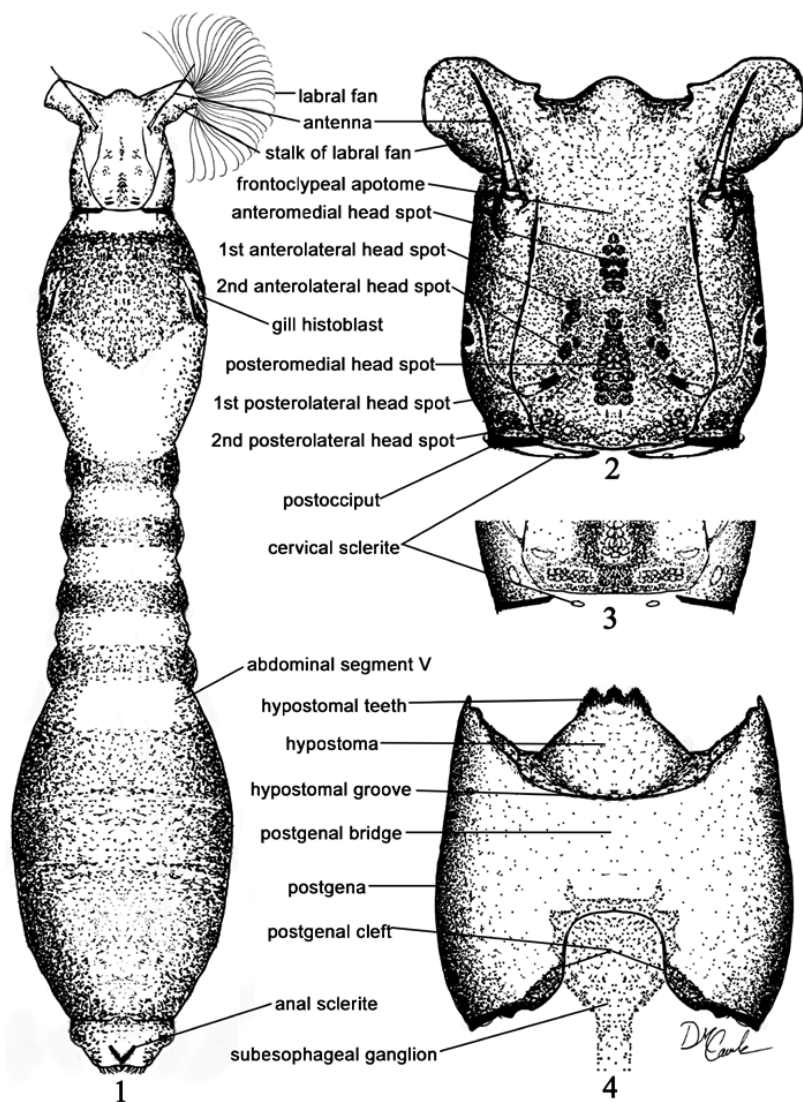
Diagrams of simuliid larval anatomy are included in figs. 1-12. Examples of larval histoblasts are shown in figs. 6 a-d. Examples of diagnostic hypostomal cleft types are illustrated in figs. 10 a-f and 11 a-b. Examples of diagnostic head spot patterns are shown in figs. 12 a-d. A listing of key larval characters can be found in table 1 (columns 1-9). All cytotoxic characters are from Adler et al. (2004).

1. Labral fans absent; head tapered anteriorly to conical labrum terminated in pronounced palatal brush; hypostomal teeth strongly flattened, rounded apically; anal sclerite Y shaped; northeastern Pennsylvania.....*Twinnia tibblesie*
- Labral fans present; head laterally subparallel; hypostomal teeth not strongly flattened or rounded apically; anal sclerite not Y shaped.....2
2. Postocciput with narrow dorsomedial gap; antenna with proximal and middle segments colorless (fig. 2); hypostoma with intermediate teeth between primary teeth; paralateral teeth absent3
- Postocciput with wide dorsomedial gap (fig. 3); antenna with proximal or middle segment pigmented, or if both colorless, then postgenal cleft extended anteriorly to or beyond hypostomal groove; hypostoma without intermediate teeth; paralateral teeth typically present4

3. Prothoracic proleg with lateral sclerite a narrow bar extended at most 1/3 distance to base of apical segment*Helodon vernalis*
- Prothoracic proleg with lateral sclerite extended half or more distance to base of apical segment.....*Prosimulium* ... 11
4. Hypostoma with lateral and sublateral teeth clustered on prominent common lobes; hypostoma with heavily sclerotized anterior portion occupying at least 1/3 length5
- Hypostoma without lateral and sublateral teeth clustered on prominent common lobes; hypostoma with heavily sclerotized anterior portion occupying at most 1/6 length7
5. Abdominal segment 9 without pair of ventral tubercles, at most with transverse midventral bulge*Stegopterna mutata*
(Currently diploid sexually reproducing populations of this taxon are referred to as *Stegopterna diplomutata*, e.g. Adler et al., 2004.)
- Abdominal segment 9 with pair of prominent ventral tubercles.....6
6. Antenna with proximal segment two or more times longer than middle segment, distal segment with dark bands or mottling; Pennsylvania.....
.....*Greniera abdita*
- Antenna with proximal segment at most as long as middle segment; distal segment entirely dark; Delaware*Greniera longicornis*
7. Hypostoma with prominent median tooth, sublateral teeth distinctly posterior to median and lateral teeth; compound rectal papillae often present (fig. 9)...
.....*Simulium*... 23
- Hypostoma without prominent median tooth, sublateral teeth not distinctly posterior to median and lateral teeth; 3 simple rectal papillae present (fig. 8)
.....8
8. Abdomen without abrupt expansion at segment 5, and without pair of ventral tubercles on segment 9; antenna shorter than stalk of labral fan (figs. 2 & 5); hypostoma with anterior margin not distinctly concave; anal sclerite present
.....9
- Abdomen with abrupt expansion at segment 5 (figs. 1 & 7), and with pair of ventral tubercles on segment 9; antenna longer than stalk of labral fan (figs. 1 & 12 a-d); hypostoma with anterior margin distinctly concave; anal sclerite absent10
9. Body dark; chromosome arm IIIL standard; northern New Jersey.....
.....*Cnephia dacotensis*
- Body dark or pale; chromosome arm IIIL with fixed inversions IIIL-4 and IIIL-5.....*Cnephia ornithophilia*
10. Gill histoblast of 8 filaments; northern New Jersey*Ectemnia invenusta*
- Gill histoblast of 10 filaments. Coastal Plain.....*Ectemnia primaeva*

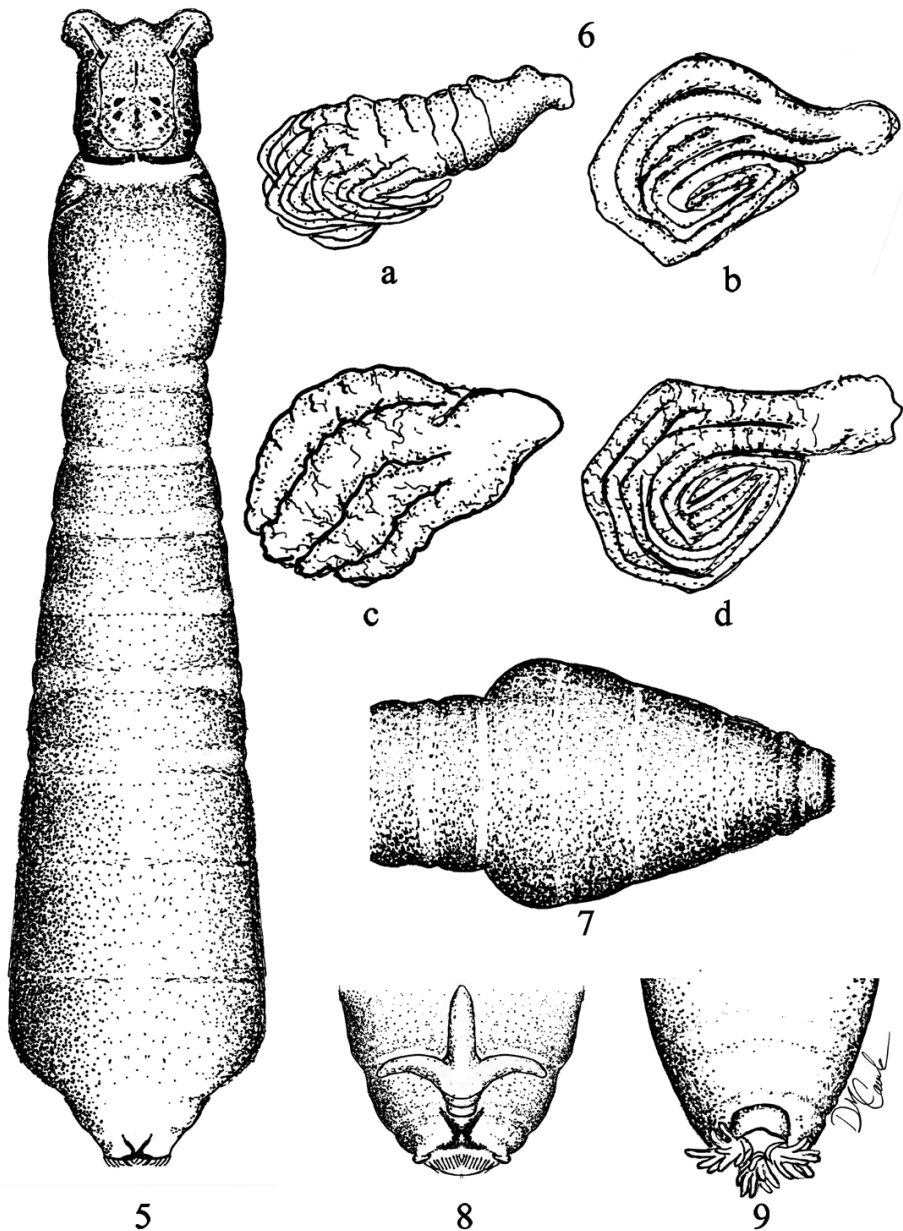
Prosimulium

11. Antenna shorter than stalk of labral fan (fig. 2); abdomen gradually expanded posteriorly (fig. 5); gill histoblast with more than 20 filaments12



Figs. 1-4. Simuliid larval anatomy; 1) dorsal view of *Simulium appalachiense* body; 2) dorsal view of *Prosimulium magnum* head; 3) dorsal view of *Simulium decorum* head showing incomplete closure of cervical sclerites; and 4) ventral view of *Simulium vittatum* head.

- Antenna as long as or longer than stalk of labral fan (figs. 1 & 12 a-d); abdomen rather abruptly expanded at segment 5 (figs. 1 & 7); gill histoblast with less than 17 filaments.....15
- 12. Body grayish, banded with conspicuous intersegmental lines; northern New York*Prosimulium multidentatum*
- Body pale grayish to dark brown with inconspicuous intersegmental lines13
- 13. Body grayish and head yellowish; chromosomes with IIS-25 homozygously inverted*Prosimulium canutum*
- Body brownish greenish and head yellowish brown to dark brown; chromosomes without IIS-2514
- 14. Sex chromosomes undifferentiated*Prosimulium magnum*
- Sex chromosomes differentiated in base of IIIS arm and sometimes IIIL arm *Prosimulium albionense*
- 15. Body grayish, typically strongly banded; postgenal cleft gradually narrowed anteriorly (fig. 10 a); chromosomes with parabalbiani marker inverted and in distal half of IIIL arm, IIIL arm attached to end of IIIS arm*Prosimulium clandestinum*
- Body brownish to grayish, typically not strongly banded; postgenal cleft subrectangular and truncate to slightly rounded anteriorly; chromosomes with parabalbiani marker in standard orientation and in proximal half of IIIL arm, IIIL arm attached to IIIS arm at centromere.....16
- 16. Frontoclypeal apotome yellowish white, contrasting strongly with dark brown head spots *Prosimulium arvum*
- Frontoclypeal apotome yellowish brown to brown, variously contrasting with brown head spots17
- 17. Frontoclypeal apotome with anterolateral head spots yellowish or apparently absent; gill histoblast an inflated club with 16 filaments (fig. 6 a).....*Prosimulium rhizophorum*
- Frontoclypeal apotome with anterolateral head spots typically brownish (fig. 2); Gill histoblast with 3 trunks terminating in 14-16 total filaments.....18
- 18. Frontoclypeal apotome with half of first posterolateral head spot brown (fig. 2); body typically grayish with weak bands; chromosome arm IIIS with "blister" marker inverted in at least 1 homologue *Prosimulium fuscum*
- Frontoclypeal apotome with first posterolateral head spot yellowish or apparently absent (fig. 12 a-b); body brownish without bands; chromosome arm IIIS without "blister" inversion19
- 19. Gill histoblast with filaments branched from 3 inflated trunks; New York*Prosimulium saltus*
- Gill histoblast with filaments branched from 3 at most slightly swollen trunks20
- 20. Hypostoma with each of 2 outer sublateral teeth on each side asymmetrical, extended anteriorly to same level as lateral teeth, giving anterior margin straight or convex appearance; Massachusetts*Prosimulium approximatum*



Figs. 5-9. Simuliid larval anatomy; 5) dorsal view of *Prosimulium magnum* body; 6) gill histoblasts of: a) *Prosimulium rhizophorum*, b) *Simulium anchistinum*, c) *Simulium fibrinflatum*, and d) *Simulium jenningsi*; 7) dorsal view of *Ectemnia invenusta* terminal abdominal segments; 8) dorsal view of *Cnephia dacotensis* terminal abdominal segments showing simple rectal papillae; and 9) dorsal view of *Simulium appalachiense* terminal abdominal segments showing compound rectal papillae.

- Hypostoma with each of 2 outer sublateral teeth on each side symmetrical, slightly, to distinctly posterior to lateral teeth, giving anterior margin concave appearance.....21
- 21. Hypostoma with lateral teeth extended anteriorly well beyond sublateral teeth*Prosimulium fontanum*
- Hypostoma with lateral teeth extended anteriorly slightly beyond sublateral teeth.....22
- 22. Chromosomes with standard arm associations (IS + IL, IIS + IIL).....*Prosimulium mixtum*
- Chromosomes with whole-arm interchange (IS + IIL, IL + IIS); Virginia and Pennsylvania*Prosimulium transbrachium*

Simulium

- 23. Distal antennal segment at most extended 1/2 its length beyond fan stalk; abdominal segment 9 in lateral view with ventral tubercles typically shorter than wide.....24
- Distal antennal segment extended more than 1/2 its length beyond fan stalk; abdominal segment 9 in lateral view with ventral tubercles longer than wide27
- 24. Postgenal bridge medially longer than width of postgenal cleft (fig. 4); rectal papillae simple (fig. 8).....subgenus *Psilozia* 25
- Postgenal bridge medially shorter than width of postgenal cleft; rectal papillae compound (fig. 9).....26
- 25. Inhabitant of wide variety of lotic systems, chromosomes with standard sequence in distal half of IS; males typically with IIL-1 heterozygous*Simulium tribulatum*
- Typically inhabitant of streams cooler than 22°C; chromosomes typically with IS-7 homozygously inverted or heterozygous; males without IIL-1 inversion*Simulium vittatum*
- 26. Postgenal cleft globose, widest near midlength; head capsule pale; middle antennal segment not annulate; Maine..... *Simulium furculatum*
- Postgenal cleft V-shaped, widest posteriorly; head capsule dark; middle antennal segment annulate.....*Simulium innoxium*
- 27. Width of postgenal cleft less than twice medial length of postgenal bridge (fig. 10 d)28
- Width of postgenal cleft more than twice medial length of postgenal bridge (figs. 10 e-f, 11 a-b)*Simulium (Simulium)* 40
- 28. Middle antennal segment annulate; gill histoblast of 4-12 filaments29
- Middle antennal segment without annulations; gill histoblast with 4, 6 or 8 filaments.....30
- 29. Hypostoma with lateral teeth extended anteriorly beyond median tooth; rectal papillae with simple lobes (fig. 8); gill histoblast with 12 filaments; small streams.....*Simulium congareenarum*

- Hypostoma with median and lateral teeth extended anteriorly to about same level; rectal papillae with compound lobes (fig. 9); Gill histoblast of 4 filaments; large streams and rivers *Simulium emarginatum*

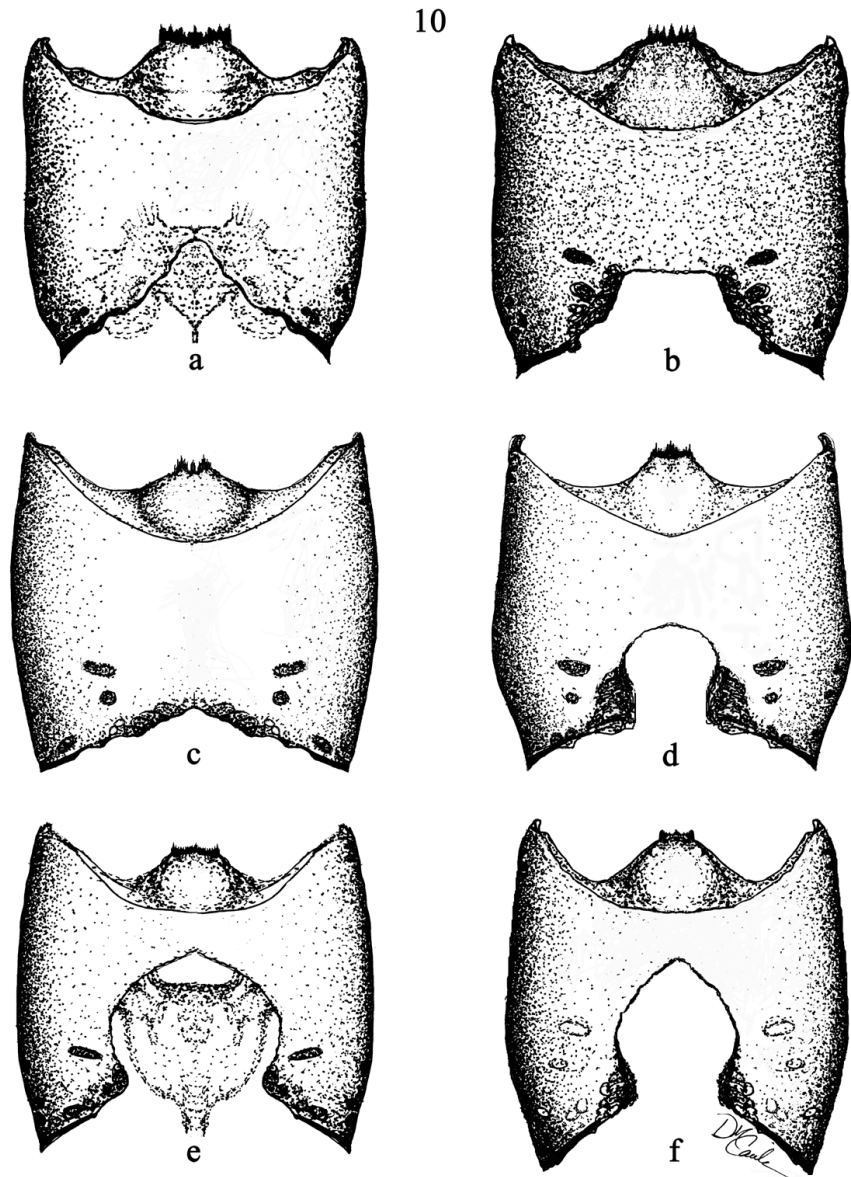
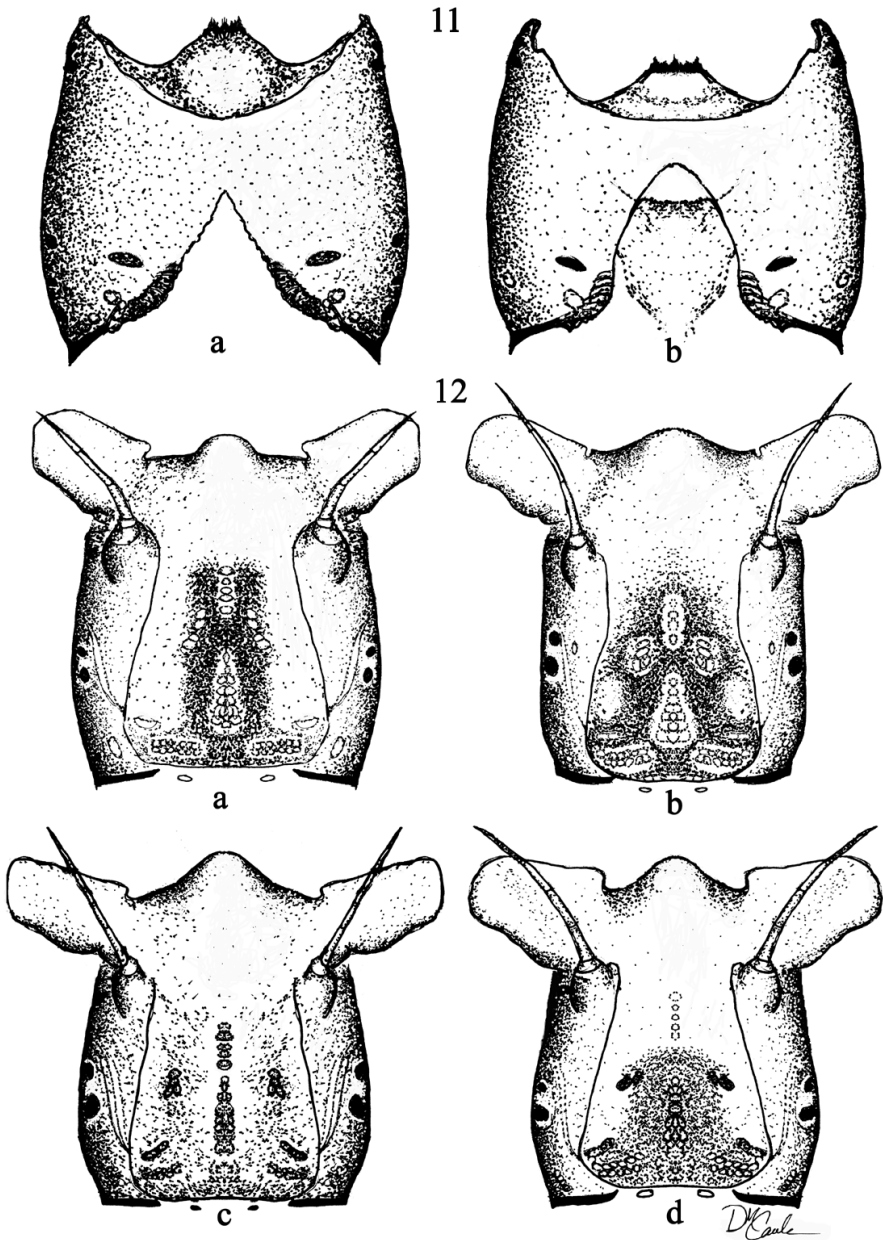


Fig. 10. Ventral view of larval head showing hypostomal cleft: a) *Prosimulium clandestinum*, b) *Prosimulium magnum*, c) *Stegopterna mutata*, d) *Simulium gouldingi*, e) *Simulium fibrinflatum*, and f) *Simulium decorum*.

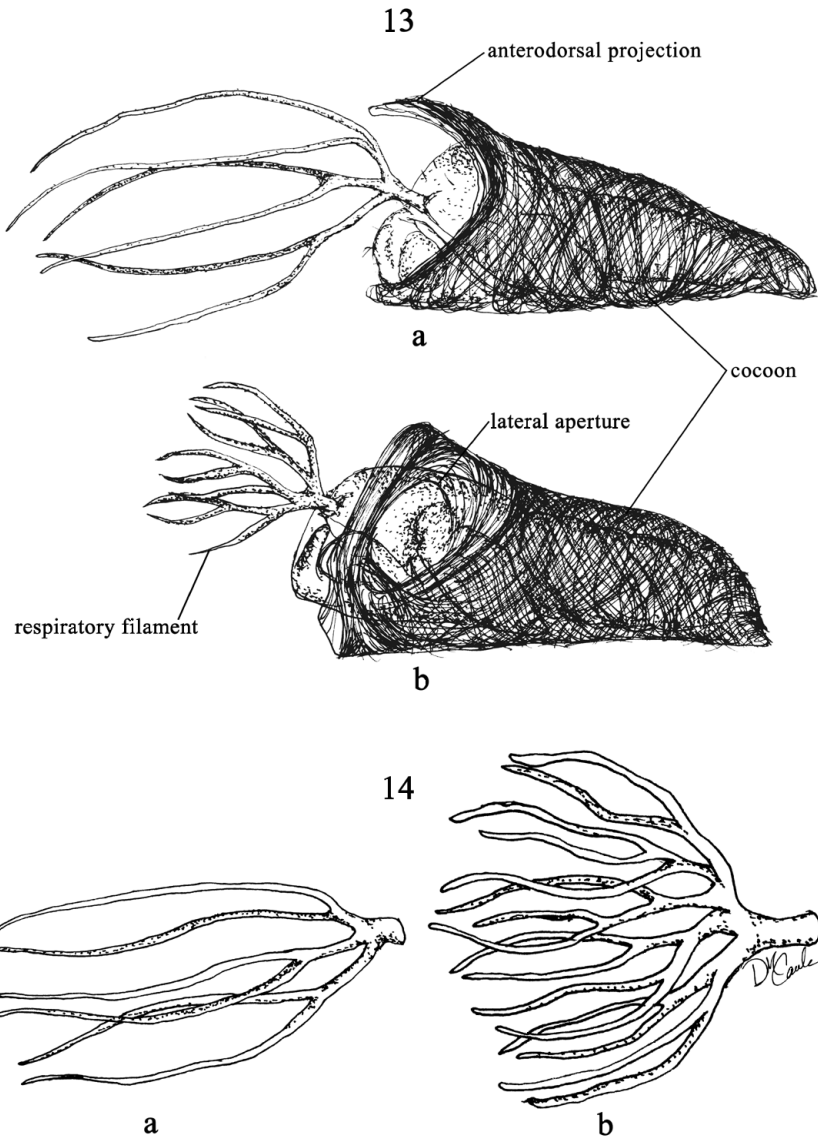
30. Anterolateral head spots on each side separated by at least width of one spot; hypostoma with anterolateral margin of ventral wall bearing longitudinal sulcus*Simulium rivuli*
- Anterolateral head spots on each side separated by less than width of one spot (figs. 2, 12 a-d); Hypostoma with anterolateral margin of ventral wall not bearing longitudinal sulcus31
31. Postgenal cleft with truncate anterior margin; rectal papillae simple (fig. 8); chromosomes with haploid number of 2*Simulium (Eusimulium)* 32
- Postgenal cleft with broadly rounded or pointed anterior margin; rectal papillae simple or compound; chromosomes with haploid number of 3*Simulium (Nevermannia)* 33
32. Postgenal cleft not biarcuate anteriorly, extended slightly less than one half distance to hypostomal groove; chromosomes with "bulge" marker closer than ring of Balbiani to centromere*Simulium bracteatum*
- Postgenal cleft biarcuate anteriorly, extended about one-third distance to hypostomal groove; chromosomes with ring of Balbiani closer than "bulge" marker to centromere*Simulium pilosum*
33. Gill histoblast with 6 or 8 filaments34
- Gill histoblast with 4 filaments.....36
34. Gill histoblast with 6 filaments; postgenal bridge medially about as long as hypostoma (fig. 10 d)*Simulium gouldingi*
- Gill histoblast with 8 filaments; postgenal bridge medially shorter than hypostoma35
35. Frontoclypeal apotome with medial brown stripe extended anteriorly beyond antennal bases; postgenal cleft dome shaped, nearly parallel-sided*Simulium croxtoni*
- Frontoclypeal apotome without medial brown stripe extended anteriorly beyond antennal bases; postgenal cleft arrowhead shaped, widest posterior to mid-length.....*Simulium fionae*
36. Postgenal bridge medially longer than hypostoma.....*Simulium craigi*
- Postgenal bridge medially as long as or shorter than hypostoma37
37. Postgenal cleft surrounded by faint brownish H-shaped mark; body brownish*Simulium silvestre*
- Postgenal cleft not surrounded by faint brownish H-shaped mark; body reddish to greenish grey38
38. Postgenal bridge medially as long as hypostoma; abdomen without pale dorsomedial or intersegmental bands; gill histoblast with ventral trunk at least 4 times length of dorsal trunk*Simulium impar*
- Postgenal bridge medially shorter than hypostoma; abdomen with weak pale dorsomedial and intersegmental bands; gill histoblast with ventral trunk subequal in length to dorsal trunk39
39. Abdomen posterodorsally with dark reddish area; postgenal cleft pointed anteriorly; gill histoblast of 4 filaments*Simulium loerchae*
- Abdomen posterodorsally without dark reddish area; postgenal cleft rounded anteriorly (fig. 10 d); gill histoblast of 4-8 filaments*Simulium quebecense*



Figs. 11 and 12. Larval head; 11) Ventral view showing hypostomal cleft: a) *Simulium parnassum*, b) *Simulium tuberosum*; and 12) dorsal view showing spot pattern: a) *Simulium decorum*, b) *Simulium venustum*, c) *Simulium ubiquitousum*, and d) *Simulium vandalicum*.

40. Head with negative head-spot pattern (figs. 12 a-b) or without spots; gill histoblast of 6 or 8 filaments41
- Head with positive head-spot pattern (figs. 2, 12 c-d), although some head spots can be weak, or absent.....43
41. Frontoclypeal apotome with dark pigment restricted to central elongate or H-shaped pattern (fig. 12 a); subesophageal ganglion typically not ensheathed with pigment; gill histoblast of 8 filaments.....*Simulium decorum*
- Frontoclypeal apotome with dark pigment either absent or not forming central elongate or H-shaped pattern; gill histoblast of 6 filaments 42
42. Chromosomes typically without IIII-5 invers.....*Simulium verecundum*
- Chromosomes with IIII-5 homozygously inverted or heterozygous.....
.....*Simulium hematophilum* and *S. venustum*
43. Postgenal cleft bulbous, about as long as wide, with anterior cleft absent or obtuse (fig. 10 e).....44
- Postgenal cleft arrow head shaped, longer than wide, with anterior cleft acute (fig. 11 b)55
44. Postgenal cleft rounded anteriorly and separated from hypostomal groove by about 1/3 length of hypostoma; abdominal cuticle with numerous postero-dorsal setae; Virginia.....*Simulium slossonae*
- Postgenal cleft slightly pointed and separated from hypostomal groove by 1/3 or more than length of hypostoma (fig. 10 e); abdominal cuticle with or without posterodorsal setae*Simulium (Simulium) jenningsi* group 45
45. Gill histoblast with 12 filaments.....*Simulium luggeri*
- Gill histoblast with 6-10 filaments46
46. Abdominal segment 9 with ventral tubercles vestigial or absent; gill histoblast with reticulate surface sculpture47
- Abdominal segment 9 with ventral tubercles small and slender to large and conical; gill histoblast without reticulate surface sculpture49
47. Gill histoblast with 10 filaments.....*Simulium jenningsi*
- Gill histoblast with 6 filaments.....48
48. Gill histoblast with filaments at most slightly curled apically and with apices blunt (fig. 6 c).....*Simulium fibrinflatum*
- Gill histoblast with filaments doubly curled apically with apices attenuate ...
.....*Simulium notiale*
49. Gill histoblast with ventralmost trunk thickest and 5 branched (typically with 9 total filaments); female frontoclypeal apotome darkened posteriorly to encompass all head spots.....*Simulium definitum*
- Gill histoblast with ventralmost trunk not thickest (fig. 6 b) and 5 branched (typically with 8 or 10 total filaments); frontoclypeal apotome not darkened posteriorly to encompass all head spots50
50. Uncurled gill histoblast at most 2 times length of head; body pigment greenish or grayish, with pigmentation of abdominal segments subequal in intensity; abdominal segment 9 with ventral tubercles minute and slender51

- Uncurled gill histoblast more than 2 times length of head; body variously pigmented, with abdominal segment 1 or occasionally 5 more heavily pigmented than remaining abdominal segments; abdominal segment 9 with ventral tubercles larger and more conical53



Figs. 13 and 14. Simuliid pupal anatomy; 13) lateral view of pupae: a) *Simulium impar*, and b) *Simulium jenningsi*; and 14) gill of: a) *Simulium ubiquitum*, and b) *Prosimulium fuscum*.

51. Postgenal bridge less than 1/2 length of hypostoma; gill histoblast of 8 filaments; posterior proleg typically with more than 80 rows of hooks.....*Simulium podostemi*
- Postgenal bridge more than 1/2 length of hypostoma; gill histoblast of 8-10 filaments; posterior proleg typically with 80 or fewer rows of hooks52
52. Dorsal trunk of histoblast thickened; ventral trunk of gill histoblast with third branch subbasal (fig. 8 b); chromosome arm IIS with ring of Balbiani closer than "bulge" marker to centromere.....*Simulium anchistinum*
- Dorsal trunk of histoblast not thickened (fig. 6 d); ventral trunk of gill histoblast with third branch basal; chromosome arm IIS with "bulge" marker closer than ring of Balbiani to centromere*Simulium nyssa*
53. Gill histoblast of 10 filaments arising from 1 long, basally swollen, gradually tapered trunk; filaments 5 and 6 (dorsal to ventral) typically not petiolate.*Simulium jonesi*
- Gill histoblast of 8-10 filaments arising from variously thickened trunk; filaments 5 and 6 (dorsal to ventral) petiolate54
54. Gill histoblast with ventralmost petiole typically 1/10 or less length of uncurled gill histoblast; Coastal Plain*Simulium lakei*
- Gill histoblast with ventralmost petiole typically 1/7 or more length of uncurled gill histoblast; Pennsylvania Piedmont*Simulium chlorum*
55. Postgenal cleft triangular, anteriorly angled at about 45°; postgenal bridge medially about as long as hypostoma (fig. 11 a); gill histoblast of 6 filaments; abdomen posteroventrally with white patch*Simulium parnassum*
- Postgenal cleft not triangular, anteriorly angled at about 60°; postgenal bridge medially about 1/2 as long as hypostoma (fig. 11 b); gill histoblast of 6-16 filaments; abdomen posteroventrally without white patch56
56. Abdomen gradually expanded posteriorly (fig. 5); mature larvae more than 6 mm long; gill histoblast with 10-16 (rarely 8) filaments; Massachusetts*Simulium marmanum*
- Abdomen abruptly expanded at segment 5 (figs. 1 & 7); mature larvae typically less than 6 mm long; gill histoblast of 6 filaments.....*Simulium (Simulium) tuberosum* group 57
57. Frontoclypeal apotome with anteromedial and posteromedial spots separated by the diameter of one head spot (fig. 12 c); gill histoblast with trunks longer than wide*Simulium ubiquitum*
- Frontoclypeal apotome with anteromedial and posteromedial spots separated by diameter of 2-3 head spots (fig. 12 d); gill histoblast with no more than 1 trunk longer than wide58
58. Body dark gray or blackish, with pigment uniform, or if banded then intersegmental areas mottled grayish; head brownish orange with dorsal head spots obscure; chromosome arm IIS with "bulge" marker closer than ring of Balbiani to centromere*Simulium conundrum*
- Body gray to brown with pigment in bands; head yellowish brown to brown-

- ish orange with dorsal head spots distinct; if head brownish orange, then chromosome arm IIS with ring of Balbiani closer than “bulge” marker to centromere59
59. Body grayish with whitish area on posterior half of thorax in shape of inverted triangle (fig. 1); chromosome arm IIS with “bulge” marker often closer than ring of Balbiani to centromere*Simulium appalachiense*
- Body if with whitish area, then confined to posterior 1/4 of thorax and not in shape of inverted triangle; chromosome arm IIS with ring of Balbiani closer than “bulge” marker to centromere60
60. Head brownish orange, typically with head spots surrounded by brown pigment, at least posteriorly (fig. 12 d); body dark gray; Chromosome arm IIS with FG sequence heterozygous or homozygous*Simulium vandalicum*
- Head typically yellowish or yellowish brown with head spots not surrounded by brown pigment; body pale gray; chromosome arm IIS without FG sequence61
61. Chromosome arm IIS with ring of Balbiani and “bulge” marker closely approximated without intervening bands; IIS without heavy subterminal band*Simulium perissum*
- Chromosome arm IIS with ring of Balbiani and “bulge” marker separated by intervening bands; IIS with heavy subterminal band *Simulium tuberosum*

KEY TO BLACK FLY PUPAE OF NEW JERSEY AND VICINITY

For a diagram of simuliid pupal anatomy refer to fig. 13a and b. For views of dissected pupal gills refer to fig. 14 a and b. A listing of key pupal characters can be found in table 1 (columns 10-14).

1. Gill with 13 or more filaments.....2
- Gill with 9-12 filaments12
- Gill with 8 filaments24
- Gill with 5-6 filaments33
- Gill with 4 filaments42
2. Cocoon rigid slipperlike (figs. 13 a-b) ...*Simulium tribulatum* and *S. vittatum*
- Cocoon shapeless saclike3
3. Abdominal terga 7-8 or 9 without anterior row of spine combs4
- Abdominal terga 7-8 or 9 with anterior row of spine combs6
4. Gill with 16 filaments branched from 3 elongate inflated trunks.....
-*Twinnia tibblesie*
- Gill with 17-23 filaments branched from 2 short subequal trunks.....5
5. Abdomen with terminal spines directed posterolaterally, gills branched over basal half*Greniera longicornis*
- Abdomen with terminal spines directed dorsally, gills branched in basal 1/5*Greniera abdita*
6. Gill with more than 16 filaments7

- Gill with 13-16 filaments9
- 7. Abdominal segments 8 and 9 with strongly curled setae laterally; abdomen without pleurites on segments 4 and 5; gill with 17-50 filaments arising from short thick knoblike base*Cnephia dacotensis* and *C. ornithophilia*
- Abdominal segments 8 and 9 with straight or slightly curved setae laterally; abdomen with large pleurites on segments 4 and 5; gill with 20-75 filaments variously arising from base8
- 8. Gill with 20-28 filaments*Prosimulium canutum* and *P. multidentatum*
- Gill with 24-75 filaments*Prosimulium albionense* and *P. magnum*
- 9. Gill with 16 slender filaments branching along single inflated furrowed trunk*Prosimulium rhizophorum*
- Gill with 13-16 slender filaments not branching along single inflated furrowed trunk (fig. 14 b)10
- 10. Gill with 16 slender filaments arising from 3 inflated main trunks*Prosimulium saltus*
- Gill with 13-16 slender filaments arising from 3 uninflated to slightly inflated main trunks (fig. 14 b)11
- 11. Gill with dorsal trunk bearing undivided outer branch with 3 filaments and divided inner branch with 5 filaments*Helodon vernalis*
- Gill with dorsal trunk bearing 3 main branches, or divided outer branch with 5 filaments and inner branch with 3 filaments (fig. 14 b)
.....*Prosimulium arvum*, *P. approximatum*, *P. clandestinum*,
P. fontanumatum, *P. fuscum*, *P. mixtum*, *P. transbrachium*
- 12. Pupa on silk stalk; gill filaments thick with scalelike surface sculpture and with all filaments convergent distally*Ectemnia primaeva*
- Pupa without silk stalk; gill filaments thin without scalelike surface sculpture and with all filaments not convergent distally13
- 13. Cocoon with anterodorsal projection (fig. 13 a)*Simulium congareenarum*
- Cocoon without anterodorsal projection (fig. 13 b)14
- 14. Cocoon nonrigid short-saclike*Stegopterna diplomutata* and *St. mutata*
- Cocoon rigid, long slipperlike (figs. 13 a-b)15
- 15. Gill with 11 or 12 filaments*Simulium luggeri*
- Gill with 9 or 10 filaments16
- 16. Cocoon boot shaped17
- Cocoon slipper or shoe shaped (figs. 13 a-b)18
- 17. Cocoon without wide apical loops, gill with 9 filaments arranged in an open rosette*Simulium innoxium*
- Cocoon with several wide apical loops, gill with 10 filaments arranged in bushlike pattern*Simulium murmanum*
- 18. Gill filaments with reticulate surface sculpture (fig. 13 b) *Simulium jenningsi*
- Gill filaments with transverse furrows19
- 19. Gill with ventral trunk swollen, or with ventral petiole swollen for more than 1/2 length20

- Gill with ventral petiole typically not swollen for more than 1/2 length21
- 20. Gill with 9 filaments, with filaments 5 and 6 from dorsum typically petiolate*Simulium definitum* (in part)
- Gill of 10 filaments, with filaments 5 and 6 from dorsum typically sessile ...
.....*Simulium (Simulium) jonesi*
- 21. Gill 3/5 or less length of pupal body, typically slightly swollen basally22
- Gill 1/3 or more length of pupal body, typically not swollen basally23
- 22. Head dorsally with dense uniform microtubercles*Simulium anchistinum*
- Head dorsally with sparse irregular microtubercles*Simulium nyssa*
- 23. Gill with ventral petiole of ventral trunk typically less than 1/8 length of gill
.....*Simulium lakei* (in part)
- Gill with ventral petiole of ventral trunk typically more than 1/6 length of gill
..... *Simulium chlorum* (in part)
- 24. Cocoon with anterodorsal projection (fig. 13 a) 25
- Cocoon without anterodorsal projection (fig. 13 b)26
- 25. Gill with dorsal filament typically divergent at nearly 90-degree angle
.....*Simulium fionae*
- Gill with dorsal filament typically divergent at less than 90-degree angle
.....*Simulium croxtoni*
- 26. Pupa on silk stalk; gill filaments all convergent distally....*Ectemnia invenusta*
- Pupa not on silk stalk; gill filaments not all converging distally27
- 27. Cocoon without large apertures (numerous small gaps may be present) (fig. 13 a).....28
- Cocoon with one or more large anterior apertures per side (fig. 13 b)30
- 28. Gill with 4 pairs of petiolate filaments*Simulium podostemi*
- Gill with at least one filament arising independently from base, or with at least one trio of petiolate filaments..... 29
- 29. Cocoon with many small gaps, with at least one filament branched from base of gill, dorsal trunk with 3 filaments*Simulium decorum*
- Cocoon without small gaps, filaments not branched from base of gill, dorsal trunk with 2 filaments*Simulium furculatum*
- 30. Head and thorax smooth, without microtubercles; gill of 6 filaments
.....*Simulium fibrinflatum*
- Head and thorax with sparse to dense microtubercles; gill of 8-10 filaments .
.....31
- 31. Gill with ventral trunk and ventral petiole swollen
.....*Simulium definitum* (in part)
- Gill typically without swelling of ventral trunk or ventral petiole..... 32
- 32. Gill with ventral petiole of ventral trunk typically more than 1/6 length of gill
.....*Simulium chlorum* (in part)
- Gill with ventral petiole of ventral trunk typically less than 1/8 length of gill
.....*Simulium lakei* (in part)
- 33. Cocoon with anterodorsal projection (fig. 13 a).....34
- Cocoon without anterodorsal projection (fig. 13 b)35

34. Cocoon with anterodorsal projection shorter than wide ...*Simulium slossonae*
 -- Cocoon with anterodorsal projection longer than wide ...*Simulium gouldingi*
35. Cocoon with one or more anterior apertures per side (fig. 13 b)36
 -- Cocoon without apertures (fig. 13 a)37
36. Gill with middle pair of filaments on short petiole arising from base of ventral pair; filaments often, but not always, swollen their entire length
*Simulium fibrinflatum* (in part)
 -- Gill with middle pair of filaments nearly sessile, and arising from base of gill or from base of dorsal pair; filaments never swollen their entire length
*Simulium notiale*
37. Head and thorax with reticulate rugosity*Simulium parnassum* (in part)
 -- Head and thorax smooth or with microtubercles, but without rugosity38
38. Gill with at least two trunks longer than wide (fig. 14 a)
*Simulium ubiquitum*
 -- Gill with at least two trunks about as long as wide39
39. Gill filaments in dorsal view divergent laterally. Head and thorax with uniformly arranged microtubercles*Simulium verecundum*
 -- Gill filaments in dorsal view aligned more or less in vertical plane; head and thorax smooth or with variously arranged microtubercles 40
40. Gill typically more than half as long as pupal body, and with all filaments of subequal thickness*Simulium venustum* and *S. hematophilum*
 -- Gill often about half as long as pupal body, and with filaments decreasing in thickness from dorsal to ventral41
41. Head and thorax with numerous microtubercles*Simulium appalachiense*,
S. conundrum, *S. perissum*, *S. tuberosum*, and *S. vandalicum*
 -- Head and thorax smooth, without microtubercles
*Simulium parnassum* (in part)
42. Cocoon with long anterodorsal projection (fig. 13 a)43
 -- Cocoon without distinct anterodorsal projection (fig. 13 b) 46
43. Gill in lateral view with dorsalmost filament divergent basally from ventral filament at angle of 50 degrees or greater44
 -- Gill in lateral view with dorsal filament divergent basally from ventral filament at angle of 50 degrees or less *Simulium craigi*
44. Head and thorax with flat uniformly distributed microtubercles
*Simulium loerchae*
 -- Head and thorax with rounded irregularly distributed micro-tubercles45
45. Gill with filaments of dorsal pair branched more in horizontal plane
*Simulium rivuli*
 -- Gill with filaments of dorsal pair branched more in vertical plane
*Simulium silvestre*
46. Gill with ventral trunk at least 4 times length of dorsal trunk (fig. 13 a)
*Simulium impar*
 -- Gill with ventral trunk less than 3 times length of dorsal trunk47

47. Gill laterally with dorsal filament strongly divergent from other three filaments *Simulium bracteatum* and *S. pilosum*
 -- Gill laterally with dorsal filament not strongly divergent from other three filaments 48
48. Gill filaments with reticulate surface pattern *Simulium quebecense*
 -- Gill filaments with transverse furrows *Simulium emarginatum*

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Table 1. Verification table for simuliid species of New Jersey and vicinity. (1) Cleft type; a = wide shallow quadrangle, b = small v, c = vestigial, d = deep notch, e = shallow notch, f = shallow v, g = u shaped, h = biarcuate, i = square-like, j = blunt arrowhead-like, k = deep v shaped, l = globose, m = pointed arrowhead-like; (2) Cleft index: average length of hypostomal bridge/cleft width at mid-length; (3) Hypostomal teeth: + = paralaral teeth present, -- = paralaral teeth absent; (4) Head spouts: + = Positive, -- = Negative; (5) Cervical sclerite: + = complete, -- = incomplete; (6) Labral fans: + = present, -- = absent; (7) Antennal length: -- = shorter than labral fan stalk, + = longer than labral fan stalk, a = stalk absent; (8) Abdominal shape: + = abruptly expanded, -- = gradually expanded; (9) Rectal papillae: -- = simple, + = compound; (10) number of gill filaments; (11) Gill formula; M = multi-branched, actual branching pattern; (12) Cocoon aperture; -- = absent, + = present; (13) Cocoon shape: a = Sac-like, b = on silk stalk, c = slipper-like, d = boot-like; (14) Cocoon projection: -- = Absent, + = Present.

* Regional species not yet known from New Jersey.

TAXON			LARVAE										PUPAE			
Tribe, Genus, Subgenus, and Species group	1	2	3	4	5	6	7	8	9	10	11	12	13	14		
Prosimuliini <i>Prosimulium</i> (<i>Prosimulium</i>) magnum species group	<i>P. multidentatum</i> *	a	1.1	--	+	+	--	--	--	20-28	M	--	a	--		
	<i>P. albionense</i>	a	1.4	--	+	+	--	--	--	24-75	M	--	a	--		
	<i>P. conatum</i>	a	1.4	--	+	+	--	--	--	20-28	M	--	a	--		
	<i>P. magnum</i>	a	1.4	--	+	+	--	--	--	24-75	M	--	a	--		
<i>Prosimulium</i> (<i>Prosimulium</i>) hiripes species group	<i>P. approximatum</i> *	a	1.2	--	+	+	+	+	--	16	M	--	a	--		
	<i>P. arum</i>	a	1.5	--	+	+	+	+	--	16	M	--	a	--		
	<i>P. claudesitum</i>	b	1.4	--	+	+	+	+	--	16	M	--	a	--		
	<i>P. fontanumatum</i> *	a	1.3	--	+	+	+	+	--	16	M	--	a	--		
	<i>P. fuscum</i>	a	1.3	--	+	+	+	+	--	16	M	--	a	--		
	<i>P. mixtum</i>	a	1.5	--	+	+	+	+	--	16	M	--	a	--		
	<i>P. rhizophorum</i>	a	1.2	--	+	+	+	+	--	16	M	--	a	--		
	<i>P. saltus</i> *	a	1.3	--	+	+	+	+	--	16	M	--	a	--		
<i>Helodon</i> (<i>Parachelodon</i>)	<i>P. transbrachium</i> *	a	1.3	--	+	+	+	+	--	16	M	--	a	--		
<i>Twinnia</i> (<i>Twinnia</i>)	<i>H. vernalis</i> *	b	1.6	--	+	+	+	+	--	16	M	--	a	--		
	<i>T. tibbles</i> *	c	>6	--	+	+	a	+	--	16	M	--	a	--		
<i>Simulium</i> (<i>Greniera</i> (<i>Greniera</i>)	<i>G. abdita</i> *	d	<1.4	+	+	--	+	+	--	16-23	M	--	a	--		
	<i>G. longicornis</i> *	e	3.5	+	+	--	+	+	--	22-23	M	--	a	--		
<i>Stegopterna</i> (<i>Stegopterna</i>)	<i>St. diplomata</i>	f	1.7	+	+	+	+	+	--	12	M	--	a	--		
	<i>St. mutata</i>	f	1.7	+	+	+	+	+	--	12	M	--	a	--		
<i>Cnephia</i> (<i>Cnephia</i>)	<i>C. dacotensis</i>	a	1	+	+	+	--	--	--	17-50	M	--	a	--		
	<i>C. ornithophila</i>	a	1	+	+	+	--	--	--	17-50	M	--	a	--		
<i>Ectemnia</i> (<i>Ectemnia</i>)	<i>E. invenusta</i>	g	1.1	+	--	+	+	+	--	8	M	--	b	--		
	<i>E. primaeva</i> *	g	1	+	--	+	+	+	--	10	M	--	b	--		
<i>Simulium</i> (<i>Hellichella</i>)	<i>S. congaenarum</i>	h	2	+	--	+	+	+	--	12	4(2+1)	--	c	+		
	<i>S. rivuli</i> *	g	1.7	+	+	--	+	+	--	4	2, 2	--	c	+		
<i>Simulium</i> (<i>Boreosimulium</i>) <i>Simulium</i> (<i>Eusimulium</i>)	<i>S. emarginatum</i>	h	1.5	+	+	+	+	+	+	4	2, 2	--	c	--		
	<i>S. bracteatum</i>	i	1.9	+	+	+	+	+	--	4	M	--	c	--		

<i>Simulium</i> (<i>Nevermannia</i>) vernum species group	<i>S. pilosum</i> *	i/h	1.9	+	+	+	+	+	+	+	+	+	+	4	M	---	c	+
	<i>S. craigi</i> *	g	1.3	+	+	+	+	+	+	+	+	+	+	4	2, 2	---	c	+
	<i>S. croxtoni</i>	g	0.8	+	+	+	+	+	+	+	+	+	+	8	2, 2, 1, 1+2	---	c	+
	<i>S. flonae</i>	j	0.8	+	+	+	+	+	+	+	+	+	+	8	M	---	c	+
	<i>S. gouldingi</i>	j	1.1	+	+	+	+	+	+	+	+	+	+	6	2, 2, 2	---	c	+
	<i>S. impar</i>	g	1.2	+	+	+	+	+	+	+	+	+	+	4	2, 2	---	c	---
	<i>S. loerchae</i> *	k	1.0	+	+	+	+	+	+	+	+	+	+	4	2, 2	---	c	+
	<i>S. quebecense</i>	g	0.8	+	+	+	+	+	+	+	+	+	+	4	2, 2	---	c	---
	<i>S. silvestre</i>	j	0.9	+	+	+	+	+	+	+	+	+	+	4	2, 2	---	c	+
	<i>Simulium</i> (<i>Schoenbaueria</i>)	<i>S. fuculatum</i> *	j	0.7	+	+	+	+	+	+	+	+	+	+	8	M	---	c
<i>Simulium</i> (<i>Psilozia</i>)	<i>S. tribulatum</i>	g	1.2	+	+	+	+	+	+	+	+	+	+	14-16	M	---	c	---
	<i>S. vittatum</i> s.s.*	g	1.2	+	+	+	+	+	+	+	+	+	+	14-16	M	---	c	---
<i>Simulium</i> (<i>Hemicnetha</i>) <i>Simulium</i> (<i>Simulium</i>) <i>Simulium</i> (<i>Simulium</i>) <i>jenningsi</i> species group	<i>S. innoxium</i> *	k	0.8	+	+	+	+	+	+	+	+	+	+	9	M	---	d	---
	<i>S. anchistinum</i>	l	0.3	+	+	+	+	+	+	+	+	+	+	10	2, 2, 2(1+2)	+	c	---
	<i>S. chlorum</i> *	l	0.3	+	+	+	+	+	+	+	+	+	+	8	M	+	c	---
	<i>S. definitum</i>	l	0.3	+	+	+	+	+	+	+	+	+	+	8-9	M	+	c	---
	<i>S. fibriniflatum</i>	l	0.3	+	+	+	+	+	+	+	+	+	+	6	2, 2, 2	+	c	---
	<i>S. jenningsi</i>	l	0.3	+	+	+	+	+	+	+	+	+	+	10	2, 2, 2(2+1)	+	c	---
	<i>S. jonesi</i> *	l	0.3	+	+	+	+	+	+	+	+	+	+	10	M	+	c	---
	<i>S. lakei</i>	l	0.3	+	+	+	+	+	+	+	+	+	+	8-10	M	+	c	---
	<i>S. luggeri</i>	l	0.3	+	+	+	+	+	+	+	+	+	+	12	M	+	c	---
	<i>S. notale</i>	l	0.3	+	+	+	+	+	+	+	+	+	+	6	2, 2, 2	+	c	---
	<i>S. nyssa</i> *	l	0.3	+	+	+	+	+	+	+	+	+	+	10	2, 2, 2(1+2)	+	c	---
	<i>S. podostemi</i> *	l	0.1	+	+	+	+	+	+	+	+	+	+	8	2, 2, 2, 2	+	c	---
<i>Simulium</i> (<i>S.</i>) <i>machyschevi</i> s.g.	<i>S. nurmanum</i> *	m	0.1	+	+	+	+	+	+	+	+	+	+	10	M	+	d	---
<i>Simulium</i> (<i>S.</i>) <i>noelleri</i> s.g.	<i>S. decorum</i>	m	0.4	+	+	+	+	+	+	+	+	+	+	8	M	---	c	---
<i>Simulium</i> (<i>S.</i>) <i>parnassum</i> s.g. <i>Simulium</i> (<i>S.</i>) <i>slossonae</i> s.g. <i>Simulium</i> (<i>Simulium</i>) <i>tuberosum</i> species group	<i>S. parnassum</i>	k	1.0	+	+	+	+	+	+	+	+	+	+	6	2, 2, 2	---	c	+
	<i>S. slossonae</i> *	l	0.1	+	+	+	+	+	+	+	+	+	+	6	2, 2, 2	---	c	+
	<i>S. appalachense</i>	m	0.4	+	+	+	+	+	+	+	+	+	+	6	2, 2, 2	---	c	---
	<i>S. conundrum</i> *	m	0.4	+	+	+	+	+	+	+	+	+	+	6	2, 2, 2	---	c	---
	<i>S. perissum</i>	m	0.4	+	+	+	+	+	+	+	+	+	+	6	2, 2, 2	---	c	---
	<i>S. tuberosum</i>	m	0.4	+	+	+	+	+	+	+	+	+	+	6	2, 2, 2	---	c	---
	<i>S. ubiquitum</i>	m	0.4	+	+	+	+	+	+	+	+	+	+	6	2, 2, 2	---	c	---
	<i>S. vandaliacum</i>	m	0.4	+	+	+	+	+	+	+	+	+	+	6	2, 2, 2	---	c	---
<i>Simulium</i> (<i>Simulium</i>) <i>venustum</i> species group	<i>S. hematophilum</i> *	m	0.4	+	+	+	+	+	+	+	+	+	+	6	2, 2, 2	---	c	---
<i>S. venustum</i>	m	0.4	+	+	+	+	+	+	+	+	+	+	6	2, 2, 2	---	c	---	
<i>S. verecundum</i>	m	0.4	+	+	+	+	+	+	+	+	+	+	6	2, 2, 2	---	c	---	