

## SEVEN NEW SOUTHERN SPECIES OF THE MAYFLY GENUS HEXAGENIA, WITH NOTES ON THE GENUS.\*

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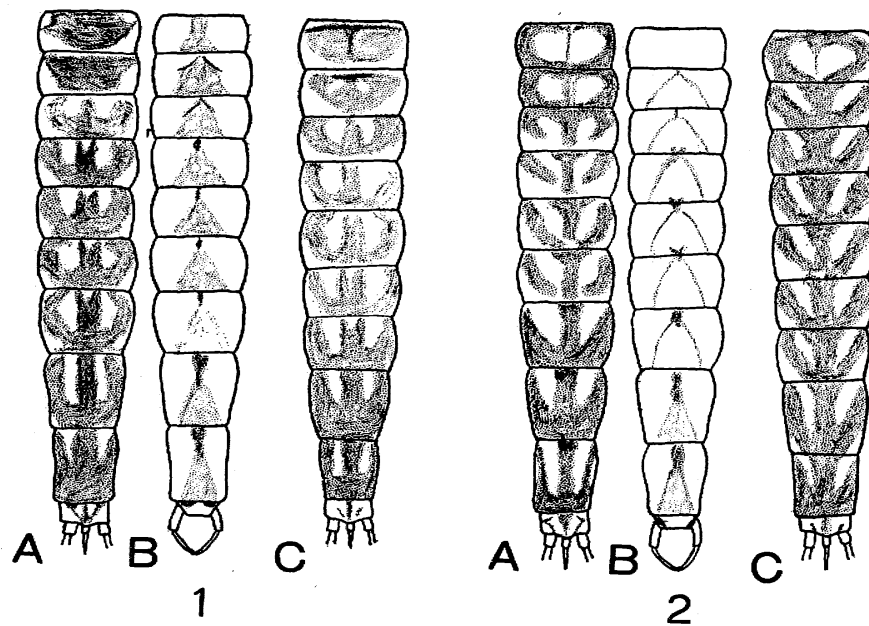
From material in the collection at Cornell University, and from other material collected by Prof. J. G. Needham from West Virginia, and by Miss L. E. Brett and the author from North Carolina, seven new southern species of the genus *Hexagenia* are herein described. An attempt has been made to formulate keys to the known species of *Hexagenia* in the United States and Canada, for both males and females (in so far as the latter are known). Likewise a tabulation of some of the characters of the males of each species has been prepared, in the hope that this table may supplement the key, and aid in identification. Color patterns of both males and females of the new species are given, to supplement those of several previously described species published by other authors. Notes on several species of *Hexagenia* nymphs are likewise presented.

In descriptions of the wings of the various species, the term "costal margin" is used to include both the costal and subcostal cells. Where reference is made to dark spots in the wing, such spots are formed, as in the species *H. bilineata*, by some of the cross veins being margined or bordered on each side with black or very dark purple.

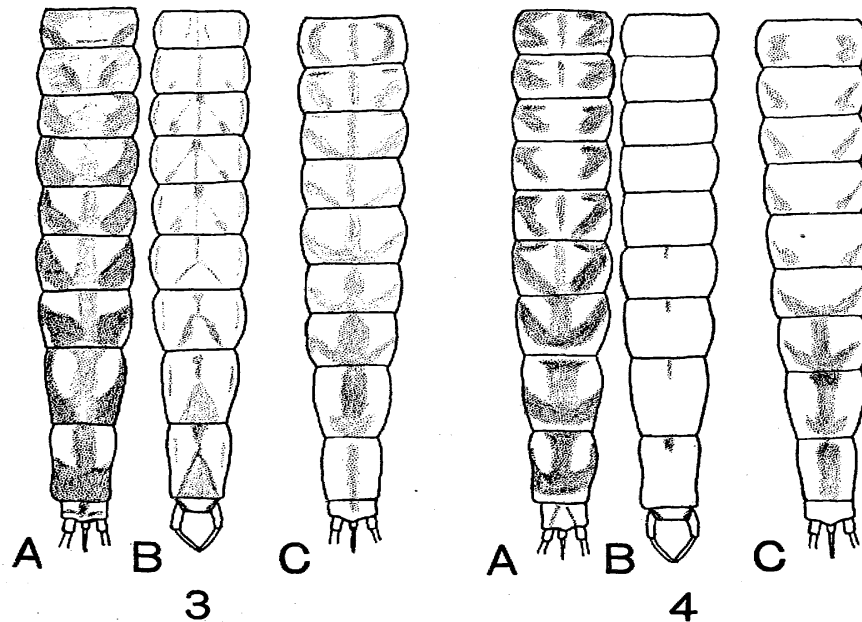
### COLOR PATTERNS.

Typical color patterns of the abdomens of the males of several species of the genus *Hexagenia* have been figured by previous writers. Thus Ulmer, 1921, (p. 237, Figs. 6 and 7) has figured *H. bilineata* and *H. limbata*; and McDunnough, 1927, (p. 117, Fig. 1) has shown *H. bilineata*, *H. atrocaudata*, *H. rigida*, *H. affiliata*, and *H. viridescens*. In the present article are given typical patterns for the seven new species herein described. The first figure of each group represents the dorsal aspect of the male abdomen; the second, the ventral aspect of the same; the third (not known for *H. rosacea*) shows the dorsal aspect of the abdomen of the female. (See text Figures 1-7.)

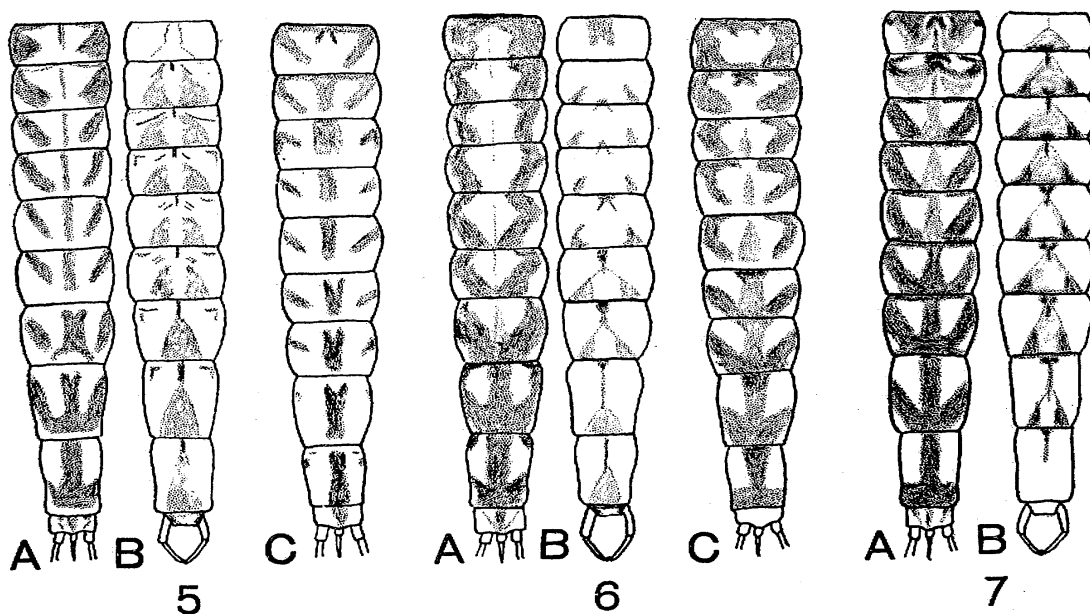
\*Contributions from the Limnological Laboratory of Cornell University.



1. *Hexagenia mingo*. A and B, dorsal and ventral abdominal markings of male; C, dorsal of female.
2. *Hexagenia orlando*. A and B, dorsal and ventral abdominal markings of male; C, dorsal of female.



3. *Hexagenia elegans*. A and B, dorsal and ventral abdominal markings of male; C, dorsal of female.
4. *Hexagenia carolina*. A and B, dorsal and ventral abdominal markings of male; C, dorsal of female.



5. *Hexagenia weewa*. A and B, dorsal and ventral abdominal markings of male; C, dorsal of female.
6. *Hexagenia marilandica*. A and B, dorsal and ventral abdominal markings of male; C, dorsal of female.
7. *Hexagenia rosacea*. A and B, dorsal and ventral abdominal markings of male.

#### TYPES OF GENITALIA.

In the tabulation of characters of *Hexagenia* males, it will be noted that the types of genitalia are indicated by Roman numerals I to VI, inclusive. These are listed in the order in which they have been described and figured. A brief résumé of these types follows.

I. *Limbata* type. First figured by Eaton, 1883-88 (Pl. VII, Fig. 11c); next by Needham, 1920, (Pl. LXXXI, Fig. 63), under the name *bilineata*, form *variabilis*; and most recently by Ulmer, 1921 (p. 236, Fig. 4). The penes are hook-like and bent forwards, in characteristic position approaching or even overlapping one another at the tips. Ulmer indicates (p. 238) that the end-joints of the forceps limbs in this form are broad. This statement does not hold good, however, for all the species examined by the writer which have the *limbata* type of genitalia. Thus, *H. venusta* has typical *limbata* type penes, but the end-joints of the forceps limbs are as slender as in typical *H. bilineata*. This type of genitalia is found in a number of species, (Fig. 19).

II. *Bilineata* type. Figured by Needham, 1920 (Pl. LXXXI, Fig. 62) as *bilineata*, form *falcata*; and by Ulmer, 1921 (p. 236, Fig. 5). In this form the penes are elongated at the tip into bill-like structures which often overlap, as the penes characteristically approach and touch one another. This form of genitalia seems confined to the one

species *H. bilineata* Say. The end-joints of the forceps limbs, as indicated by Ulmer, are characteristically thin and slender, (Fig. 14).

III. *Recurvata* type. Figured by Morgan, 1913 (p. 395, Fig. 3). The penes are recurved at the tip, and do not approach one another. The first joint of the forceps limb is remarkably short and stout, the second unusually long, the two end joints rather short and stout. This type seems confined to the single species *H. recurvata* Morgan, (Fig. 18).

IV. *Rigida* type. First figured by Eaton, 1883-88, (Pl. VII, Fig. 11b 2) as *bilineata*; by Needham, 1920 (Pl. LXXXI, Figs. 61 and 65) as *bilineata* and *falcata*; later figured and named by McDunnough, 1924 (Pl. I, Fig. 3). The penes here are long and straight, not approaching one another. The forceps limbs are stout, as are also the end-joints. This type may be confined to the species *H. rigida* McD., although several specimens in the Cornell University collection, which do not exhibit characteristic markings of this species, do possess the *rigida* type of genitalia. (Fig. 16).

V. *Atrocaudata* type. Figured by Needham, 1920 (Pl. LXXXI, Fig. 64) as *bilineata*, form *munda*; and figured and named by McDunnough, 1924 (Pl. I, Fig. 2). The penes are short and broad, bluntly pointed, and do not approach one another closely. The forceps limbs are quite thick-set; the end-joints, especially the third joint (first of the end-joints) are unusually long and stout. This type seems confined to the single species *H. atrocaudata* McD. (Fig. 12).

VI. *Carolina* type. This type somewhat resembles the *limbata* type. In a few cases the two seem to intergrade, so that it is difficult, as in the case of the new species *H. marilandica*, to state which type is present. In the typical form, however, as shown well by the other new species here described, the penes are but slightly bent, not showing the characteristic hook of *limbata*, and either stand erect, bend slightly outward, or rarely approach one another slightly. The tips always bend inward, not outward. The forceps limbs may be stout, with very long second joint, and the third joint also unusually long and stout, as in *H. weewa*, and to a lesser degree in *H. carolina*. Or they may be more slender, and the end-joints be unusually short, as in *H. elegans*. Several of the southern species show this type of genitalia. (Figs. 10, 11, 13, 17, 20, 22).

#### **Hexagenia elegans, n. sp.**

A very small species, Hind wings of male bordered with purplish brown, markings of abdomen predominantly purplish red.

#### MEASUREMENTS.

	Body	Tails	Foreleg	Fore-wing
Male subimago..... (3 specimens)	13½-15	14-17	5	11-12
Female subimago..... (2 specimens)	16 -17	12-12½	5-6	12-14
Male imago..... (20 specimens)	12 -17	30-38	8-10	10½-12
Female imago..... (20 specimens)	14 -19	18-27	5-7	12-18

## MALE IMAGO.

*Head:* Upper portion of compound eye golden tan. Vertex cream-colored, occiput flesh-colored. Ocelli ringed at base with black, above this with purplish rose. Dorsal aspect of frontal carina purplish. Second antennal joint and base of filament light rose. Diameter of eye is to space between the eyes approximately as 1:1.

*Thorax:* Prothorax flesh-colored, with two longitudinal dorsal mahogany-red stripes. Meso- and metanotum and portion of pleurum of metathorax creamy white. Mesopleurum light red-brown. Prosternum white with dark purple spot posteriorly. Anterior of mesosternum and all of metasternum dark mahogany-red. Posterior of mesosternum lighter shade of same.

*Legs:* Femur and tibia of foreleg dark rose-red; tarsus purplish-brown except proximal half of second, third and fourth joints, which are white. Other legs white. Claws, distal joint of tarsus except at base, distal border at fourth tarsal joint, and faint border at other tarsal joinings, purplish brown.

*Wings:* Very iridescent. Fore wing with dark brown costal border, to vein R. Outer margin of hind wing purplish-brown. Main longitudinal veins of fore wing, of costal area of hind wing, and cross veins of both wings, purplish black. In both wings, prominent purplish-black spots.

*Abdomen:* Ground color white, faintly flushed with pink ventrally on segments 1-6; definitely yellowish on 7-10. Dorsal markings consist of reddish-brown longitudinal median stripe on 7-10, continued forward as a faint grey line on 1-6, very narrow on 1-3. On each side of tergites 1-9, a rose-brown oblique mark, its base on or near the posterior margin, extends laterally to the pleural fold. On tergites 1-4 it has the shape of a parallelogram, on 5-9 wedge-shaped. This mark varies in color on different specimens from rose or red-brown to greyed lavender. Tergite 10 with brown oblique lateral marks. Sternite 9 with a rose-colored triangle, its base on the posterior margin, its apex not attaining the anterior margin. Other sternites with rose lateral stripes from posterior border half-way to pleural fold, extending obliquely forward toward mid-ventral line. In light-colored specimens these stripes do not attain the median line; in darker specimens, they reach it near the anterior border.

*Genitalia:* Very slender, of the *carolina* type. Basal joint of forceps limb, distal one-third on the second joint, and its ventral ridge, purplish brown (in light specimens, grey). The two short distal joints, which are remarkably small, light brown to yellowish. Forceps base purplish brown, a rose spot on each side. Penes with ventral purplish brown stripe. (Fig. 11).

*Tails:* Distal portion of each joint dark brown, with darker ring at joining. Proximal portion of each greyish white. In some joints the dark brown occupies all but a narrow white proximal ring.

## FEMALE IMAGO.

Entire body creamy white. Ocelli ringed with black, rose spot on each side at base. Grey-purple stripe on pronotum, becoming golden yellow on mesonotum. Yellowish brown oblique mark along main lateral suture of mesopleurum, to base of middle leg.

*Legs:* Foreleg with rose band at base of femur and near distal end of tibia. Claws, distal two-thirds of last tarsal joint, and all joinings except base of femur, purple-brown. Other legs with claws and last tarsal joints similar, but no color at joinings save those of the third and fourth tarsal segments.

*Wings* tinged with greenish yellow; longitudinal veins yellow, cross veins purple black. Neither wing with brown or purple margin.

*Abdomen:* Dorsally with longitudinal dark-grey median stripe, as in male. Tergites 1 and 2, in some specimens, with large central grey-black patch; 1 margined posteriorly with black. Grey-brown arms extend forward for a short distance from each side of median brown band, at posterior margin.

*Tails:* Yellowish white, ringed indistinctly with grey at joinings. In proximal portion, every third or fourth joining with blackish-purple ring.

*Holotype:* ♂, imago. Taken from the Chowan River, near Winton, Hertford Co., N. C. by Miss L. E. Brett. Second week of August, 1930. No. 917.1 in C. U. collection.

*Allotype:* ♀, imago. Same. No. 917.2 in C. U. collection.

*Paratypes:* 12 ♂s and 8 ♀s, all imagos. Same place and collector. Second and third weeks of August, 1930. No. 917.3-.22, in C. U. collection.

Miss L. E. Brett gives the following account of the collecting of *Hexagenia elegans*.

"These *Hexagenias* were captured in northeastern North Carolina at Tuscarora Beach, on the Chowan River, about three miles east of the little town of Winton and eight miles from the point where the Meherrin and the Nottaway Rivers unite to form the Chowan. This location is approximately seventy miles from the sea.

At the point where the *Hexagenias* were caught the river is something like 35 to 40 feet deep and 500 feet or more in width. On the west bank is a wide sandy beach and on the east a swamp extending a mile out from the river.

The *Hexagenias* were seen in great numbers between eight and ten o'clock in the evening during the latter part of July and most of August. The writer first saw them sitting on the electric light wires over the bathing beach. Upon investigation they were discovered on the window of the merry-go-round ticket office and even swarming on the canvas at the top of the merry-go-round, which was some 150 yards from the water. They took possession of the dance pavilion and became a nuisance at the soda shop. Some were even found

sitting on passersby at the beach. They literally took the place 'by storm.' The adults were seen as early as 7:30 o'clock dipping in the shallow waters.

When this discovery was made, cages were secured and the mayflies were picked by hand from every object in sight, put in the cages and left to finish transformation. Many of them did transform, while others died in the process. Then a search for the nymphs was made. But though the sandy silt was dug up out as far as a person could wade, no trace of a single nymph could be found."

### *Hexagenia mingo*, n. sp.

A medium-sized species. Hind wing of male with or without purplish outer margin. Dorsal aspect of abdomen with reddish brown markings.

#### MEASUREMENTS.

	<i>Body</i>	<i>Tails</i>	<i>Foreleg</i>	<i>Fore-wing</i>
Male subimago..... (1 specimen)	17½	19	5	15
Female subimago..... (1 specimen)	25	?	6	20
Male imago..... (2 specimens)	17½	32-36	12	14½
Female imago..... (1 specimen)	23	29	9	21

#### MALE IMAGO.

*Head:* Light tan. Vertex with cream yellow markings. Black ring at base of ocelli, and space between them black. Dorsal aspect of median carina dark grey. Occiput with purplish red marks. Upper part of compound eye cream to light tan. Second antennal joint and filament brown. Compound eye is to space between eyes approximately as 1: 0.75.

*Thorax:* Pronotum light tan, with rather wide dark reddish brown stripes, extending to wing bases. Mesonotum light tan with dark brown markings. Anterior of mesopleurum and metanotum light brown. Other pleura cream-white. Anterior third of prosternum cream-white, other parts very dark reddish brown. Mesosternum light red brown in center, bordered by dark brown. Metasternum dark brown.

*Legs:* Coxa and trochanter of foreleg brown. Femur and tibia mahogany red-brown, darker at joinings. Tarsus dull yellowish brown, darker at joinings and with darker streaks. Other legs canary yellow. Claws, fifth tarsal joint and joinings of all but first tarsal joint purplish brown.

*Wings:* Costal margin of fore wing reddish brown except at apex and next to vein C in basal portion, which regions are light tan. Longitudinal and cross veins of both wings dark purplish. Several cross veins in each wing margined with purple. Hind wing with definite purplish-brown outer margin in some specimens, but lacking in others.

*Abdomen:* Cream white or faintly pinkish ground color, yellow on 8-10. Rather wide median longitudinal stripe on dorsum, dark reddish brown; wider at posterior margin of each tergite. On 3-9, wide reddish brown bands arise from median stripe at posterior margin, extend outward to pleural fold just below the anterior margin, then upward and inward to meet the anterior margin a short distance from median stripe. Each side of each tergite is thus largely reddish brown, the ground color showing slightly at anterior lateral angle, in a large triangle at posterior lateral angle, and a triangular to round spot on each side of center, enclosed except anteriorly near median line. Tergite 10 yellow with greyish brown stripe, and two lateral stripes ending in dark spots near anterior lateral angle. Ventrally, light reddish brown triangles, their bases on the posterior margin, extend forward to the anterior margin on sternites 1-8. Wider basally on 1-6, narrow on 7 and 8. Each triangle becomes darker in color over ganglionic area, and on posterior sternites a dark mark extends on median line almost the length of the segment. In center of each sternite near median line, a clear round spot. Sternites 9 and 10 yellow, with reddish median line, no lateral marks.

*Tails:* Rudimentary median tail with dark band at each joining, dorsally. Joints of outer tails light yellow-brown in basal half, darker brown distally, joinings still darker. Near distal end of seta, joints brown except for yellow proximal ring.

*Genitalia:* Almost intermediate between *carolina* and *limbata* types, but considered here as of the *limbata* type. Forceps base yellow with two purplish brown spots at anterior margin, opposite forceps limbs. Forceps limbs yellow; basal joint streaked ventrally with purplish brown. Distal end of second joint and the short end joints same color. Penes with purplish brown streak on distal half, ventrally. (Fig. 21).

#### FEMALE IMAGO.

General color of body creamy yellow. *Head* bright sulphur yellow. Vertex cream-colored with two broad purplish-black oblique lateral bands from posterior outer margin toward center. Median carina, bases of ocelli and space between them, black. Antenna as in male.

*Thorax:* Pronotum greyish white with purplish grey longitudinal stripes. Mesonotum cream, with faint greyish marks near center, a purplish brown median mark on posterior half, its posterior extension same color. Metanotum cream with purplish markings. Pleura cream marked with light brown. Thoracic sternites cream; posterior of prosternum, anterior of mesosternum, and coxæ of middle legs marked with purplish brown.

*Legs:* Creamy white. On foreleg trochanter and dorsal aspect of femur streaked with rose. Joinings of femur, tibia and tarsus, as well as claw and most of fifth tarsal joint, dark purplish. Lavender mark near distal end of tibia. On other legs, claw and fifth tarsal joint, likewise joinings of last three tarsal joints, greyed lavender.

*Wings:* Costal border of fore wing yellowish. Vein C amber; other longitudinal veins in upper part of fore wing purplish brown. Cross veins purple-black.



*Abdomen:* Color pattern arranged very much as in male, but the anterior extensions of the lateral bands not approaching the median line. Thus a greater amount of ground color is visible between these lateral arms and the median longitudinal stripe. Median stripe dark greyish brown; on tergites 3-7, bifid anteriorly. Lateral marks same general color. Eggs within body give pink tinge to all anterior segments, before their deposition. Tergite 10 yellow. Ventrally, ganglionic areas white. A short purplish streak on median line at anterior of sternite 9 and indistinct purplish lateral marks on 10. Sternites 9 and 10 definitely yellow. No other ventral marks.

*Tails:* Creamy white, purplish black at joinings.

*Holotype:* ♂. Reared from nymph taken at Millwood, W. Va., by Prof. J. G. Needham. June 25, 1930. No. 920.1 in Cornell Univ. collection.

*Allotype:* ♀. Same as above. No. 920.2, in Cornell University collection.

*Paratypes:* ♂ imago, and ♂ and ♀ subimagoes. Same. No. 920.3-7, in Cornell collection.

#### *Hexagenia marilandica*, n. sp.

A rather large species, superficially similar to *H. rosacea*, but anterior abdominal tergites lacking median stripe. Second tarsal joint of foreleg of male proportionately longer, and compound eye somewhat smaller.

#### MEASUREMENTS.

	<i>Body</i>	<i>Tails</i>	<i>Foreleg</i>	<i>Fore-wing</i>
Male imago..... (1 specimen)	18	48	12	16
Female imago..... (1 specimen)	27	36	8	25

#### MALE IMAGO.

*Head:* Greyish white. Vertex cream-colored. Upper half of compound eyes slate grey. Ocelli with broad black basal ring, above this a narrower lavender ring. Dorsal aspect of median carina purplish black. Second antennal joint purplish, filament light brown. Compound eye is to space between eyes approximately as 1:1.

*Thorax:* Pronotum with yellowish tinge, the purplish brown longitudinal stripes rather broad and extending to wing base. Mesonotum and pleura creamy white, the former bordered and the latter marked with light brown. Metanotum creamy yellow with lavender markings. Prosternum white, two purple streaks between the legs: Mesosternum dark purplish rose anteriorly, its posterior portion light tan with lavender to rose marks on each side. Metasternum white, bordered laterally and posteriorly with purplish. Antecoxal pieces light tan flushed with rose.

*Legs:* Coxa and trochanter of foreleg purplish. Femur and tibia rose-red, darker at joinings. First tarsal joint, distal one-third of second to fourth joints, and all of the fifth joint with claws, purplish brown. Other legs creamy white. Coxa of second leg purplish red anteriorly. Claws, distal two-thirds of fifth tarsal joint, and joining of fourth and fifth, purplish brown.

*Wings:* Costal border of fore wing brown, darker in distal half but lighter again at apex. Longitudinal veins of fore wing brownish rose, cross veins purplish black in both wings. Several cross veins in each wing bordered with purplish black. No dark outer border on hind wing.

*Abdomen:* Ground color creamy white, flushed faintly with pink on dorsum; yellowish on 8-10. Greyish rose median longitudinal stripe on 6-10; indicated only as very faint grey line on 1-6. Tergite 1 purplish brown next to pleural fold and on anterior margin. Lateral oblique bands on 2-7 running from broad base on posterior margin on each side, laterally to pleural fold near anterior lateral angle. An upward and inward extension of each seems to join the base of the similar mark in the tergite directly anterior. Thus a zigzag pattern is formed along each side. On tergite 8 the lateral stripe is broader at base, more definitely rose-colored, and does not so clearly join the stripe of the anterior tergite. Tergite 9, this band is merely an extension laterally from the posterior border of the median stripe, and does not reach to the middle of the pleural fold. A small rose spot in anterior lateral angle. Tergite 10 yellow, a faint rose median stripe and two definite oblique lateral brown ones. Ventrally, the ganglionic area on each sternite indicated by a purplish mark, which on 7-9 extends more than half the length of the segment. On sternites 2-6, an oblique grey-rose mark arises from posterior border between median line and pleural fold, and extends forwards and inwards to about the middle of each side of each sternite. On 7-9, these marks are broader posteriorly and reach median line near center of sternite.

*Tails:* Near base, proximal half of each joint yellow, distal half dark reddish brown. In remainder of tail, each joint dark reddish brown, darker distally, except for yellow proximal ring.

*Genitalia:* Of the *carolina* type. Forceps base amber; penes and forceps same color. Basal and second joint of forceps limbs purplish brown. Penes with dark purplish brown longitudinal stripe. (Fig. 22).

#### FEMALE IMAGO.

*Head:* Creamy white. Median carina in dorsal aspect black distally, two dark streaks on each side near base. Ocelli ringed with black at base. Filament of antenna amber.

*Thorax:* Pronotum greyish white with broad purplish brown longitudinal stripes. Meso- and metanotum light tan with brown and amber markings. Pleura creamy white, with wide lateral suture to base of middle legs brown and amber; other sutures brown. Pro- and metasternum creamy white. Mesonotum yellowish tan with brown borders. Antecoxal pieces brownish lavender.

*Legs:* Foreleg, femur and tibia amber brown, greyish at joinings. Tarsus greyish yellow; fifth tarsal joint, claws and joinings greyed lavender. Other legs yellowish white. Claws, all but base of fifth tarsal joint, and narrow line at tarsal joinings, light greyed lavender.

*Wings:* Costal border of fore wing greyish yellow. Longitudinal veins in upper part of fore wing, and vein Sc of hind wing amber to light brown. Other longitudinal veins greyish. Cross veins of both wings purplish black.

*Abdomen:* Pale yellow dorsally, creamy white ventrally. Tergites 1 and 2 purplish grey on each side and on anterior border. Also with two short oblique grey bars from middle anterior border extending laterally from grey median line. Posterior lateral angle of 2 creamy white. 3-6 with grey triangle on median line, wider posteriorly. On 7-9, this median stripe is brownish grey, widened both posteriorly and anteriorly, darker at anterior border. Lateral oblique purple-brown marks on tergites 3-6 arising near anterior lateral angle, with wide arm extending downwards and inwards almost to posterior border at median line. Narrower arm extends parallel to anterior border, almost to median line. On 7-9 this mark arises from posterior border as wide extension of median line, and runs laterally almost to pleural fold, not extending above center of tergite. On these tergites also the marks become darker. Tergite 10 with narrow median stripe. Ventrally, a purplish black streak usually appears at each ganglionic area. No other ventral markings.

*Tails:* Yellowish, ringed with purplish black at each joining.

*Holotype:* ♂, imago. Taken at Conococheague Park, Washington Co., Md., June 3, 1925. Collected by Mr. Virgil Argo. No. 921.1, in C. U. collection.

*Allotype:* ♀, imago. Same. No. 921.2, in C. U. collection.

*Paratype:* ♀, imago. Same. This specimen lacks the purplish mark on ganglionic area, but otherwise corresponds with the female allotype. No. 921.3, in C. U. collection.

#### *Hexagenia carolina*, n. sp.

A large species, predominantly yellowish white, male with greyed rose to lavender markings. No dark outer border on hind wing.

#### MEASUREMENTS.

	<i>Body</i>	<i>Tails</i>	<i>Foreleg</i>	<i>Fore-wing</i>
Male subimago..... (2 specimens)	20-24	21-27	7-8	15-16
Female subimago..... (5 specimens)	27-35	18-32	8-9	22-25
Male imago..... (5 specimens)	20½-24	41-43	9-12	14½-17
Female imago..... (14 specimens)	25-32	35-45	10½-12	23-27

## MALE IMAGO.

*Head:* Creamy white. Upper part of compound eye golden brown. Cream-yellow markings on vertex. Ocelli with black ring at base; one purplish spot near base of compound eye, another near median carina. Dorsal aspect of median carina purplish. Compound eye is to intervening space between eyes approximately as 1:1.

*Thorax:* Pronotum creamy white, with two longitudinal purplish streaks. Meso- and metanotum yellowish with light brown markings. Brown lateral streak on mesopleurum, to base of middle leg. Ventrally, coxæ of middle legs and median anterior portion of mesosternum purplish, remainder creamy white.

*Legs:* Femur of foreleg light rose, tibia deep rose. Short first joint of tarsus purple; second, third and fourth tarsal joints creamy white, purplish at joinings. Fifth joint purple-brown except at base, claws same color. Other legs creamy white. Narrow purple line at joinings of tarsal joints; claws and distal half of fifth tarsal joint purplish brown.

*Wings:* Fore wing yellowish brown on costal border, to R. Veins C, Sc, and R golden brown, other longitudinal veins and cross veins purplish brown, except in anal region. In hind wing, Sc and R purplish brown, other longitudinal veins yellowish white; cross veins purplish black. Outer margin not darker than rest of wing membrane; no conspicuous dark spots.

*Abdomen:* Creamy white background, segments 1-7; 8 faintly, 9 and 10 definitely yellow. Posterior border of each tergite creamy white. Tergites 1-6 with faint grey median streak; 7-10 with rather broad greyed lavender median streak. Oblique lateral grey-rose mark on each side of each tergite from near posterior border medially to anterior lateral angle. On 1, this is more brownish and occupies most of each side of the tergite, with extensions along the anterior border to median line. On 2-6, extensions to median line as in 1, but narrower; 6, lateral marks joined posteriorly. 7-9, marks arise as arms from broad median stripe, on 8 and 9 not reaching anterior margin. 10 with faint purple-brown lateral line. Ganglionic area on sternite 6-10 purplish brown; on 1-5 indicated only by a white circle. Faint indication of yellow median streak on 8 and 9, and of yellowish triangle on 7, its base on posterior border. No other ventral markings.

*Tails:* Joints reddish brown, darker distally, very dark at joinings. Proximal end of each creamy white to light tan. Extreme distal end of tails creamy white.

*Genitalia:* Of the *carolina* type. Basal joint of forceps limb equal to one-half of second joint. Second joint swollen distally; the two short end joints of medium size. Purplish black line on basal joint on outer side at base, and on inner side distally. Tip of second joint purplish, two distal joints brown. Penes with purple lateral stripe on outer margin. (Fig. 20).

## FEMALE IMAGO.

*Head:* Yellowish—in life, sulphur-yellow. Markings as in male; second antennal joint brown.

*Thorax:* Pronotum greenish yellow with indistinct brown longitudinal stripes. Mesonotum flesh-colored, bordered by light brown. At base of wing in living specimen, two triangular olive patches. Metanotum yellow. Pleura and sternites flesh-colored, sutures yellow. In some specimens, mesosternum also yellow.

*Legs:* Yellow. On foreleg trochanter, spot on outer femur near distal end, and distal end of tibia, purplish rose. All joinings, claws and distal two-thirds of fifth tarsal joint purplish brown. Other legs with but indistinct lines of color at joinings, claws yellowish basally and dark grey distally; last tarsal joint as in foreleg.

*Wings:* Amber or yellow tinted throughout. Main longitudinal veins yellow to whitish, cross veins rose to purple.

*Abdomen:* Pale yellow when eggs have been deposited, flesh-colored to salmon-pink before this. Prominent median stripe on tergites 7–10 as in male, its narrow extension forward to tergite 1, yellow. In life, this median line on 8 is bordered with greenish, and posteriorly with sulphur-yellow spots near pleural folds. No green on 9, but more yellow. Markings of tergites very similar in position to those of male, but narrower and less extensive, in color dull lavender. Ventrally, ganglionic areas as in male, but purplish streaks on 6–10 very narrow or lacking. Sternites 8–10 sulphur-yellow.

*Tails:* Yellowish white, very indistinctly more grey at joinings.

*Holotype:* ♂, imago. Taken at Hamburg Lake, on Brush Creek, 10 miles north of Greensboro, N. C., June 6, 1929. No. 916.1, in C. U. collection.

*Allotype:* ♀, imago. Same place, same time. No. 916.2, in C. U. collection.

*Paratypes:* 1 ♂, 4 ♀s, imagoes; 1 ♂, 3 ♀s, subimagoes. Same place, same time. No. 916.3–.11, in C. U. collection.

*Hexagenia carolina* was first captured at Hamburg Lake, a small artificial lake owned by a local angling club. Shortly after 8 P. M., on June 1, as we were driving along the highway between Greensboro and Summerfield, a considerable number of large yellowish female *Hexagenias* appeared, flying toward the headlights. On parking the car, it was discovered that no collecting net had been put in, but the big mayflies were flying so slowly and so close to the road that it was possible to capture many of them by hand, literally picking them out of the air as they passed. Many fell to the road and were crushed by passing autos. They were most numerous near the bridge

over the outlet of the lake. All taken that evening were subimago females.

Three days of cool weather were followed on June 6 by a warmer evening, and we returned to the lake, arriving in time to see many of the *Hexagenias* emerging from their nymphal skins at the surface of the water. They rose quite high almost at once, flying straight toward the tree tops. They could be taken only with the net, and the majority escaped it. When the lights of the car were turned on, two subimago males were taken, along with several more females. Another trip to the lake on June 7 yielded many more females and several males. On this evening also, we were able, by the use of a flashlight, to collect great numbers of nymphal skins, as they floated downstream toward the overflow on one side of the dam.

Many subimagoes of both sexes were kept until they attained the imago state. One male required 22 to 23 hours to complete its transformation, another male 23 to 24 hours. Three females varied from  $22\frac{1}{2}$  to  $26\frac{1}{2}$  in their subimaginal state.

Nymphs which seem to correspond identically with the nymph skins taken at Hamburg Lake were found in the mud along one bank of the South Toe River, near Micaville, N. C., on July 3, 1930. None of these transformed.

*Hexagenia carolina* (?) On the morning of June 27, 1929, a fine male was found on the door screen of a house at Franklin, N. C., on a bluff just above the Little Tennessee River. On the evening of July 3, two female subimagoes were taken as they arose from the river, and many others were seen but could not be captured. These two females were kept until they transformed into imagoes.

The females seem very similar to those taken at Hamburg Lake, but the male exhibits certain differences from the males of *H. carolina* taken at that lake. It differs in these respects: tails 55 mm. in length, light reddish brown with wide dark brown markings at joinings; distal end of second joint of forceps not swollen, as in typical *H. carolina*; ganglionic markings extend anteriorly to segment 4, indistinctly to 2; upper part of eye slate grey instead of golden brown.

When more specimens can be obtained, it may be apparent that these taken at Franklin are a different species. Meantime I leave them tentatively under *H. carolina*.

**Hexagenia weewa, n. sp.**

A large species, the females bright canary yellow, the males marked with purplish brown. Hind wing of male with purplish outer border and with dark spots.

## MEASUREMENTS.

	Body	Tails	Foreleg	Fore-wing
Male imago..... (4 specimens)	22-24	55-67	17-19	17-19
Female imago..... (13 specimens)	24½-30	40-47	10-12½	24-28

## MALE IMAGO.

*Head:* Yellowish white. Upper half of compound eyes purplish grey. Ocelli ringed at base with greenish, above this with a wider band of amber brown. Dorsal aspect of median carina brownish at tip, black in center. Second antennal joint and proximal portion of filament amber brown. Compound eye is to space between eyes approximately as 1:0.75.

*Thorax:* Pronotum light tan, longitudinal stripes purplish brown, extensions to wing base brown. Mesonotum creamy white bordered with brown. Metanotum yellowish. Pleura of mesonotum brown, other pleura yellowish to brownish. Prosternum anteriorly creamy white, posterior half very dark purplish brown. Anterior portion of mesosternum and all of metasternum dark purplish brown. Posterior of mesosternum lighter shade of same color.

*Legs:* Ventral of coxa and all of trochanter, femur, tibia and first tarsal joint of foreleg mahogany brown. Proximal half of tarsal joints two to four yellow; distal half purplish brown. Fifth tarsal joint and basal half of claws dark purplish brown, claws distally dark grey. Other legs yellowish white, very faint purple line at tarsal joinings. Claws pearl-grey ventrally, brownish dorsally. Fifth tarsal joint purplish brown except at base.

*Wings:* Costal margin of fore wing, to R, reddish brown. C, Sc and R brown, other longitudinal veins of both wings purplish brown. Cross veins purplish black. Hind wing with purplish outer margin, and several purplish black spots in usual area.

*Abdomen:* Ground color white, sometimes faintly tinted with lavender; 8-10 faintly yellowish. Tergites with well-defined median longitudinal streak. Wide and dark purple on 7-9, somewhat narrower on 1-6 and 10. On 1-6 greyish purple, bifid anteriorly. Purplish brown oblique lateral marks arise from anterior lateral angles of tergites 1-7, extending backwards and upwards, but not reaching posterior border. On 1 and 2 these marks are triangular, with base on pleural margin, and narrow extensions along the anterior border to median line. On 3-7 the triangular appearance gradually gives way to an elongated streak with pointed free ends. On 8 and 9 these marks are outward extensions of the median longitudinal stripe, and do not attain the anterior margin. 10 yellowish, with oblique lateral brownish bars.

Ventrally, the ganglionic area in each sternite marked with purplish black. An irregular lavender-brown triangle on sternites 1-9, becoming narrower on 8 and 9. Its apical third lighter lavender, defined laterally by two brown streaks. In center of each sternite, on each side of median line, a small clear round spot. Sternites 1-5 and 8, with narrow purple posterior border.

*Tails:* Basal joints light brown, dark brown at joinings. In remainder of tail, joints dark reddish brown, slightly darker distally, each with a narrow yellow proximal ring.

*Genitalia:* Of *carolina* type. Forceps base purplish brown. Basal joint of forceps limb on ventral side streaked with purple. Distal end of second joint, and both end joints, greyed lavender. Penes greyish, with purplish brown ventral streak. Remarkable for the great relative length of the second joint of the forceps limb, which is three-fifths the length of the first. The end-joints, especially the third, are likewise unusually long and stout. (Fig. 17).

#### FEMALE IMAGO.

Entire body clear canary yellow. Ocelli as in male. Median carina black at base and near distal end. Purplish-brown spot between ocellus and compound eye.

*Thorax:* Faint purplish-grey streak on pronotum. Pleurum and sternum of mesothorax flushed with orange.

*Legs:* Light yellow, first pair with lavender marks on trochanter, streak near base of femur, and mark near base of tibia, almost encircling it. Joinings of tarsus, and all but base of fifth tarsal joint, also blunt claw, dark purplish-brown. Pointed claw amber with purple mark. Claws and fifth tarsal joint of other legs similar. Faint purple line at tarsal joinings, no other marks.

*Wings:* Tinted throughout with clear amber yellow. Longitudinal veins in upper half of fore wing canary yellow, all others white to yellowish. Majority of cross veins purplish black.

*Abdomen:* Tergites with median longitudinal stripe and lateral oblique marks, much as in male, but latter less intense in color. On 7, the lateral mark arises from purple streak near posterior border of tergite and extends forwards and outwards. All tergites bordered posteriorly with white along central portion. Purple spot on anterior part of pleural fold on sternite 9. Ventrally, purplish black median line marks each ganglionic area.

*Tails:* Yellowish white, each joining with white proximal ring.

*Holotype:* ♂, imago. Taken at Chipola Lake, Fla., near the village of Weewa-hitchka, by Prof. J. G. Needham, April 8, 1927. No. 918.1, in C. U. collection.

*Allotype:* ♀, imago. Same as above. No. 918.2, in C. U. collection.

*Paratypes:* 3 ♂s, 13 ♀s. Same as above. No. 918.3-17, in C. U. collection.



Of the collecting of *Hexagenia weewa*, Prof. Needham gives the following account:

"The capture of *Hexagenia weewa* occurred on this wise. Prof. C. R. Crosby and I were passengers on the Apalachicola River steamboat *John C. Callahan, Jr.* On the evening of the eighth of April, this big boat ventured up the Chipola River above Dead Lake to Cotton Bluff to take on some barrels of turpentine. Near Cotton Bluff the boat got stuck in one of the bends of that crooked little stream just at nightfall. The searchlight was turned on, and in the beam of light that it cast upstream the mayflies rose above the black waters by thousands. Along with multitudes of midges and a few other mayflies of the genus *Ephemerella*, the big yellow female *Hexagenias* came fluttering up to the light. They settled all over the front of the boat, two or three layers deep wherever there was support. They flew in our faces and clung to our clothing. One could gather them up by barrelsful. But among the many thousands of females, only two or three males were seen."

#### *Hexagenia rosacea*, n. sp.

A rather large species, superficially similar to *H. carolina* and *H. marilandica*. Distinguishable from the former by the brighter and more extensive color pattern, the shorter femur, and by the genitalia. From the latter it may be distinguished by the greater amount of color on the anterior abdominal tergites, the shorter second tarsal joint, and by the genitalia. The compound eye is also proportionately larger than in either of these species.

#### MEASUREMENTS.

	<i>Body</i>	<i>Tails</i>	<i>Foreleg</i>	<i>Fore-wing</i>
Male imago.....	20	50	12	17

#### MALE IMAGO.

*Head:* Greyish white. Median carina in dorsal aspect rose distally, base black. Upper portion of compound eye cream-colored. Ocelli with black ring at base, rose ring above this. Cream-colored markings on vertex. Filament of antenna rose, basal joints cream. Compound eye is to the space between the eyes approximately as 1:0.75.

*Thorax:* Pronotum greyish white, with two longitudinal purplish-red streaks extending to wing bases. Mesonotum whitish with cream-white markings, bordered by rose-brown. Metanotum yellow with rose markings. Prosternum white with faint lavender streak posteriorly. Mesosternum very deep rose, shading to light rose and with white posterior border. Metasternum purplish rose. Pleura white with lateral rose stripes to base of middle legs.

*Legs:* Coxa posteriorly in distal half, trochanter and femur of foreleg rose. Tibia deep rose. First short tarsal joint, and distal third

of second to fourth joints, very deep purplish rose. Fifth joint except at base, and claws, same color. Other legs white, tarsal joinings with narrow purplish line. Blunt claw and distal two-thirds of fifth joint of tarsus purplish grey, pointed claw lighter shade of same color.

*Wings:* Very iridescent. Costal margin of fore wing, to R, light brown in basal half, dark brown distally. Veins C, Sc, and R of fore wing golden brown, other longitudinal veins dark purple. Hind wing without dark outer margin.

*Abdomen:* Ground color white on segments 1-6, definitely yellow on 7-10. Dorsally, rather wide median stripe on all tergites, greyish brown on 1-5, reddish brown on 6-10; becomes progressively wider from 7-9. Tergites 1 and 2 dull rose-grey except for white mark near pleural fold, another on each side near anterior margin, and pinkish crescent on posterior margin at median line. 2-7 with deep rose oblique lateral stripes from anterior lateral angle to posterior margin, joining median stripe. Lateral stripe becoming wider on 6 and 7. Narrow extension along anterior margin halfway to median line. 3 with pink crescent as in 1 and 2. 4-9 with deep rose posterior border. 8 and 9, lateral mark becomes a short wide extension of median stripe from posterior margin, not attaining anterior margin. 10 bright yellow at bases of tails, brown oblique line on each side. Pleural folds white, yellowish on 8 and 9. Ventrally, ganglionic area marked in each sternite by dark rose streak. Sternite 1 with rose triangle, its base on posterior margin, its apex halfway to anterior margin. Sternites 2-10 bordered posteriorly with deep rose. On each side a small deep-rose triangle, base on posterior margin, extending forward less than half the length of each sternite.

*Tails:* Near base, each joint yellow proximally, deep rose in distal half, with wide reddish-black ring at joining. Near center of tail, joints yellow proximally, dark brown in distal two-thirds, darker at joining. More distally, joints dark brown throughout, save for narrow light proximal ring.

*Genitalia:* Of *carolina* type, the distal forceps joints somewhat less slender than in *H. carolina*. Forceps limbs golden yellow basally, becoming tinged with reddish brown on distal joints. Penes golden yellow, streaked longitudinally with rose-brown. (Fig. 10).

*Holotype:* ♂, imago. Taken on window screen at Penrose, N. C., near headwaters of French Broad River, July 14, 1930. No. 922.1, in C. U. collection.

#### **Hexagenia orlando, n. sp.**

A rather small species. Fore wing of male with reddish brown costal border; narrow purplish outer margin on hind wing. Ground color of abdomen of male yellow to light tan, with dark brown markings. Female marked in purple.

## MEASUREMENTS.

	<i>Body</i>	<i>Tails</i>	<i>Foreleg</i>	<i>Fore-wing</i>
Male imago..... (12 specimens)	14-18	36-45	9-13	11-14
Female imago..... (1 specimen)	17	21	?	15

## MALE IMAGO.

*Head:* Upper part of compound eye golden brown. Ocelli with greyish-black basal ring and purplish brown ring above this. Second antennal joint purplish brown, filament light brown. Vertex marked with greyish purple near center, with orange laterally and posteriorly. Occiput purplish, an orange mark on each side next to compound eye. Dorsal aspect of median carina dark purplish, grey at tip. Diameter of compound eye is to space between eyes approximately as 1:0.75.

*Thorax:* Pronotum light tan, longitudinal stripes dark purple-brown. Mesonotum yellowish tan, greenish centrally, in the anterior three-fourths. Brown spot in center in posterior fourth. Bordered laterally and posteriorly with golden brown and cream. Metanotum yellowish brown with cream markings centrally and posteriorly. Pleura yellowish to golden brown with cream markings; sutures brown. Anterior half of prosternum yellow, posterior half dark brown with purplish streak between legs. Meso- and metasternum golden brown laterally, and on posterior of mesosternum; medially reddish brown. Posterior of mesosternum bordered with reddish brown.

*Legs:* Coxa and trochanter of foreleg dark brown; femur and tibia dark reddish brown, darker at joinings. First tarsal joint dark brown; second to fourth yellow basally, purplish brown distally. Fifth tarsal joint and claw purplish brown. Other legs yellow. Joinings of tibia and tarsus and of all tarsal joints, also claw and fifth tarsal joint, purplish brown.

*Wings:* Fore wing with reddish brown costal border. Hind wing with narrow purplish brown outer margin. In fore wing a few cross veins narrowly margined with purplish black; in hind wing, several widely margined. Longitudinal veins in both wings golden brown, cross veins purplish black.

*Abdomen:* Ground color yellow to light tan, becoming deep yellow on segments 8-10. Median dorsal line with rather broad blackish-brown stripe on tergites 6-9, and with narrower dark grey streak on 1-5, in these latter tergites wider anteriorly. On 10 this median line is narrow and black. On 1-7, an oblique lateral band arises at the anterior lateral angle and extends backwards and inwards to join the median stripe at the posterior margin. Each of these bands is wide anteriorly, narrow posteriorly, except on 7, where the reverse is true. On 8 and 9 these marks arise from the center of the median stripe at the posterior border, and occupy the entire posterior lateral angle. A narrow extension may continue up along the pleural fold to the anterior margin. Ventrally, a purplish-brown streak marks each ganglionic area; another similarly-colored faint mark occurs in each anterior lateral angle of sternites 1-8. Sternite 1 may show two

clear round spots in center, one on each side of the median line. On 9, an orange triangle with base on posterior margin, extends to anterior margin. On 1-8, the sides of similar triangles are faintly indicated as brown slightly wavy lines.

*Genitalia:* Of the *carolina* type, quite slender, the second joint of the forceps limb slightly more than twice as long as the first joint. Forceps base and first joint of forceps limb amber brown with cream markings. Second joint greyish white in basal half, purplish brown distally. End joints light purplish brown, dark brown at joining. Penes dark brown ventrally, yellow dorsally. (Fig. 13).

*Tails:* At base, each joint yellow proximally and light brown distally, dark brown at joinings. In all the remainder of the tail except at tip, each joint dark reddish brown with narrow proximal yellow ring, joinings dark brown to black. At tip, joints light brown, joinings black.

#### FEMALE IMAGO.

*Head:* Yellow. Upper part of compound eye dark grey. Occiput and vertex mottled with dark brown. Ocelli ringed with black at base, and black spot laterally next to compound eyes. Dorsal aspect of median carina black. Antennal filament light brown.

*Thorax:* Pronotum yellowish with purplish-brown longitudinal stripes. Mesonotum straw yellow bordered with darker yellow, and with grey markings. Metanotum yellow marked with black. Pleura cream to light yellow. Prosternum light yellow, dark streak between legs. Meso- and metasterna brighter yellow, no definite markings.

*Legs:* Foreleg missing, from only specimen available. Other legs straw yellow; the claws, fifth tarsal segment and joining of other joints of tarsus, faint greyed lavender.

*Wings:* Fore wing with faint yellow costal border. Longitudinal veins of both wings golden yellow, cross veins purplish brown.

*Abdomen:* Creamy white, yellowish on 8-10. Tergites with greyed purple markings, somewhat as in male. Wide median band on tergites 6-10, on 6 and 7 expanding anteriorly and giving off two lateral arms toward center of each side of tergite. Same median band on 1-5, but not so wide, expanded in the anterior half and the lateral fan-shaped arms more prominent (except in 1) than on 6 and 7. Lateral oblique stripes arise from anterior lateral angles of tergites 1-7, expand widely in center of each side, becoming narrower as they join the median band at the center of the posterior border. On 1 and 2 these stripes are so wide as almost to obliterate the white triangle in the posterior lateral angle. On 8-10 these stripes arise from the posterior median line as extensions of the median stripe, proceeding forwards and outwards to pleural fold; a narrow line may then extend along pleural fold to anterior border. Ventrally, each ganglionic area is indicated by a purplish-black triangle or streak. On 10, two oblique black lines on each side of center of sternite. No other ventral markings.

*Tails:* Greyish white, marked at each joining with dark maroon.

*Holotype*: ♂, imago. Taken at Orlando, Fla., by Mr. M. D. Leonard, May 20, 1927. No. 919.1, in C. U. collection.

*Allotype*: ♀, imago. Same location and collector, June, 1926. No. 919.2, in C. U. collection.

*Paratypes*: 11 ♂s. Same as holotype. No. 919.3-13, in C. U. collection.

KEY TO HEXAGENIA MALES.

1. Both wings suffused throughout with bronze.....**H. recurvata**  
Wings in large part hyaline..... 2
2. Costal margin of fore-wing light brown in proximal half, dark brown distally; hind wing heavily bordered with purplish brown along outer edge, this border occupying approximately one-fourth the length of the wing.....**H. atrocaudata**  
Wings not as above..... 3
3. Costal border of fore-wing heavily bordered with brown; hind wing with evident brown outer margin, but this border not occupying one-fourth of the wing..... 4  
Hind wing lacking brown border on outer margin; fore wing usually with costal margin darker than rest of wing..... 11
4. Fore wing under 15 mm. in length..... 5  
Fore wing over 15 mm. in length..... 7
5. Both wings definitely tinged with yellow or greenish yellow..... **H. venusta**  
Wings not tinged with yellow or greenish yellow..... 6
6. Fore wing under 13 mm. in length; both fore and hind wings with numerous dark spots..... **H. elegans**  
Fore wing over 13 mm. in length; fore wing lacking dark spots..... **H. mingo**
7. Bilineata type of genitalia; both wings tinged with light brown. **H. bilineata**  
Genitalia and wings not as above..... 8
8. Rigida type of genitalia; abdominal tergites each with two bright yellow triangular spots based on the anterior margin..... **H. rigida**  
Genitalia and abdominal markings not as above..... 9
9. Carolina type of genitalia; abdominal tergites whitish with oblique purplish brown markings..... **H. weewa**  
Limbata type of genitalia; abdominal tergites dark brown with paler markings..... 10
10. Fore wing 18 mm. in length; costal margin dark red-brown throughout; eye unusually large..... **H. viridescens**  
Fore wing 17 mm. in length; costal margin yellowish brown, lighter in proximal half; eye not unusually large..... **H. occulta**
11. Both wings tinted almost uniformly with light bistre-grey; costal margin of fore wing distinctly bistre-grey..... **H. munda**  
Wings not uniformly tinted with grey; costal margin of fore wing brown.... 12
12. Fore wing not exceeding 15 mm. in length..... **H. orlando**  
Fore wing exceeding 15 mm. in length..... 13
13. Wings tinted lightly with greenish yellow..... **H. limbata**  
Wings not tinted with greenish yellow..... 14
14. Fore wing over 19 mm. in length; abdominal tergites dark brown, marked on each side with yellow spots not based on the anterior margin, **H. affiliata**  
Fore wing under 19 mm. in length; abdominal tergites whitish with rose to red markings..... 15
15. Fore and hind wings with dark spots; anterior abdominal tergites without median stripe..... **H. marilandica**  
No spots in fore wing, few in hind wing; anterior abdominal tergites with median purplish-brown stripe..... **H. rosacea**

## KEY TO HEXAGENIA FEMALES.

(NOTE.—Females of *H. munda* and *H. rosacea* not included.)

1. All principal longitudinal veins, and majority of cross veins, of both fore and hind wings, heavily bordered with dark reddish brown. . . . *H. recurvata*  
Wings not as above. . . . . 2
2. Outer margin of hind wings and costal margin of fore wings bordered with brown. . . . . 3  
No brown border on outer margin of hind wings; fore wings may have brown or yellow costal margin. . . . . 6
3. Fore wing under 20 mm. in length. . . . . 4  
Fore wing over 20 mm. in length. . . . . 5
4. Hind wing heavily bordered with purplish brown; costal margin of fore wing dark brown in distal half, light brown in proximal half. . . . *H. atrocaudata*  
Hind wing narrowly bordered with reddish brown, and with numerous dark spots; costal border of fore wing dark brown in proximal half, light brown in distal half. . . . . *H. rigida*
5. Fore wing over 25 mm. in length; hind wing faintly bordered with greyish brown. . . . . *H. viridescens*  
Fore wing under 25 mm. in length; hind wing with prominent brown border, and with several distinct black spots. . . . . *H. bilineata*
6. Wings tinted throughout with yellow or greenish yellow. . . . . 7  
Wings not definitely tinged with greenish yellow or yellow throughout. . . . . 9
7. Fore wing under 24 mm. in length. . . . . 8  
Fore wing over 24 mm. in length. . . . . *H. weewa*
8. Fore wing tinged with greenish, especially on costal border. Several cross veins near base of Sc and R margined with brown. . . . . *H. elegans*  
Both wings strongly tinged with greyish yellow. Cross veins near base of Sc and R not margined with brown as above. . . . . *H. venusta*
9. Fore wing 23 mm. or over. . . . . 10  
Fore wing under 23 mm. . . . . 11
10. Main cross veins and portions of many principal longitudinal veins of both wings rose-colored. . . . . *H. carolina*  
Main cross veins of both wings purplish black. Veins C, Sc and R of fore wing, and Sc of hind wing, light brown; other longitudinal veins grey. . . . . *H. marilandica*
11. Fore wing 20–22 mm. in length. . . . . 12  
Fore wing less than 20 mm. in length. . . . . *H. orlando*
12. Costal border of fore wing reddish brown; cross veins purplish rose. . . . . 13  
Costal border of fore wing yellowish; cross veins purple-black. . . . . 14
13. Wing 22 mm. in length; abdomen marked with very dark red-brown, . . . . . *H. affiliata*  
Wing 20 mm. in length; abdomen marked with purplish brown. . . . . *H. occulta*
14. Veins C and Sc yellowish, other veins greyish white. . . . . *H. limbata*  
Vein C amber; other longitudinal veins in upper part of fore wing purplish brown. . . . . *H. mingo*

## TABULATION OF CHARACTERS.

## HEXAGENIA MALES.

SPECIES	Gen.	Wing	F : tb	Tb : t	T. jts.	Th.	Abdom.	Pattn.	Eye	F. lg : body
<i>recurvata</i>	III	15-18	1:2	1:1	1:1.2	dark brown	yellow	light brown	yellow tan	1:1.4
<i>atrocaudata</i>	V	19½	1:1.7	1:1	1:1	v. dark brown	yellow	dark brown to bl.	orange	1:2
<i>bilineata</i>	II	16	1:1.6	1:1.5	1:1.3	v. dark brown	red-brown	dark brown to bl.	dark brown	1:1
<i>limbata</i>	I	13-15	?	?	?	?	yellow	dark brown	green-yellow	?
<i>rigida</i>	IV	16	1:1.9	1:1.5	1:1.1	dark brown	yellow	dark brown	dark brown	1:1.4
<i>viridescens</i>	I	18	1:1.7	1:1.3	1:1.2	v. dark brown	dk. red-brown	light brown	dark brown	1:1
<i>affiliata</i>	I	19½	1:1.6	1:1.2	1:1.2	dark red	yellow	dark brown to bl.	dark green brown	1:1.4
<i>occulta</i>	I	17	1:1.7	1:1.2	1:1.3	dark red-brown	red-brown	dark red-brown	v. dark brown	1:1
<i>munda</i>	I	14	?	?	?	brown	yellow	brown to bl.	?	?
<i>venusta</i>	I	13-16	1:1.8	1:1.2	1:1	dark purple brown	yellow	purple brown	dark grey	1:1.3
<i>carolina</i>	VI	14-17	1:1.2	1:1.5	1:1.1	red-brown	creamy white	greyed rose	golden brown	1:2
<i>rosacea</i>	VI	17	1:1.7	1:1.3	1:1.1	dark red	creamy white	deep rose	cream	1:1.7
<i>marilandica</i>	VI	16	1:1.7	1:1.4	1:1.5	dark red	creamy white	deep rose	slate grey	1:1.7
<i>mingo</i>	I	14½	1:1.7	1:1	1:1	dark brown	creamy white	red-brown	cream	1:1.5
<i>orlando</i>	VI	12-14½	1:2	1:1	1:1.2	light tan	light tan	dark brown	golden brown	1:1.5
<i>elegans</i>	VI	10-12	1:1.5	1:1.2	1:1.2	purple rose	creamy white	deep rose	golden tan	1:1.7
<i>weewa</i>	VI	17-19	1:1.9	1:1.4	1:1.2	purple brown	white	dark purple brown	purple grey	1:1.2

## EXPLANATION OF ABBREVIATIONS USED IN TABULATION OF CHARACTERS.

Gen.—genitalia type.  
 I—type limbata.  
 II—type bilineata.  
 III—type recurvata.  
 Wing—length of fore wing.  
 F : tb.—proportionate length of femur to tibia.  
 Tb : t.—proportionate length of tibia to tarsus.  
 T. jts.—proportionate length of 3rd to 2nd tarsal joints.  
 Th.—color of thoracic sternites.  
 Abdom.—general groundcolor of abdomen.  
 Pattn.—general color pattern of abdomen.  
 Eye—color of upper portion of compound eye.  
 F. lg:body—proportionate length of fore leg to body.

IV—type rigida.  
 V—type atrocaudata.  
 VI—type carolina.

## THE NYMPHS.

A comparative study of eleven species of *Hexagenia* nymphs seems to indicate that only a few of the external structures show sufficient variation between species to serve as a basis for classification. Of these, the most important are (1) the shape of the frontal process of the head, and (2) the mandibular tusks. Of secondary importance are (1) the maxillæ, (2) the claws, and (3) the tails. In one species only, *H. recurvata*, the structure of the antennæ and the first rudimentary pair of gills serve as distinctive characters. The color of the body, the color pattern, and the color of gills and tails may be useful to supplement structural differences.

The frontal process may be square-cut or truncate, as in *H. atrocaudata*, (see plate, Fig. 1, d); angular, as in *H. recurvata*, (plate, Fig. 1, b); conical, as in *H. carolina* (plate, Fig. 1, c); or dome-shaped, as in *H. mingo* (plate, Fig. 1, a). In some species, as in Nymph No. 3, this process may be dome-shaped in the female and conical in the male. In the tabulation of nymphal characters, the head of the female has been considered, and any variations in the frontal process of the male are indicated in the brief description of each species.

The relative length of the head and of that portion of the tusks protruding beyond it is indicated for male and female in the tabulation. The tusks of the female are larger and longer than those of the male. Since, however, the head of the female is likewise wider and longer than that of the male, the relative length of tusk protruding beyond the head may be greater in the case of the male. The amount of curvature of the tusks is also characteristic. These show the least curvature in *H. recurvata*, in which species they are likewise provided with long hairs from base to tip, on the outer margin. The tusks of the other nymphs studied have hairs on the outer margin only in the basal half, the distal half being hairy on the inner margin only. The tusks of *H. carolina* are the longest.

The relative length of the maxillary palp to that of the entire length of the maxilla, and of the length of its first joint to the galea-lacinia, seem to be fairly constant specific characters. The third claw has been considered as being the least subject to injury and other modifications from external sources. Figures of the third claw of each species are given (Figs. 2, 3, 8, 9),



and show specific variations. The outer tails are stouter than the middle one, in all these species, and in most cases slightly shorter. In *H. bilineata* the tails of the male are proportionately much longer than those of the female. The color of the tails, and the presence or absence of darker rings at the joinings, seem to be specific.

In *H. recurvata*, the antennæ have only short inconspicuous hairs throughout their entire length, while in all the other species the antennæ possess very long hairs in that region from near the base to beyond the middle, and very short hairs at the tip. In *H. recurvata* likewise, the first rudimentary gill is simple, not bifid as in all the others.

#### DESCRIPTION OF NYMPHS.

##### **Hexagenia bilineata.**

Tusks reddish brown, gently upcurved in distal half. First joint of maxillary palp shorter than galea-lacinia. Palp less than twice length of body of maxilla. Outer tails banded indistinctly at joinings with greyish red-brown. Tails of males proportionately longer than those of females. Head and pronotum dark red-brown. Meso- and metathorax and legs red-brown. Abdominal tergites pinkish grey, each margined and bordered with grey and marked with red-brown. Ventrally light red-brown. Gills red-brown in center, fringes reddish grey. Body long and slender. Claws long and slender, not curved at tip; base slightly swollen.

*Distribution:* Iowa—Fairport, Andalusia Chute, Keokuk.

##### **Hexagenia recurvata.**

First rudimentary pair of gills simple, not bifid as in other species. Tusks red-brown; short and stout, only slightly upcurved. Fringed with long hairs on entire outer margin. First joint of maxillary palp equal in length to galea-lacinia. Palp less than twice length of body of maxilla. Middle tail greyish white. Head and pronotum light red. Meso- and metanotum darker red. Legs yellowish tinged with red. Abdominal tergites red-brown, margins and joinings light tan. Gills dark purplish grey in center, fringes light purplish grey. Anterior abdominal segments and thorax stout. Head and posterior abdominal segments relatively slender. Claws moderately stout, swollen at base, tip slightly curved.

*Distribution:* New York—McLean, Freeville, Michigan Hollow; Massachusetts—Granby; West Virginia—Moore's Creek at Wardensville; Michigan—Marquette Co.

**Hexagenia atrocaudata.**

Tusks red-brown, very dark distally; curve outward and downward basally, strongly upward distally. First joint of maxillary palp longer than galea-lacinia. Palp twice the length of body of maxilla. Middle tail yellowish. Head, dorsum of thorax, legs and last two abdominal tergites yellow-brown margined and marked with yellow. Anterior abdominal tergites and ventral surface grey-white, tinged with lavender. Gills very dark purple in center, fringes dark grey-purple. Body stout. Claws broad and short, swollen at base; tip slightly curved.

*Distribution:* New York—Ithaca (Beebe Lake). Reared by Prof. J. G. Needham. Indiana—Howe; West Virginia—'Smoke Hole,' Wardensville, Athens, Greenbrier River, Marlinton.

**Hexagenia carolina.**

Tusks red-brown, darker distally. Very long, almost equalling front leg in length. Upcurved distally. First joint of maxillary palp equal to or slightly longer than galea-lacinia. Palp not quite twice length of body of maxilla. Middle tail very light yellow. Head and dorsum of thorax yellow-brown. Abdominal tergites greyish lavender margined with white. Ventral surface white. Gills dark purple in center, fringes dark greyish purple. Body moderately stout. Claws short and stout, swollen at base; very short pointed tip, slightly curved.

*Distribution:* North Carolina—Hamburg Lake, near Greensboro, South Toe River, at Micaville.

**Hexagonia mingo.**

Frontal process tending toward conical, in some males. Tusks yellowish brown, extreme tip dark red-brown. Medium in length, only slightly upcurved. First joint of maxillary palp shorter than galea-lacinia. Palp almost twice length of body of maxilla. Outer tails of male grey-lavender at joinings, these bands at base alternately wide and narrow. Middle tails of both sexes white. Head and dorsum of thorax red-brown. Legs creamy white. Abdominal tergites creamy white, marked with purplish grey. Ventrally creamy white. Gills dark grey-purple in center, fringes lighter grey-purple. Body rather slender. Claws rather slender, base very little swollen. Tip somewhat curved.

*Distribution:* West Virginia—Millwood, reared by Prof. J. G. Needham.

*Nymph No. 1.*

Tusks yellowish brown; extreme tip dark red-brown. Medium in length, upcurved at tip. First joint of maxillary palp almost equal to galea-lacinia. Palp less than twice length of body of maxilla. Outer tails of male light grey with purplish-black joinings. Middle tail of male, and all tails of female, light yellow. Head and dorsum of thorax dark brown in male, in female slightly lighter. Abdominal tergites white; in male marked with purplish brown, in female with light grey.

Ventrally creamy white; dark ganglionic streaks on sternites 6-9, less distinct in female. Gills bluish purple in center, fringes same. Body stout. Claws short and stout, swollen at base; tip slightly curved.

*Distribution:* West Virginia—Wheeling, Grass Lick Run; Virginia—Mountain Lake.

*Nymph No. 2.*

*Note:* These specimens not fully matured.

Tusks yellowish brown, extreme tip very dark brown. Medium in length. Rather strongly upcurved distally. First joint of maxillary palp equal to galea-lacinia. Palp almost twice length of body of maxilla. Middle tail white. Head light yellow-brown. Thorax and legs creamy white. Abdominal tergites bluish white marked with purplish grey. Ventrally creamy white. Gills light purple-grey in center, fringes same color but lighter. Body very slender. Claws very slender and long.

*Distribution:* North Carolina—Pacolet River, near Tryon.

*Nymph No. 3.*

*Note:* Markings of these nymphs are strikingly similar to the color pattern of mature *H. rigida*.

Frontal process of male conical. Tusks light red-brown throughout length. Medium in length, gently upcurved. First joint of maxillary palp shorter than galea-lacinia. Palp less than twice length of body of maxilla, which is quite stout. Middle tail yellowish white. Head and dorsum of thorax red-brown. Legs yellow. Abdominal tergites purplish brown, marked and margined posteriorly with cream. Ventrally, thorax grey-white. Abdominal sternites cream, with dark ganglionic streaks on 6-9 in female. Gills purplish-black in center, fringes dark purple-grey. Body long and slender. Claws rather short, fairly slender, not swollen at base.

*Distribution:* Michigan—Alcona Co.

*Nymph No. 4.*

Tusks greyish yellow, dark red-brown at extreme tip. Medium in length, gently upcurved. First joint of maxillary palp almost equals galea-lacinia. Palp less than twice length of body of maxilla. Middle tail white. Head and dorsum of thorax light brown. Legs white. Abdominal tergites bluish white marked with purplish grey. Ventrally white; with dark ganglionic streaks on 6-9 sternites of both sexes. Gills dark purple-grey in center, fringes very light purple-grey. Body slender. Claws very long and slender.

*Distribution:* Florida—Gainesville and Torreya.

*Nymph No. 5.*

*Note:* Of this species, female specimens only.

Tusks yellowish brown basally; distal half red-brown. Medium long, upcurved distally. First joint of maxillary palp almost equals

galea-lacinia. Palp equal to twice length of body of maxilla. Middle tail white. Head and dorsum of thorax light yellow-brown. Legs cream. Abdominal tergites cream-white marked with purplish grey. Ventrally cream-white, with purplish ganglionic streak on sternites 7-9. Gills dark purple-grey in center, fringes lighter purple-grey. Body medium stout. Claws long and slender; not swollen at base.

*Distribution:* Florida—Gainesville.

*Nymph No. 6.*

Frontal process rather conical in male. Tusks yellowish, distal half reddish. Medium long, sharply upcurved distally. First joint of maxillary palp approximately equal to galea-lacinia. Palp less than twice length of body of maxilla. Middle tail creamy white. Outer tails of male dark brown with wide dark purplish-brown joinings. Head of male very dark red-brown, dorsum of thorax lighter red-brown. Head and thorax of female light brown. Abdominal tergites of male yellow with reddish-brown markings; of female, white with lavender-grey markings. Ventral of thorax light tan. Sternites of abdomen creamy white with purplish-black ganglionic streaks on 6-9. Gills light grey-lavender in center, fringes same. Body medium slender. Claws rather stout, swollen at base; only slightly curved.

*Distribution:* North Carolina—Tuckaseegee River, at Jackson.

KEY TO ELEVEN SPECIES OF HEXAGENIA NYMPHS.

1. Frontal process angular; first rudimentary gill simple.....*H. recurvata*  
Frontal process not angular; first rudimentary gill bifid..... 2
2. Frontal process square-cut or truncate.....*H. atrocaudata*  
Frontal process not truncate..... 3
3. Frontal process conical..... 4  
Frontal process dome-shaped or rounded..... 6
4. Body of female exceeding 30 mm. in length; body of male 23 mm. or longer.....*H. carolina*  
Body of female less than 30 mm.; of male, less than 23 mm..... 5
5. Tails of male longer than those of female; outer tails and body red-brown.....*H. bilineata*  
Tails of male not exceeding those of female; tails and body creamy white.....*Nymph No. 2*
6. Third claw short and stout, much swollen at base..... 7  
Third claw long and slender, little if any swollen at base..... 8
7. Tarsus as wide as greatest width of claw; abdomen of male white, outer tails light grey.....*Nymph No. 1*  
Tarsus narrower than greatest width of claw; male abdomen yellow, outer tails dark brown.....*Nymph No. 6*
8. Outer tails of male ringed at joinings with darker color.....*H. mingo*  
Outer tails of male not ringed at joinings with darker color..... 9
9. Body of female exceeding 25 mm. in length..... 10  
Body of female less than 25 mm. in length.....*Nymph No. 4*
10. Abdominal tergites purplish brown with cream markings; palp less than twice body of maxilla.....*Nymph No. 3*  
Abdominal tergites white with purplish grey markings; palp equal in length to twice body of maxilla.....*Nymph No. 5*

TABULATION OF CHARACTERS OF NYMPHS.

Species	Body of Male	Body of Female	Outer Tail Male	Outer Tail Female	Hd. vs. Tusk, Male	Hd. vs. Tusk, Female	Frontal Process	Outer Tail
<i>atrocaudata</i>	23-28	27-35	9-11	9-11	2½ : 2½	2½ : 3½	square	yellow
<i>binelecta</i>	15-22	21-26	9-11	7-8½	2 : 3	2½ : 3½	conical	light red-brown
<i>carolina</i>	23-28	32-36	8-12	11-14	2 : 4	3 : 5	dome	yellow
<i>mingo</i>	16½-21½	25-27	8-10	9	2 : 2½	3 : 3½	dome	white
<i>recurvata</i>	20-25	25-29	11-13	12-14	2 : 2	2½ : 2½	angular	purple-brown
No. 1	21-21½	27-32	9	10-11	2 : 2½	3 : 4	dome	♂ light grey ♀ yellow
No. 2*	17-19	18-21	5½	5½	1¾ : 2¼	1½ : 2	conical	white
No. 3	20	27	7	9-10	2 : 3	3 : 3	dome	yellow
No. 4	16*	17-19½	7	6-8	1½ : 2½	2 : 3	dome	white
No. 5		27		9		2 : 2½	dome	white
No. 6	18-22½	*25-26	6½-8	7-8	2 : 2½	2 : 3	dome	♂ brown ♀ white

## EXPLANATION OF TABULATION:

All measurements given in millimeters. Blank spaces mean no specimens. For shape of frontal process, see figures. \* = specimens not yet fully mature.

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## EXPLANATION OF PLATE.

## GENUS HEXAGENIA.

- Fig. 1. Frontal processes of heads of female nymphs. a—*H. mingo*. b—*H. recurvata*. c—*H. carolina*. d—*H. atrocaudata*.
- Fig. 2. Third claws of nymphs. a—Nymph No. 5. b—Nymph No. 4. c—Nymph No. 3. d—Nymph No. 1.
- Fig. 3. Maxillæ of female nymphs. a—Nymph No. 1. b—*H. recurvata*. c—Nymph No. 2. d—Nymph No. 4. e—*H. bilineata*. f—Nymph No. 6. g—Nymph No. 3.
- Fig. 4. Head of nymph, *H. recurvata*.
- Fig. 5. Head of nymph, *H. carolina*.
- Fig. 6. Mandibular tusks of female nymphs. a—Nymph No. 1. b—*H. recurvata*. c—Nymph No. 2. d—Nymph No. 4. e—*H. bilineata*. f—Nymph No. 6. g—Nymph No. 3.
- Fig. 7. Third claws of nymphs. a—*H. mingo*. b—Nymph No. 6. c—*H. atrocaudata*. d—*H. recurvata*. e—*H. carolina*.
- Fig. 8. Third claw of *H. bilineata*.
- Fig. 9. Third claw of Nymph No. 2.
- Fig. 10. Male genitalia, *H. rosacea*.
- Fig. 11. Male genitalia, *H. elegans*.
- Fig. 12. Male genitalia, *H. atrocaudata*.
- Fig. 13. Male genitalia, *H. orlando*.
- Fig. 14. Male genitalia, *H. bilineata*.
- Fig. 15. Mandibular tusks of female nymphs. a—*H. mingo*. b—Nymph No. 5. c—*H. atrocaudata*. d—*H. carolina*.
- Fig. 16. Male genitalia, *H. rigida*.
- Fig. 17. Male genitalia, *H. weewa*.
- Fig. 18. Male genitalia, *H. recurvata*.
- Fig. 19. Male genitalia, *H. limbata*.
- Fig. 20. Male genitalia, *H. carolina*.
- Fig. 21. Male genitalia, *H. mingo*.
- Fig. 22. Male genitalia, *H. marilandica*.
- Fig. 23. Maxillæ of female nymphs. a—*H. mingo*. b—Nymph No. 5. c—*H. atrocaudata*. d—*H. carolina*.

New Species of Hexagenia  
Jay R. Traver

PLATE I.

