

THE DISTRIBUTION OF *CULEX P. PIPIENS* AND *C. P.*  
*QUINQUEFASCIATUS* IN NORTH AMERICA<sup>1</sup>

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In recent years a great deal of work has been done on the relationships between various members of the *Culex pipiens* complex. It is now generally recognized that there are at least two more or less well-defined members, *Culex p. pipiens* and *C. p. quinquefasciatus*. The status of *Culex molestus* has not yet been completely investigated but it would appear that it is a strain or group of strains of *pipiens* s.s., possibly an urban biotype. Most of the pertinent literature on this group of mosquitoes has been collected in a symposium published by the Royal Entomological Society of London (Mattingly *et al.*, 1951). Due to the difficulty of differentiating the various members of the complex, their distributions are only vaguely known. This study is designed to provide more complete information on the distributions of these forms in North America.

METHODS

Three forms in the complex are at present known from North America, *pipiens*, *quinquefasciatus*, and "molestus". The identification of the latter rests upon a biological characteristic, autogeny; morphologically, the form is difficult to separate from *pipiens*. The present study was done from a morphological point of view; if specimens of "molestus" are included they could not be separated from *pipiens*.

The only reliable character for separating individual *pipiens* and *quinquefasciatus* was described by Sundararaman (1949). This is a ratio of two measurements of various parts of the male genitalia. This measurement has been adopted by a succession of workers (Barr and Kartman, 1951; Mattingly *et al.*, 1951; Knight and Malek, 1951; Dobrotworsky and Drummond, 1952; Knight, 1953a, b, c) and has proved reliable.

*Securing specimens.* A form letter requesting series of these forms was circulated to culicidologists in North America. This resulted in about 150 lots of material, two of which were not from North America. The contributors of this material made the study possible. Individual specimens were not requested and were usually not studied.

*Mounting specimens.* Each lot was numbered on receipt and stored in alcohol to preclude insect damage. The insects were cleared for a few minutes in hot 10% KOH, washed in water, neutralized in a dilute acetic acid solution, dehydrated in 95% alcohol, cleared and dissected in creosote, and mounted in

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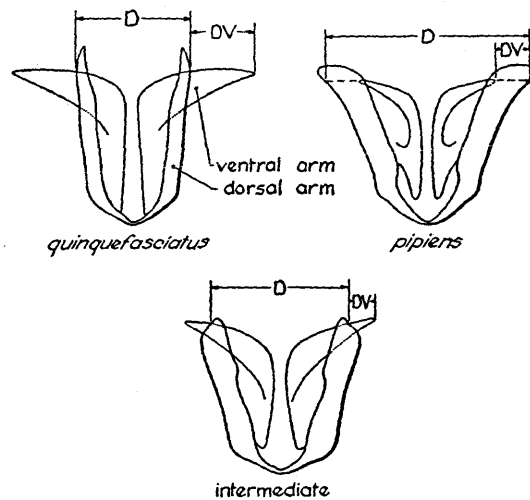


fig. 1. Measurements taken of the dorsal and ventral mesosomal arms of the male genitalia of *Culex pipiens*.

balsam. KOH clearing was carried out only long enough to relax the specimens and remove the internal organs; the sclerotized areas were not allowed to become appreciably lighter in color. The genital capsules were handled by lots and were arranged in several rows on a slide; up to 49 individuals were mounted on a slide. This, of course, facilitated measuring the specimens and storing the slides. The capsules were first arranged in rows in a thin sheet of balsam on a slide. Broken bits of cover-slips were arranged around the specimens to support the cover-slip while the preparation was still wet. The slide was allowed to dry for several days and then more balsam and a cover-slip were added. This technique was also used in the study by Barr and Kartman (1951).

*Method of measurement.* The measurements recorded are as shown in Fig. 1. DV is the extension of the ventral arm laterally of its intersection with the dorsal arm. In specimens with a negative ratio the same measurement was used. Since there was no intersection of the arms, the point where they would have intersected had the ventral arm been longer was used. Both DV measurements were recorded and an average taken. D is the distance between the two intersections of the dorsal and ventral arms. The measurements were made by means of an ocular micrometer at 100 diameters magnification. If too high a magnification is used the exact distances to be measured are more difficult to define. The measurements were estimated to the nearest half of a scale division. Terminalia which were highly distorted were not measured. If the measurements as defined above are compared with those of Sundararaman (1949) and Rozeboom (in Mattingly *et al.*, 1951) differences will be found. The reason for making this change is that the dorsal arms of the phallosome are often not pointed as shown by these authors; this is particularly true of *pipiens* specimens from northern

areas. It is believed that the modification proposed here gives somewhat more objective measurements although the difference is not great.

In the study by Barr and Kartman (1951) negative DV measurements were recorded as being zero. The inclusion of negative values in that study would not have changed the results greatly. It would appear that Sundararaman also did not record negative measurements; Christophers (in Mattingly *et al.*, 1951) first used negative ratios.

From the foregoing it is apparent that these measurements are consistent only within a study and not between different studies. The most important variables are the manner of mounting specimens and the type of measurements taken. It should be pointed out that one of the greatest sources of error is deciding the exact distance to be measured. From these considerations it is apparent that subtle statistical manipulations of the data should be avoided.

#### RESULTS

After all lots had been mounted and measured, the mean, standard deviation, and standard error of the mean were calculated for each lot. The means of each lot were plotted against latitude (fig. 8). It was found that the average ratio showed a sharp cline in latitudes across the central part of the United States. All lots taken north of this cline were examined and it was found that the ratios of *pipiens* specimens were generally less than 0.2 and the average ratios of lots of *pipiens* were less than 0.1. The same was done with *quinquefasciatus* and it was found that individuals usually had values greater than 0.4 and lots had mean values greater than 0.6. These values were selected as standards for the study. Specimens with a ratio of less than 0.2 were considered to be *pipiens*, those from 0.2 to 0.4 intermediates, and those with values above 0.4 *quinquefasciatus*. The discussion of individual lots follows.

#### Canada

*Ontario.* Ottawa; from D. G. Peterson; a lot of 28 specimens, probably reared; mean  $-0.08 \pm .01^2$ ; SD<sup>3</sup> 0.05; range  $-0.15$  to  $+0.06$ ; all *pipiens*.

*Quebec.* St. Anne de Bellevue; October 1944; from J. J. McLintock; a lot of 23 reared males; mean  $0.01 \pm .02$ ; SD 0.08; range  $-0.10$  to  $+0.21$ ; 1 intermediate, 22 *pipiens*. This sample has a single specimen which falls in the intermediate range and morphologically the specimen resembles an intermediate. Since the locality is on the St. Lawrence River it is entirely possible that this is a hybrid. No other intermediates have been found in the northern part of the range of *pipiens*.

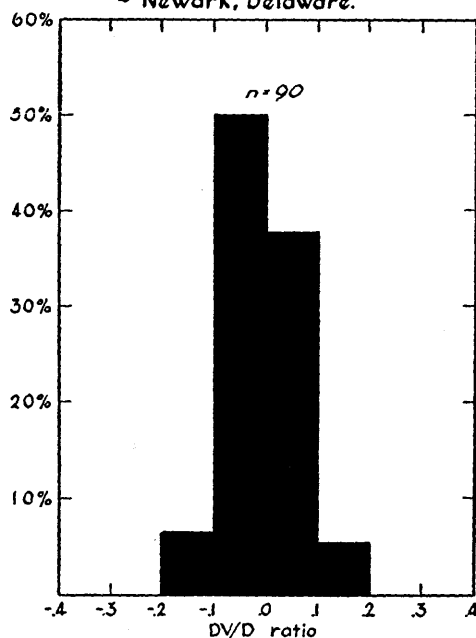
#### United States

*Minnesota.* St. Paul; Sept. 1953; a lot of 27 males reared by the author; mean  $-0.07 \pm .01$ ; SD 0.06; range  $-0.21$  to  $+0.05$ . A second sample collected by J. J. Parks contained 6 individuals; Oct. 7, 1953; mean  $-0.05$ ; range  $-0.08$  to  $0.00$ ; *pipiens*.

<sup>2</sup> Standard error of the mean.

<sup>3</sup> Standard deviation.

fig. 2. Frequency Distribution of DV/D Ratios  
of a Population of *pipiens*.  
~ Newark, Delaware.



*New York.* Freeport; Sept. 4, 1953; from G. S. Tulloch; 56 specimens; mean  $-0.02 \pm .01$ ; SD 0.06; range  $-0.15$  to  $+ .11$ ; *pipiens*. Governor's Island; Sept. and Oct. 1953; from G. B. Stansell; 15 specimens; mean  $0.00 \pm .01$ ; SD 0.04; range  $-0.05$  to  $+0.06$ ; *pipiens*.

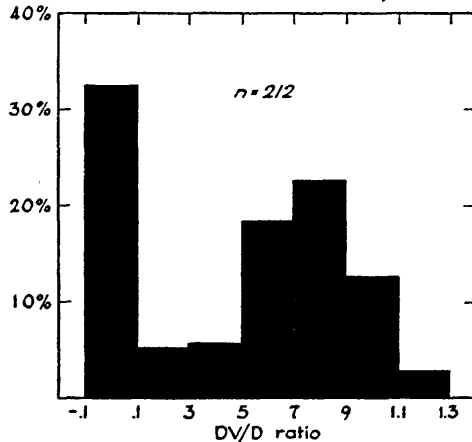
*New Jersey.* Oxford; Sept. 16, 1953; L. E. Haggmann; 49 reared males; mean  $-0.07 \pm .01$ ; SD .05; range  $-0.17$  to  $0.00$ ; *pipiens*.

*Delaware.* Newark (fig. 2); Aug. 29, 1953; R. F. Darsie; a lot of 90 males, probably reared; mean  $-0.03 \pm .01$ ; SD 0.06; range  $-0.17$  to  $+0.11$ ; *pipiens*.

*Maryland.* Several lots from W. E. Bickley. Bainbridge; July 31, 1945; 21 specimens; mean  $0.04 \pm .01$ ; SD 0.04; range  $-0.04$  to  $0.13$ ; *pipiens*. Cambridge; 4 lots taken Aug. 1-6, 1945; 47 specimens; mean  $0.04 \pm .01$ ; SD 0.05; range  $-0.05$  to  $+0.15$ ; *pipiens*. Patuxent Naval Air Station, Cedar Point, St. Mary's Co.; Sept. 8 to Oct. 1, 1945; 31 specimens; mean  $0.07 \pm .03$ ; SD 0.15; range  $-0.05$  to  $0.77$ . This sample contains 30 *pipiens* (highest value 0.19), and 1 *quinquefasciatus*.

*Illinois.* Several collections from H. H. Ross. Great Lakes; light trap, 1944 season; 49 specimens; mean  $-0.02 \pm .01$ ; SD 0.06; range  $-0.11$  to  $+0.12$ ; *pipiens*. Raymond; Oct. 5, 1939; 10 specimens; mean  $-0.01 \pm .01$ ; SD 0.05; range  $-0.09$  to  $+0.05$ ; *pipiens*. East St. Louis; light trap, Sept. 1, 1943; 15 specimens; mean  $0.03 \pm .01$ ; SD 0.05; range  $-0.07$  to  $+0.09$ ; *pipiens*. Another lot from East St. Louis; light trap, 1944 season (fig. 3); 212 specimens; mean  $0.48 \pm .03$ ; SD 0.37; range  $-0.07$  to  $+1.25$ ; this collection contains 79 *pipiens*,

fig. 3. Frequency Distribution of DV/D Ratios of a Population of *pipiens*, *quinquefasciatus*, and Intermediates. ~ East St. Louis, Illinois.

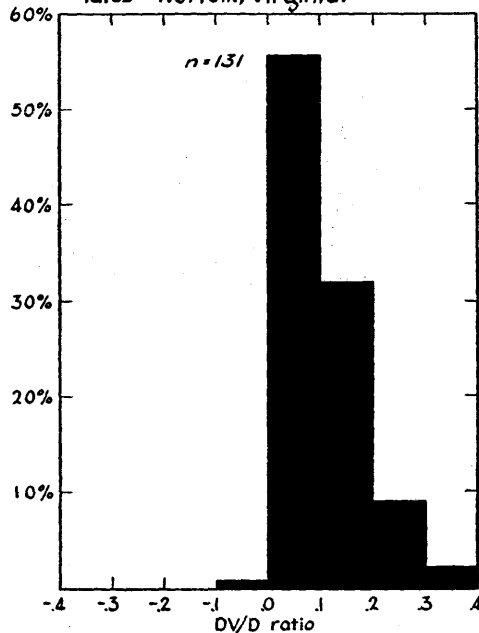


8 intermediates, and 125 *quinquefasciatus*. Cahokia; Sept. 16, 1943; taken sweeping; 66 specimens; mean  $0.83 \pm .03$ ; SD 0.22; range 0.38 to 1.25; 1 intermediate, 65 *quinquefasciatus*. Carmi; Oct. 2, 1941; 12 specimens; mean  $0.01 \pm .02$ ; SD 0.05; range  $-0.09$  to  $+0.09$ ; *pipiens*. Illinois Ordnance Plant, Crab Orchard Lake; July 9, 1942; 8 specimens; mean  $0.17 \pm 0.11$ ; SD 0.32; range  $-0.02$  to  $+0.92$ ; 7 *pipiens*, 1 *quinquefasciatus*.

*Missouri*. Kirkwood; from laboratory colony of R. S. Roberts; Aug. 28, 1952; 14 specimens; mean  $0.03 \pm .01$ ; SD 0.04; range 0.00 to 0.11; *pipiens*. Kirkwood; 3 collections from F. C. Harmston; 121 specimens; mean  $0.05 \pm .01$ ; SD 0.06; range  $-0.06$  to 0.36; 1 intermediate, 120 *pipiens*. Baden, North St. Louis; May 5, 1952; F. C. Harmston; 6 specimens; mean  $0.07 \pm .04$ ; SD 0.11; range  $-0.02$  to 0.26; 5 *pipiens*, 1 intermediate. No. St. Louis; June 14, 1952; F. C. Harmston; 10 specimens; mean  $0.04 \pm .02$ ; SD 0.05; range  $-0.04$  to  $+0.09$ ; *pipiens*. St. Louis; Oct. 1953; L. E. Ottersbach; 60 specimens; mean  $0.85 \pm .05$ ; SD 0.37; range  $-0.05$  to 1.83; 5 *pipiens*, 55 *quinquefasciatus*. St. Louis; Aug. 26, 1952; R. S. Roberts; 20 specimens; mean  $0.23 \pm .06$ ; SD 0.29; range  $-0.05$  to 0.90; 13 *pipiens*, 3 intermediates, 4 *quinquefasciatus*. University City; June 19, 1952; F. C. Harmston; 2 specimens; mean 0.04; *pipiens*. Richmond Heights; June 5, 1952; F. C. Harmston; 22 specimens; mean  $0.00 \pm .01$ ; SD 0.06; range  $-0.09$  to  $+0.16$ ; *pipiens*. Joplin; Sept. 5, 1952; R. S. Roberts; 10 specimens; mean  $0.14 \pm .03$ ; SD 0.09; range 0.02 to 0.24; 7 *pipiens*, 3 intermediates. St. Ann; July 17, 1952; F. C. Harmston; 1 specimen;  $-0.03$ ; *pipiens*.

*Kansas*. Seneca; Aug. 13, 1951; R. S. Roberts; 11 specimens; mean  $0.02 \pm .01$ ; SD 0.05; range  $-0.05$  to  $+0.13$ ; *pipiens*. Lawrence; July 28, 1951; R. S. Roberts; 15 specimens; mean  $0.04 \pm .02$ ; SD 0.07; range  $-0.06$  to  $+0.19$ ; *pipiens*. Lawrence; Aug. 24-28, 1955; reared by H. L. McMillan; 43 specimens; mean  $0.04 \pm .01$ ; SD 0.08; range  $-0.05$  to 0.36; 2 intermediates, 41 *pipiens*. Frontenac; Aug. 15, 1951; R. S. Roberts; 11 specimens; mean  $0.11 \pm .02$ ; SD 0.08; range

fig. 4. Frequency Distribution of DV/D Ratios of a Population of *pipiens* and Intermediates ~ Norfolk, Virginia.



0.05 to 0.22; 1 intermediate, 10 *pipiens*. Baxter Springs; lab colony from R. S. Roberts; 9 specimens; mean  $0.15 \pm .03$ ; SD 0.10; range 0.06 to 0.29; 5 *pipiens*, 4 intermediates.

*Virginia*. Norfolk (fig. 4); a light trap collection from R. E. Dorer; 131 specimens; mean  $0.11 \pm .01$ ; SD .07; range  $-0.06$  to 0.39; 116 *pipiens*, 15 intermediates.

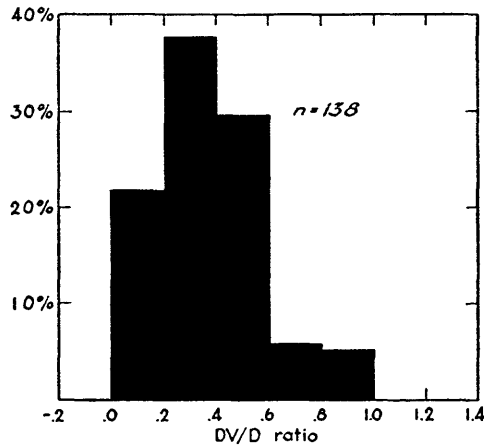
*North Carolina*. Camp Lejeune; reared by J. D. DeCoursey; 16 specimens; mean  $0.92 \pm .08$ ; SD 0.32; range 0.58 to 1.50; *quinquefasciatus*.

*Georgia*. Lakewood, Atlanta; Oct. 1955; H. D. Pratt; 103 specimens; mean  $0.91 \pm .03$ ; SD 0.29; range 0.49 to 1.44; *quinquefasciatus*. Emory University Field Station, Baker Co.; Sept. 1953; reared by M. H. Goodwin; 28 specimens; mean  $0.83 \pm .05$ ; SD 0.24; range 0.57 to 1.25; *quinquefasciatus*.

*Florida*. Orlando; reared by W. C. McDuffie; 103 specimens; mean  $0.80 \pm .02$ ; SD 0.22 range 0.50 to 1.50; *quinquefasciatus*. Miami; J. H. Heidt; 62 specimens; mean  $0.91 \pm .04$ ; SD 0.29; range 0.50 to 1.67; *quinquefasciatus*.

*Alabama*. Several lots from W. E. Snow. Florence; Oct. 12, 1954; 78 specimens; mean  $0.79 \pm .04$ ; SD 0.31; range 0.11 to 1.61; 2 *pipiens*, 4 intermediates, 72 *quinquefasciatus*. Sheffield; Nov. 18, 1953, reared; 12 specimens; mean  $0.77 \pm .08$ ; SD 0.30; range 0.55 to 1.23; *quinquefasciatus*. Winfield; 4 specimens; mean 0.64; range 0.61 to 0.71; *quinquefasciatus*. Auburn; Oct. 3, 1953; S. A. Edgar; 25 specimens; mean  $0.94 \pm .06$ ; SD 0.30; range 0.64 to 1.38; *quinquefasciatus*. Montgomery; laboratory colony of R. W. Chamberlain; 60 specimens; mean  $1.12 \pm .04$ ; SD 0.28; range 0.80 to 1.67; *quinquefasciatus*.

fig 5 Frequency Distribution of DV/D Ratios of a Population of *pipiens*, *quinquefasciatus*, and Intermediates.~ Sacramento Co., California.



*Mississippi.* All material from A. G. Peterson; all *quinquefasciatus*. Columbus; Aug. 24, 1944; 44 specimens; mean  $0.89 \pm .03$ ; SD 0.21; range 0.57 to 1.25. Greenville; Sept. 7 to Nov. 16, 1943 and 1944; 25 specimens; mean  $0.75 \pm .04$ ; SD 0.22; range 0.50 to 1.13. Tunica; Sept. 7, 1945; one specimen; 0.64.

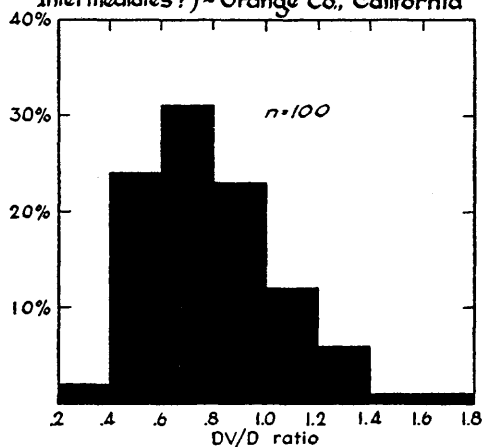
*Arkansas.* All material from T. E. McNeel. Gurdon; July 27 to Aug. 8; 14 specimens; mean  $0.85 \pm .08$ ; SD 0.30; range 0.57 to 1.20; *quinquefasciatus*. Pine Bluff; June 17, 2 specimens; 0.64 and 1.07; *quinquefasciatus*. Russellville; July 14-16; 9 specimens; mean  $0.82 \pm .12$ ; SD 0.35; range 0.58 to 1.10; *quinquefasciatus*. Bull Shoals; July 1 to Aug. 29; 9 specimens; mean  $0.32 \pm .09$ ; SD 0.26; range 0.10 to 0.90; 1 *pipiens*, 7 intermediates, 1 *quinquefasciatus*. El Dorado; Sept. 14, 1953; 7 specimens; mean  $0.87 \pm .18$ ; SD 0.46; range 0.83 to 1.00; *quinquefasciatus*.

*Texas.* Plainview; Aug. and Sept. 1953; F. C. Harmston; 17 specimens; mean  $0.99 \pm .10$ ; SD 0.36; range 0.66 to 1.66; *quinquefasciatus*. Lubbock; Aug. 1953; F. C. Harmston; 42 specimens; mean  $1.02 \pm .07$ ; SD 0.47; range 0.36 to 2.27; 2 intermediates, 40 *quinquefasciatus*. Beaumont; Aug. 1954; O. P. Breland; 65 specimens; mean  $0.87 \pm .03$ ; SD 0.22; range 0.52 to 1.36; *quinquefasciatus*. Eagle Pass; Oct. 3, 1953; 2 specimens; 0.70 and 0.80; *quinquefasciatus*. Houston; A. C. Chandler; 76 specimens; mean  $0.81 \pm .02$ ; SD 0.21; range 0.44 to 1.83; *quinquefasciatus*.

*Utah.* Salt Lake Co.; 5 collections, various dates, from L. T. Nielsen; 41 specimens; mean  $0.08 \pm .04$ ; SD 0.23 range -0.10 to 1.50; 40 *pipiens*, 1 *quinquefasciatus*.

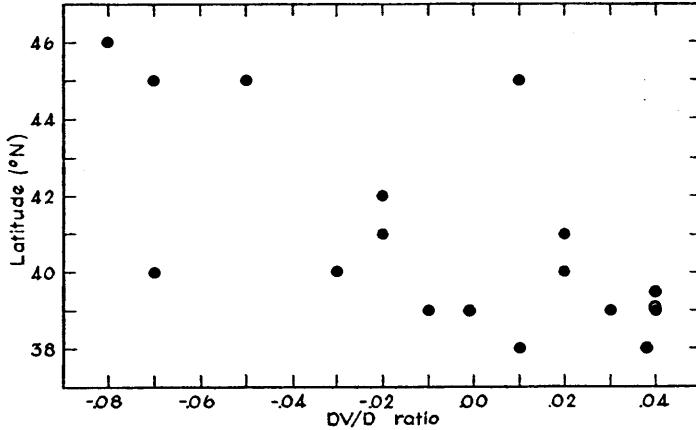
*California.* Sacramento Co. (fig. 5); Aug. 28-Sept. 22, 1947; E. C. Loomis; 138 specimens; mean  $0.36 \pm .02$ ; SD 0.20; range 0.08 to 0.88; 30 *pipiens*, 52 intermediates, 56 *quinquefasciatus*. San Joaquin Co., E. C. Loomis; 36 specimens; mean  $0.61 \pm .04$ ; SD 0.21; range 0.19 to 1.00; 1 *pipiens*, 4 intermediates, 31 *quinquefasciatus*. Stockton, San Joaquin Co.; E. C. Loomis; 4 males; mean 0.32;

fig. 6. Frequency Distribution of DV/D Ratios of a Population of *quinquefasciatus* (and Intermediates?) ~ Orange Co., California



range 0.13 to 0.58; 1 *pipiens*, 2 intermediates, 1 *quinquefasciatus*. Firebaugh, Fresno Co.; Oct. 7, 1952; E. C. Loomis; 12 specimens; mean  $0.71 \pm .09$ ; SD 0.31; range 0.43 to 1.13; *quinquefasciatus*. Fresno; Sept. 17, 1953; B. A. Newhouse and G. F. Smith; 69 specimens; mean  $0.69 \pm .02$ ; SD 0.18; range 0.33 to 1.13; 2 intermediates, 67 *quinquefasciatus*. Fresno, Oct. 16, 1953; R. C. Husbands; 209 specimens; mean  $0.76 \pm .01$ ; SD 0.19; range 0.38 to 1.38; 1 intermediate, 208 *quinquefasciatus*. Fresno; Oct. 8, 1953; R. C. Husbands; 202 specimens; mean  $0.79 \pm .02$ ; SD 0.23; range 0.43 to 2.00; *quinquefasciatus*. Selma, Fresno Co.; Nov. 30, 1953; from the Consolidated Mosquito Abatement District; 30 specimens; mean  $0.87 \pm .05$ ; SD 0.27; range 0.50 to 1.25; *quinquefasciatus*. King's Co.; E. C. Loomis; 4 specimens; mean 0.65; range 0.50 to 0.83; *quinquefasciatus*. Bakersfield; Sept. 16, 1953; B. A. Newhouse and G. F. Smith; 38 specimens; mean  $0.74 \pm 0.04$ ; SD 0.22; range 0.50 to 1.25; *quinquefasciatus*. Loma Linda, San Bernardino Co.; reared by R. E. Ryckman; 135 specimens; mean  $0.87 \pm .02$ ; SD 0.25; range 0.36 to 1.67; 1 intermediate, remainder *quinquefasciatus*. San Bernardino, San Bernardino Co.; Apr. 23, 1951; reared by R. E. Ryckman; 57 specimens; mean  $0.88 \pm .03$ ; range 0.50 to 1.38; *quinquefasciatus*. Cucamonga, San Bernardino Co.; reared by R. E. Ryckman; 11 specimens; mean  $0.64 \pm .07$ ; SD 0.24; range 0.44 to 0.83; *quinquefasciatus*. Redlands, San Bernardino Co.; Sept. 20, 1951; reared by R. E. Ryckman; 145 specimens; mean  $0.90 \pm .03$ ; SD 0.29; range 0.44 to 2.00; *quinquefasciatus*. Riverside Co.; J. N. Belkin; 21 specimens; mean  $0.97 \pm .08$ ; SD 0.35; range 0.67 to 1.50; *quinquefasciatus*. Orange Co. (fig. 6); Sept. 24, 1953; J. G. Shanafelt; 100 specimens; mean  $0.78 \pm .03$ ; SD 0.27; range 0.25 to 1.67; 2 intermediates, 98 *quinquefasciatus*. Orange Co.; Sept. 30, 1953; J. G. Shanafelt; 80 specimens; mean  $0.79 \pm .04$ ; SD 0.35; range 0.30 to 2.50; 1 intermediate, 79 *quinquefasciatus*.

fig. 7. DV/D Ratios of Collections of Typical *pipiens* vs. Latitude



*Sardinia*

Dr. T. H. G. Aitken provided a number of jointed lots from Sardinia. The coverslips were unsupported on these preparations so they are not strictly comparable with the author's material. Various dates; 104 specimens; mean  $-0.11 \pm .004$ ; SD 0.05; range  $-0.22$  to  $+0.03$ ; *pipiens*.

*Puerto Rico*

Mayaguez. I. Fox; 11 specimens; mean  $0.83 \pm .11$ ; SD 0.36; range 0.57 to 1.50; *quinquefasciatus*.

*Liberia*

Monrovia. G. J. Burton; 8 specimens; mean  $0.90 \pm .14$ ; SD 0.40; range 0.71 to 1.38; *quinquefasciatus*.

DISCUSSION

From the foregoing data (Figs. 8 & 9) it can be seen that in general in North America only *pipiens* is found north of about 39°N. and only *quinquefasciatus* south of about 36°N. Between these two latitudes *pipiens*, *quinquefasciatus*, intermediates, and various mixtures of the three are found.

It would appear (Fig. 7) that there is a gradual cline in the *pipiens* s. s. population, smaller values being found in the north and larger ones in the south. This may be due to introgression of *quinquefasciatus* genes from the south. The Norfolk, Virginia collection (Fig. 4) would support this view since it is composed of *pipiens* and intermediates; no *quinquefasciatus* were found in that locality.

There is a steep gradient in the average ratio in the zone of intergradation of the two forms as shown in Fig. 8. Collections from this area

<sup>4</sup> Less than .005.

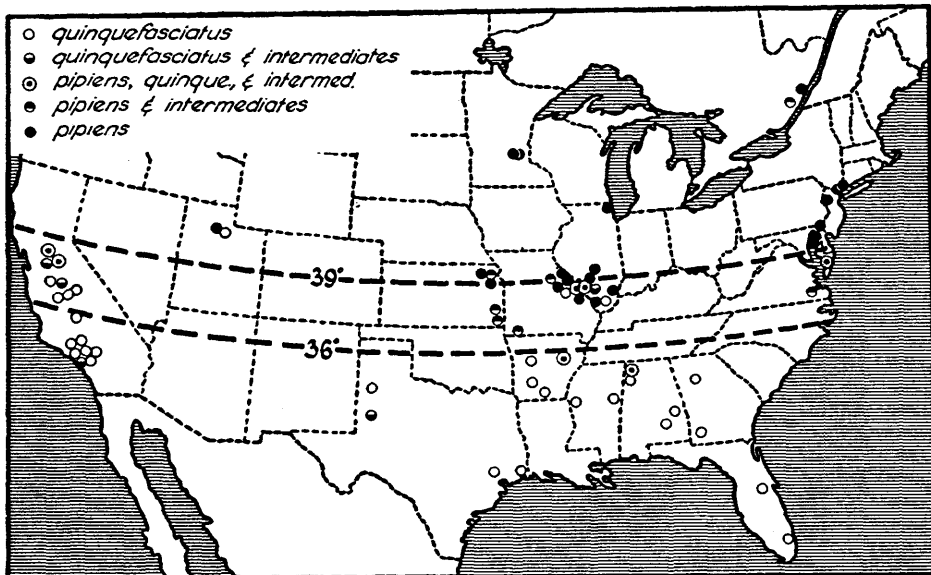
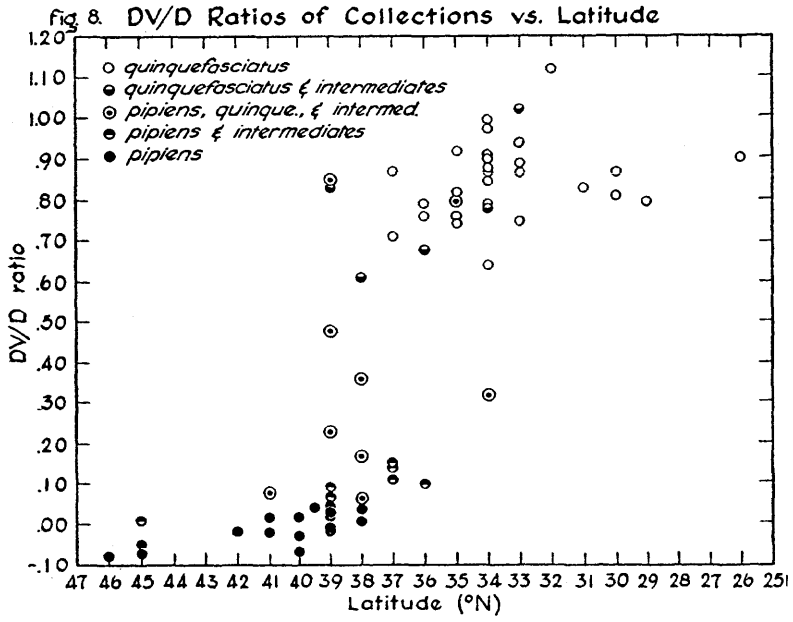


fig. 9. Distribution of *Culex p. pipiens* and *C. p. quinquefasciatus* in America north of Mexico.

are very variable and are composed of mixtures of *pipiens*, *quinquefasciatus*, and intermediates. In most areas (East St. Louis, Fig. 3) the two parental forms are more common than intermediates which suggests that there may be unrecognized isolating mechanisms present. In at least one locality (Sacramento Co., Calif., Fig. 5) the forms are thoroughly intermingled which shows that there is considerable gene flow between the two forms in nature.

The ratio apparently reaches a maximum value in the *quinquefasciatus* population (Fig. 8). No cline can be seen even when collections from equatorial areas are included. In large samples of *quinquefasciatus* a few values may be found which overlap with hybrid values. This is the author's interpretation of the low values in the Orange Co., California collections (Fig. 6) since this locality appears to be so far south of the zone of intergradation (Fig. 9); it probably also accounts for the low values from Lubbock, Texas, and Loma Linda, California.

There is one outstanding *pipiens* collection, that from Bull Shoals, Arkansas, which is in the range of *quinquefasciatus*. This is a mountainous locality which suggests that the cline from *pipiens* to *quinquefasciatus* might be found on the sides of mountains in the *quinquefasciatus* zone.

*Systematic position.* In some localities (St. Louis, Fig. 3) *pipiens* and *quinquefasciatus* seem to be isolated for the most part even though there appears to be some gene flow between the two forms. In such localities one might be tempted to consider the forms separate species but to the author this makes the species concept very subjective. Since there appears to be some gene flow between the forms in such localities, the author would consider the forms subspecies. In other localities (Sacramento Co., Fig. 5) the forms appear to be thoroughly intermingled. In such localities one would consider the forms to be no more than subspecies at best. In view of the arguments of Wilson and Brown (1953) one should consider the objective reality of the subspecies concept as applied to these forms. At the present time it would appear that each form has a complex of biological characteristics which differentiates it from the other form, although these characteristics have not been studied from a quantitative point of view. These characteristics include the amount of space needed for mating, the ability to overwinter, and preferences in breeding places and hosts. The author therefore favors retention of subspecific status for the two forms although it would be well to study other clines in these forms to learn whether they have steep gradients which parallel the presently discussed one. It should be pointed out that present evidence indicates the inheritance of the DV/D ratio to be multifactorial and not due to one or two genes.

"*Culex molestus*" is a complicating factor in the complex since it appears to have a discontinuous distribution throughout the range of *pipiens*. Since autogeny (the ability to lay eggs without blood) is diagnostic for "*molestus*" this can be considered another biological characteristic of the *pipiens* population; autogeny is unknown in *quinquefasciatus*.

Finally, the author believes that this complex should be studied more intensively in the zone of intergradation between the two forms. There appear to be

isolating mechanisms between *pipiens* and *quinquefasciatus* in most localities which are not recognized at the present time. Hybrid sterility does not seem likely in view of the work of Sundararaman (1949) and Barr and Kartman (1951). Rozeboom and Gilford (1954) were not able to demonstrate "psychological" or behavioral barriers to mating in these forms.

#### ADDENDUM

Since the above was written the author has received a series of males from the Los Angeles, California area through the courtesy of Dr. J. N. Belkin. These included 55 specimens of which three were *pipiens*, 13 intermediate, and 39 *quinquefasciatus*. The most interesting series was a group of six specimens from Wilmington which had ratios ranging from .03 to .43; three of the six were *pipiens*. From this information it is clear that there is a hybrid swarm on the coast of California near Los Angeles. This information also demonstrates that what the author considered to be normal variants from Orange County, California were actually intermediates. The only other specimens which appeared to be normal variants in this study were those from Lubbock, Texas. Further collecting would probably reveal a hybrid swarm in that area as well.

#### SUMMARY

The DV/D ratio was measured in about three and a half thousand males of *pipiens* and *quinquefasciatus*, mostly from North America. It was found that the average ratio in a collection of *pipiens* is usually 0.1 or less and in *quinquefasciatus* 0.6 or more. In individual specimens the ratio is usually less than 0.2 in the former and more than 0.4 in the latter. In North America north of 39°N. only *pipiens* is usually found; south of 36°N. only *quinquefasciatus* is generally present. Collections from between these latitudes may contain one or the other form, intermediates, or various mixtures of the three. There seems little doubt but that the forms do hybridize in nature. In some localities (Sacramento, Calif.) intermingling seems to be much freer than in others (East St. Louis, Ill.). At the present time it seems wisest to retain subspecific names for the two forms.

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