# VARIATION IN JUNONIA COENIA IN MISSISSIPPI (NYMPHALIDAE)

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Concerning Junonia coenia, Klots (1951) wrote: "We do not yet fully understand the relationships of the various forms of this butterfly. . . . A great deal of careful study and thorough analytical work is needed." The present paper discusses results of a study of some aspects of variation in Junonia coenia coenia (Hübner) in Mississippi. The 105 Mississippi specimens which were studied were collected over a 10-year period, represented dates of capture in all 12 months and localities in 17 counties representing all sections of the state, and included 52 males and 53 females. Of the 105 specimens, 83 were taken in Hinds County and a total of 86 in the southwestern region of Mississippi as defined by Mather and Mather (1958), 12 were from the southeastern region, three from the northwestern, and two each from the northeastern and east central regions. No indication of intra-state geographical variation was detected. Features examined included: (a) Length of right forewing, measured with dividers and scaled to the nearest 1.0 mm; (b) Underside ground color (dark, intermediate, light); (c) Presence of subapical spot on forewing upperside as seen by the unaided eye (absent, faint, present); (d) Maximum diameter of each eyespot on the hindwing upperside, measured to the nearest 0.1 mm using an eyepiece micrometer and a magnification of  $10 \times$ ; and (e) Ratio of diameters and areas of the eyespots on the hindwing upperside. Data on each of these features are presented and discussed below.

### Forewing length

The range of forewing lengths was 19 to 31 mm, distributed by month of capture as shown in Table 1; mean monthly values are indicated by open squares. The mean forewing length increases gradually from a minimum of about 21 mm in January to a maximum of about 27 mm in October, after which it decreases rapidly to about 24 mm in November and 22 mm in December. The peak in October and rapid decrease thereafter may coincide with the beginning of cold weather; the earliest date for killing frost in central Mississippi is October 10 and the average date is November 5.

In Virginia, Clark and Clark (1951) reported mean forewing lengths for the typical spring and fall form as 24 mm in males, 27 mm in females,



and noted that summer specimens are a little larger and individuals of another form confined to localized wet areas are still larger, about 28 mm for males and 30 mm for females. Field (1940) reported size values for the Kansas population, normal range 45 to 50 mm, 60 mm for large females, and 35 mm for "dwarfs." Assuming that these may be converted to forewing lengths by subtracting 2 mm from each value for thorax width and dividing the remainder by two, the normal Kansas forewing length is 21.5 to 24 mm and the extremes are 16.5 and 29 mm. It would

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	DARK		INTE	RMEDIATE	LIGHT	
	No	%	No	%	No	%
JAN	7	88	1	12	-	-
FEB	5	100	-	-	-	-
MAR	2	66	1	33	-	-
APR	T	7	3	21	10	72
MAY	-	-	-	-	5	100
JUN	-	-	-	-	5	100
JUL	-	-	-	-	3	100
AUG		-	I	14	6	86
SEP	8	61	1	8	4	31
Сст	6	45	5	40	2	15
Nov	3	37	4	50	1	13
DEC	18	85	2	10	I	5
TOTAL	50		18		37	

TABLE 2									
DISTRIBU	TION OF	105 Spf	ECIME	NS OF J. C	с. с	OENIA FE	ROM MISS	ISSIPPI BY	DEPTH OF
Ground	Color	Below	AND	Month	IN	WHICH	TAKEN,	SHOWING	SEASONAL
CHANGE IN DEPTH OF GROUND COLOR UNDERSIDE									

therefore appear that the individuals comprising the Mississippi population are somewhat smaller in size than those of the Virginia population and very slightly larger than those of the Kansas population; and that our sample includes three specimens that are larger than the largest Field found and none as small as the smallest he found.

#### GROUND COLOR OF UNDERSIDE

The distribution of specimens by underside ground color and month of capture by number and percentage is shown in Table 2. No specimens with light ground color below were among those taken in January, February, or March; none with dark ground color below were among those taken in May, June, July, or August. The major seasonal shift from dark to light appears to take place between March and April, and



Fig. 1. Percentage distribution by months of capture of Mississippi specimens of *J. c. coenia* having light, intermediate, and dark ground color on underside.

from light to dark between August and September; the former being somewhat more abrupt than the latter. In central Mississippi the March-April shift coincides with a change in mean temperature from below  $60^{\circ}$  F to above  $60^{\circ}$  F ( $16^{\circ}$  C), and the August-September shift with a change from above  $80^{\circ}$  F to below  $80^{\circ}$  F ( $27^{\circ}$  C). The mean rainfall for March is higher than for any other month (5.9 inches), and is lowest for October (2.5 inches). The August–September shift does not accompany an increase in average monthly rainfall; the mean values for August, September, and October being 4.0, 3.1, and 2.5 inches respectively. I have observed no association between depth of ground color below and moistness of habitat in Mississippi. The percentage relations of specimens of different depths of ground color below by months are shown in Figure 1.

#### SUBAPICAL SPOT ON UPPERSIDE OF FOREWING

Of the 105 specimens examined, 53 were classified as having the spot well developed; in 40 it was present but faint; and in 12 it was not visible to the unaided eye. Examination of the latter at a magnification of  $30 \times$  revealed that at least a few blue scales were present or that the specimen was so rubbed that it might be assumed that such scales could once have been present. The twelve specimens showing no visible spot had forewing lengths from 19 to 29 mm, six had forewing lengths of 19, 20, or 21 mm; thus suggesting a tendency for obsolescence of this spot to be associated with diminution in size.

### RELATIVE SIZE OF SPOTS OF HINDWING UPPERSIDE

The measured values for the maximum diameters of anterior and posterior spots for the 105 specimens are plotted in Figure 2. Solid triangles represent males, open circles represent females. For each specimen represented by a spot in Figure 2 the ratio of the diameters of anterior to posterior spot was calculated and a frequency diagram of these ratios is given as Figure 3. Figure 3 indicates a skewed distribution. The most frequent ratio of diameters for the Mississippi population is about 1.65, with more specimens having values larger than this and fewer having smaller values. The diagram also suggests that the specimen having the smallest ratio (1.26), reported previously (Mather and Mather, 1958) as suggestive of the phenotype of *zonalis* is more clearly a part of the Mississippi population as a whole than the specimen at the other end of the distribution which has a ratio of 2.59. In Figure 4 the points representing the four Mississippi specimens yielding the extreme data points in Figure 2 are replotted and values derived from one additional specimen in our collection, nine specimens figured in the literature (see Table 3), are indicated. The three specimens figured by Holland (1931) and Klots (1951) that are assigned to zonalis have ratios between 1.15 and 1.29. The two Mississippi specimens with the lowest diameter ratios are 1.26 and 1.36. The position in Figure 4 of the points for the six figured specimens of *coenia* suggest that the individuals com-



Fig. 2. Relation of maximum diameter of anterior and posterior eyespots on hindwing upperside for 52 male and 53 female specimens of *J. c. coenia* from Mississippi, showing extreme ratios of diameters of 1.26:1 and 2.59:1.



Fig. 3. Frequency distribution for ratios of diameters and ratios of areas of anterior and posterior eyespots on hindwing upperside for 105 specimens of J. c. coenia from Mississippi.

prising the Mississippi population may have ratios that are slightly lower than average for a "typical" *coenia* population.

Both Klots (1951) and Brown (1955) characterize *coenia* as having the anterior spot on the hindwing above "from two to three times as large as the posterior one" or "at least twice and often three times as large." This contrasts with *zonalis* in which the anterior spot is described as "little larger than the posterior one." Barnes and McDunnough (1916,

 TABLE 3

 Relation of Maximum Diameter of Anterior and Posterior Eyespots on Hindwing Upperside in Mississippi J. COENIA and Specimens Figured in the Literature as J. ZONALIS. Data Plotted in Figure 4

	DIAME OF S MI ANT- ERIOR	POT, M POST- ERIOR	RATIO OF DIAM- ETERS	FORE - WING LENGTH, MM	DATE TAKEN	LOCALITY	REFERENCE
A	4.3	2.3	1.87	20	7 JUN 1959	CLINTON, MISS.	
B	4.8	3.8	1.26	25	10 SEP 1949	CLINTON, MISS.	MATHER AND MATHER (1958) "LIKE ZONALIS"
c	9.2	5.3	1.74	30	20 OCT 1957	BROWNSVILLE, MISS.	
D	9.3	4.5	2.07	29	22 SEP 1957	PETERSBURG, VA.	
E	5.7	2.2	2.59	19	8 AUG 1954	CLINTON, MISS.	
F	6.4	2.9	2.20	-		CHAPEL HILL, N.C.	KLOTS (1951), PL 14, FIG 12 "CDENIA" 07
G	4.5	3.5	1.29	-	_		HOLLAND (1931), PL.XX, FIG 9 "GENOVEVA" or (a)
Н	4.4	3.4	1.29	-	-	TITUSVILLE, FLA.	KLOTS (1951), PL. 14, FIG 13 "ZONALIS" 07
1	4.0	3.5	1.15	-	-	_	HOLLAND (1931), PL.XX, FIG 8 "LAVINIA" or (2)
J	7.0	3.6	1.94	-	19 SEP 1925	CABIN JOHN, MD.	(LARK (1932), PL. 7, FIG 3 "COENIA" DRY FORM &
K	7.5	4.5	1.67	-			BROWN (1955), PIO4 "LAVINIA & COENIA"
L	8.5	4.6	1.85	-	25 5EP 1925	CABIN JOHN, MD.	CLARK AND CLARK (1951), PL. 5, FIG. 9 "COENIA" WET FORM &
M	9.0	5.0	1.80	-			HOLLAND (1931), PLXX, FIG 7 "COENIA" 9
N	4.9	2.6	1.89	~	-		MACY AND SHEPARD (1941), PL. I "BUCKEYE" (COENIA)

(a) BOTH REFERABLE TO ZONALIS (KLOTS, 1951)



FIG. 4. Relation of maximum diameter of anterior and posterior eyespots on hindwing upperside for four Mississippi specimens of J. c. coenia, one from Virginia, six figured in the literature, and three specimens figured in the literature representing J. zonalis. Data for these fourteen points are given in Table 1.

Plate IX, Figs. 6, 7) figure a female *coenia* from Long Island, N. Y. and a female *genoveva* from Miami, Florida. The latter is similar to that figured by Klots (1951) from Titusville, Florida as *zonalis*. Barnes and McDunnough emphasize that the feature selected to differentiate *genoveva* from *coenia* was the replacement by orange suffusion in *genoveva* of the brownish encirclement bounded outwardly by the black of the large eyespot on the dorsal surface of the forewing in *coenia*. This difference is clearly shown in Klots' figure but not emphasized by him in the text. The Mississippi specimen (Fig. 5 B) having hindwing eyespots in the size relation of figured specimens assignable to *zonalis* does not



Fig. 5. Five Mississippi specimens of J. c. coenia. Specimens A, B, C, E yielded data shown in Figure 4; A has the smallest anterior spot of the sample; B has the

have the forewing eyespots surrounded by orange, but it also lacks a clear development of the blacker outer boundary of the brownish zone surrounding this spot.

The eyespots in the hindwing upperside in *coenia* are not exactly circular but were considered to be so for the calculation of areas from diameters. If two spots have the same diameter they were assumed to have the same area. In the absence of qualifying comment to the contrary I would assume that authors who describe a spot as "twice or three times as large" as another spot must refer to the area relations of the spots in question. For this reason, Figure 3 has been provided with two scales, one showing ratios of diameters, the other showing ratios of areas computed from the diameters. The range in ratios of diameters of spots of specimens yielding data plotted in Figure 4 is from 1.15 to 2.59, hence the range in areas ("sizes") is from about 1.3 to 6.9. The ratio of spot diameters of the figures of specimens of coenia given in Klots (1951) and Brown (1955) is respectively 2.20 and 1.67 which correspond to 4.8 and 2.8 in ratios of area. The most frequent diameter ratio for the specimens of the Mississippi sample is about 1.65 which corresponds to a ratio of areas ("sizes") of about 2.7. No reference has been found in the literature to a specimen of *coenia* having an anterior spot that has an area approximately seven times that of the posterior spot (Fig. 5 E).

Based on the data and the relations presented in Figures 2, 3, and 4, it is suggested that *zonalis* may be characterized in part as having hindwing eyespots above in which the diameter of the anterior spot is less than 1.4 times (or the area less than twice) that of the posterior spot; while *coenia* may be characterized, in part, by spots in which the diameter of the anterior spot is more than 1.4 times (or the area more than twice) that of the posterior spot and including individuals in which these ratios go up at least to 2.6 and 7 respectively.

Figure 5 is a photograph of five Mississippi specimens including those representing the observed extremes of variation in the dimensional relations of the eyespots in the hindwing upperside. Those designated A, B, C, and E define the limits of the observed data for the Mississippi sample as these limits are shown in Figure 4. In specimen B the larger spot is about one and one-half times as large as the smaller spot; in specimen E the larger spot is nearly seven times as large as the smaller; these two specimens account for the two bars in the graph (Fig. 3) that are separated from the mass of the data for Mississippi.

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smallest ratio of diameters (1.26:1); C has the largest anterior and posterior spots; E has the largest ratio of diameters (2.59:1) and the smallest posterior spot; X has the smallest space between the anterior and posterior spots.

#### SUMMARY

The Mississippi population of Junonia represents a single variable population that may be called *Junonia coenia coenia* (Hübner). J. c. coenia is a population, the individuals of which characteristically have hindwing evespots of such proportionate sizes that the diameter of the anterior spot is more than 1.4 times, and its area is more than twice, that of the posterior spot. All but two of 105 Mississippi specimens studied had hindwing spots with ratios of diameters of 1.4 or more. The Mississippi specimens have the hindwing spots of upperside somewhat more nearly equal in size than appears to be the case for *coenia* in the rest of its range. The Mississippi individuals range in size from those having a forewing as short as 19 mm to others having a forewing as long as 31 mm. The size increases from a January average minimum of about 21 mm to an October average maximum of 27 mm and then decreases rather rapidly. The ground color of underside is predominantly dark from September through March, and light from April through August. More individuals having light ground color persist after August than do individuals with dark ground color after March. No association of ground color of underside with moistness of habitat or variation of average rainfall was found. The change in depth of ground color of underside with season appears more abrupt than does the change of size with season. A majority of the Mississippi specimens showed a well-developed subapical spot in the forewing above; in most of the remaining specimens such a spot was visible but faint; in 12 of 105 specimens it was not visible to the unaided eye. An association of tendency for obsolescence of this spot with diminution of wing length was noted.

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