Pyrgus sp. (group of *P. communis* (Grote))
Rio Cañon 12–19.VI (4♂ 2♀); Rio Salado 30.VI (2♀)
Pholisora catullus (Fabricius)
Rio Cañon 10.VI (1)
Ancyloxypha arene (Edwards)
Rio Cañon 16–18.VI (1♂ 1♀)
Copaeodes aurantiaca (Hewitson)
Rio Cañon 18–26.VI (6)
Hylephila phyleus (Drury)
Rio Cañon 10.VI (1♂ 1♀)
Amblyscirtes nysa Edwards
Rio Cañon 26.VI (1♀)

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CONTINUOUS VARIATION IN RELATED SPECIES OF THE GENUS *CATOCALA* (NOCTUIDAE)

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The genus *Catocala* has been extensively studied for more than a century. In fact, at the turn of the century, American journals dealing with the Lepidoptera sometimes devoted the bulk of their coverage to this genus. Even with all this attention many taxonomic problems remain. These problems have defied classical morphological techniques, perhaps because they centered around characters differing in kind rather than amount. This study is, in the main, descriptive of the variation existing in several frequently used diagnostic characters. However, the species used in the examples were selected to suggest the utility of these statistical descriptions in taxonomic studies. They may supplement a knowledge of classical morphology and ecology.

Methods

An unselected sample of over 1500 *Catocala* of 30 species was taken during the summer of 1961 at a Mercury vapor light operated on the edge of a deciduous wood at the University of Michigan, Edwin S. George

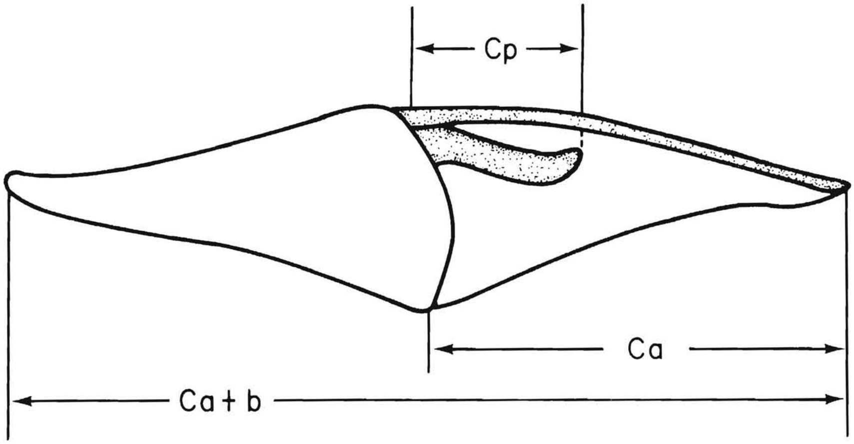

Fig. 1. Schematic diagram of the right clasper of the genus *Catocala*, showing the measurements used.

Reserve, Pinkney, Michigan. From this sample the following series were studied:

78 male *C. ilia* Cramer
25 male *C. palaeogama* Gueneė̀
25 male *C. retecta* Grote
17 male *C. sordida* Grote[1]
7 male *C. gracilis* Edwards[1]

The following measurements were made on each of the 152 specimens: wing span (WS), total right valva (clasper) length (C a + b), length of distal clasper segment (Ca) and length of clasper projection (Cp) (Fig. 1). The measurement WS was considered a reflection of the overall size of the moth. Cp and Ca, being heavily sclerotized, are more reliable measures than C a + b.

RESULTS

Table 1 presents the mean and standard deviation of the four variables for the five species considered.

Table 2 presents the coefficients of correlation of each of the variables on all other variables. The overall size of the moth as measured by WS is not significantly correlated to the size of the genitalia. However, the various genitalia measurements are not independent. Cp was chosen for further analysis.

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[1] Determined by A. E. Brower, Augusta, Maine, to whom we are grateful for many helpful comments.

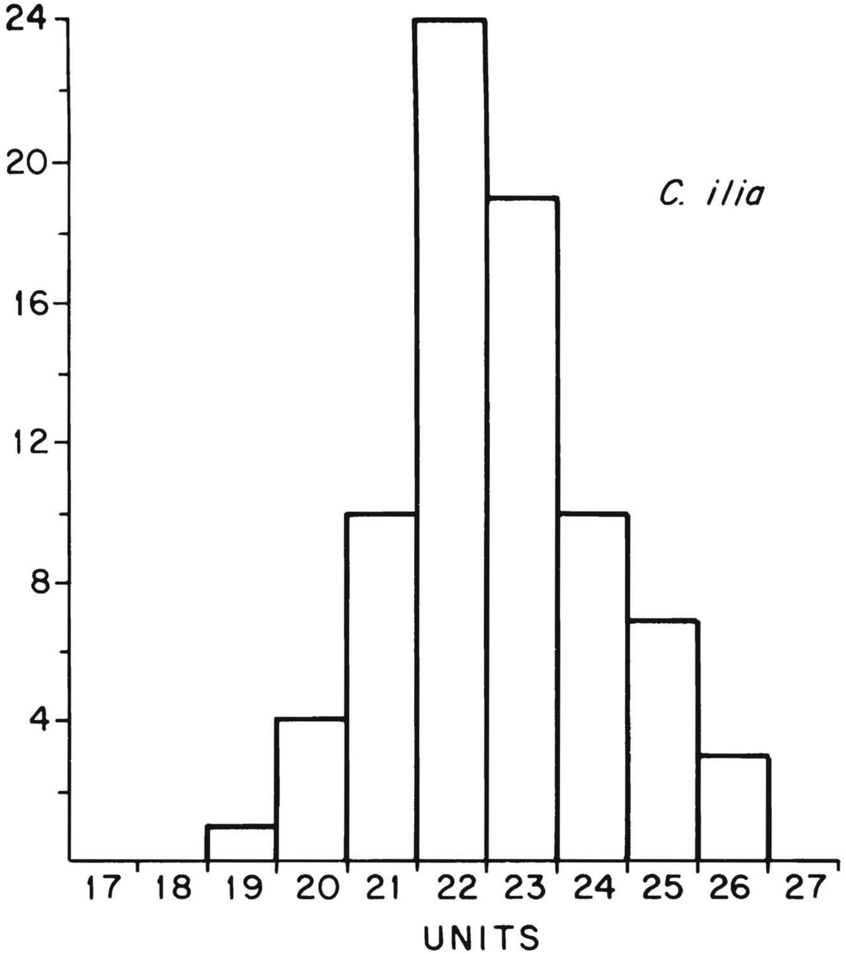
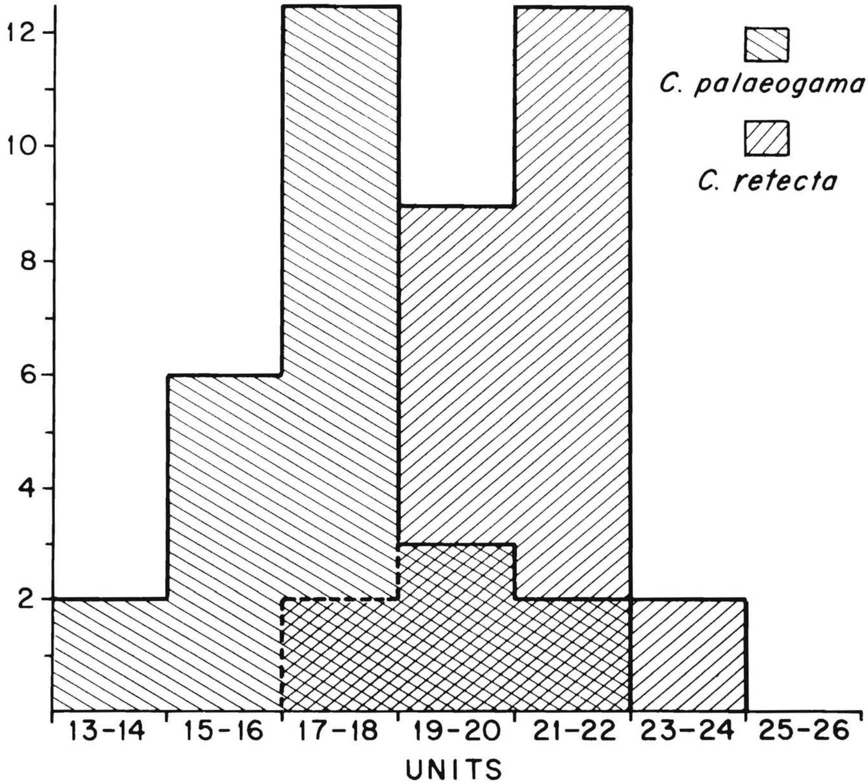


Fig. 2. Frequency distribution of the clasper projection (C p) in *Catocala ilia.*

Figure 2 presents the frequency distribution of Cp for *Catocala ilia.* It approaches the normal distribution.

Figure 3 presents the frequency distribution of Cp for *C. palaeogama* superimposed on *C. retecta.* These two species are closely related but distinct species. The measurement of Cp definitely indicates two populations with some overlap. The "t" test of difference of the means is significant at a $P < 0.001$.

Figure 4 presents the frequency distribution of Cp for *C. gracilis* superimposed on *C. sordida.* These species are closely related and individual specimens are often impossible to determine with certainty.


12
10
8
6
4
2
C. palaeogama
C. retecta
13-14
15-16
17-18
19-20
21-22
23-24
25-26
UNITS

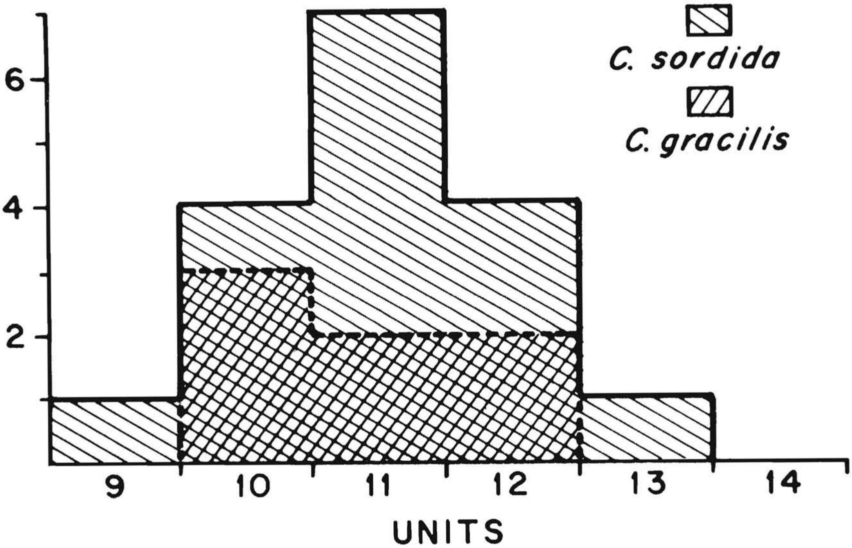

6
4
2
C. sordida
C. gracilis
9
10
11
12
13
14
UNITS

TABLE 1: MEAN AND STANDARD DEVIATION OF FOUR VARIABLES FOR FIVE SPECIES OF *CATOCALA*[1]

		Mean	Standard deviation
ilia	WS	77.14103	2.97926
	C a + b	78.20513	4.95003
	C a	40.02564	2.61849
	C p	22.64103	1.51164
palaeogama	WS	67.96000	2.09126
	c a + b	59.20000	4.46281
	C a	32.88000	3.07300
	C p	17.24000	2.14632
retecta	WS	71.48000	2.90287
	C a + b	71.64000	4.51738
	C a	40.68000	3.36304
	C p	20.68000	1.46401
gracilis	WS	41.71429	1.25357
	C a + b	35.42857	2.63674
	C a	20.14286	1.57359
	C p	10.85714	0.89974
sordida	WS	41.70588	1.21268
	C a + b	38.64706	2.64436
	C a	20.23529	1.25147
	C p	11.00000	1.00000

[1] (WS measured in mm.; Ca and Cp measured in units, 50 units = 7 mm.)

Here the measurement of Cp does not indicate two populations and the "t" test is not significant, P—0.50–0.80.

DISCUSSION

Variation in the clasper of these five species of the genus *Catocala* is clearly continuous. The frequency distributions are nearly normal, implying that the character is controlled by small additive contributions from many genetic factors, no one of which is individually measurable (*i.e.*, multifactorial inheritance).

It is not surprising that closely related but distinct species (*C. retecta* and *C. palaeogama*) showed some overlapping values. The bulk of their genetic contribution is probably of identical origin. It is even less sur-

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Fig. 3. Frequency distribution of the clasper projection (C p) in *Catocala palaeogama* and *C. retecta*.

Fig. 4. Frequency distribution of the clasper projection (C p) in *Catocala gracilis* and *C. sordida*.

TABLE 2: CORRELATION COEFFICIENTS FOR FOUR VARIABLES IN FIVE SPECIES OF *CATOCALA*[1]

		WS	C a + b	C a	C p
ilia	WS	1.0000	0.24635	0.19764	0.16711
	C a + b		1.00000	0.76008	0.31197
	C a			1.00000	0.34030
	C p				1.00000
palaeogama	WS	1.00000	−0.15536	0.44011	0.14147
	C a + b		1.00000	0.26007	0.16008
	C a			1.00000	0.50362
	C p				1.00000
retecta	WS	1.00000	0.37913	0.54990	0.53767
	C a + b		1.00000	0.45561	0.00076
	C a			1.00000	0.57073
	C p				1.00000
gracilis	WS	1.00000	−0.10805	0.70007	0.25332
	C a + b		1.00000	0.38448	0.45163
	C a			1.00000	0.48769
	C p				1.00000
sordida	WS	1.00000	0.55031	0.25436	0.15462
	C a + b		1.00000	0.61213	−0.04727
	C a			1.00000	−0.04994
	C p				1.00000

[1] (WS measured in mm.; Ca and Cp measured in units, 50 units = 7 mm.)

prising that *C. gracilis* and *C. sordida* completely overlap, since they are of similar size, shape and coloration. Their eggs and larvae are nearly identical. They feed on the same food plant (*Vaccinium*). Several possibilities exist to explain this degree of overlap. The sample may be too small to demonstrate a difference. However the frequency distributions give no evidence that these samples are abnormal. There may be hybridization in Michigan. This is very possible if the two species are isolated mainly by weak ecological factors which may be ineffective in this area where *C. gracilis* is on the very edge of its range. Finally it is recognized that parallel varietal forms occur (*e.g.*, some specimens of both species may have a dark shade along the inner third of the forewing). It is possible that these two species are in fact a single breeding population which has been artificially separated on the basis of monomeric traits having diverse gene frequencies in various geographic areas.

The study of continuously varying characters, such as those considered in this report, is unlikely to give definitive results. However it is likely that most adaptive radiation is on the basis of quantitative rather than monomeric traits. Thus such characters are appropriate material for the study of racial and geographic variation.