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STUDIES ON THE *CATOCALA* (NOCTUIDAE) OF SOUTHERN NEW ENGLAND. I. ABUNDANCE AND SEASONAL OCCURRENCE OF THE SPECIES, 1961–1969

THEODORE D. SARGENT
Department of Zoology, University of Massachusetts, Amherst, Massachusetts
and
SIDNEY A. HESSEL
Entomology Section, Peabody Museum, Yale University, New Haven, Connecticut

The *Catocala* moths pose an interesting evolutionary enigma. This large genus, consisting of some 200 species in the broadest use of the generic name, is characterized by extensive sympatry throughout most North Temperate regions of the world, and its members occupy a relatively narrow ecological niche, the larvae being oligophagous and the adults being cryptically marked when at rest on tree trunks. In New England alone, at least 52 *Catocala* species are known to occur (Forbes 1954), and we have taken as many as 21 species on a single night at one location.[1] Nevertheless, natural hybrids are unknown. This tremendous array of sympatric and rather closely related species immediately raises the question as to what sorts of mechanisms operate to limit natural hybridization within the genus. One long-range goal of these studies is to describe such mechanisms through detailed analyses of the behavior, ecology, and genetics of these moths.

Despite the popularity of the North American *Catocala* moths with collectors, relatively little of their total biology is known. They have been treated taxonomically by Grote (1872, 1873, 1876), Hulst (1880,

[1] 20 August 1961, Washington, Connecticut: *C. epione, antinympha, badia, habilis, flebilis, obscura, residua, retecta, dejecta, palaeogama, subnata, neogama, ilia, parta, concumbens, sordida, andromedae, ultronia, grynea, praeclara,* and *amica.*

1884), Hampson (1910), McDunnough (1938), and Forbes (1954). Plates depicting most of the North American species are available in Holland (1903) and Barnes and McDunnough (1918). Present knowledge of the life histories and geographic ranges of the New England *Catocala* is summarized in Forbes (1954).

Information on the behavior and ecology of these moths is scanty and largely anecdotal. Some observations on the resting habits of adults have been recorded (e. g. Bunker, 1874; French, 1880; Johnson, 1882; Rowley and Berry, 1909; Kettlewell, 1958; Sargent and Keiper, 1969). Limited data on the movements of adults have been obtained from studies of color-marked individuals (Brower, 1930). Virtually nothing is known of courtship and mating behaviors—a fact that has precluded any detailed studies on the genetics of these moths.

The present report constitutes a first step in our study of the *Catocala* of southern New England: an account of the species that are present, based on daily counts of adults taken for several years in two localities. It is hoped that these data will provide a foundation for planning further investigations, will serve as a record for future comparative purposes, and will stimulate others to obtain comparable data from their localities.

Methods

The basic data utilized in this report are daily counts of adult *Catocala* taken in the vicinity of Amherst, Massachusetts (Area 1) for the years 1964 through 1969; and from Washington, Connecticut (Area 2) for the years 1961 through 1965, 1967, and 1969.

Area 1. Records here are based on collecting of 2009 specimens by T. D. Sargent and two graduate students at several localities in Franklin and Hampshire Counties in north-central Massachusetts, all localities lying within 10 miles of the center of Amherst. The vast majority of the records are from two sites, one in Pelham (1964–66) and another in Leverett (1967–69). *Catocala* taken at bait, a brown sugar-beer mixture painted onto tree trunks, comprise 84% of the records from this area, whereas *Catocala* taken at lights (several 150-watt incandescent bulbs, and one 15-watt black light fluorescent tube) comprise 12% of the records. The additional 4% of the records are based on the finding of resting moths in nature. *Catocala* were recorded on a daily basis from 1 July to 1 September (except for occasional 1 to 2 day absences, or days of extremely inclement weather), and more sporadically from 1 September to 1 November each year.

Area 2. Records here are based on collecting of 5806 specimens by S. A. Hessel at one site in Washington, Litchfield County, in west-central

Connecticut; this site lies approximately 65 air-miles to the southwest of Amherst, Massachusetts.[2] All records of *Catocala* from this area are based on specimens taken at lights, most at one Robinson mercury vapor light-trap, and some at one 15-watt black light fluorescent tube. These lights were in operation from mid-March to mid-November each year (except for occasional 1 to 3 day absences).

Several important differences in collecting procedures between the two areas should be stressed:

(1) Captures in Area 1 were predominantly at bait; captures in Area 2 were exclusively at lights.

(2) Collecting in Area 1 was generally terminated by midnight; in Area 2 the Robinson trap was operating continuously from dusk to dawn.

(3) Several collecting sites are included in Area 1; Area 2 includes only one collecting site.

(4) Collecting in Area 1 was sporadic after September 1, but continued unabated in Area 2.

Because of these differences, the records for the two areas will be presented separately.

It should also be noted that some *Catocala* individuals may have been recorded on more than one occasion, as the majority of specimens in both areas were released after examination. However, studies of color-marked *Catocala* in Area 1 (Sargent, in prep.) indicate that very few individuals are captured on more than one occasion.

The species of *Catocala* were identified as keyed and described in Forbes (1954), and the species names used throughout this report are from that source. It should finally be noted that specific distinctions were not always made between *gracilis* and *sordida* in both areas, and among *crataegi*, *blandula*, and *mira* in Area 1. It is known from mounted specimens, however, that all of these species occurred in both areas.

In area 1, the sex of *Catocala* specimens was determined, and the precise time of their capture noted. These data are not included in the present report, but will be treated in subsequent papers.

Results and Discussion

Abundance. The *Catocala* taken each year in Areas 1 and 2 are enumer-

[2] This site lies at the bottom of a very narrow north-south valley through which an all-season stream flows southward. The lower end of the valley, only one mile distant, opens onto terrain which rolls gently southward to the Connecticut coast, while northward, the Litchfield Hills, of which it is part, become the Berkshires of Massachusetts. The surrounding hills are largely mixed deciduous woodlands, but include several seral stages resulting from the abandonment of farms, pastures, and woodlots of the Colonial period. Climatically, as demonstrated by meteorological maps, the site is to be included with territory considerably more northern than with the Connecticut and Hudson River valleys of its latitude.

TABLE 1. *Catocala* spp. recorded in the Amherst, Mass. area, 1964–69.

Species	Numbers of Individuals & (Percent of Yearly Total for All Species)						Totals and Percent of Grand Total for Entire Period
	1964	1965	1966	1967	1968	1969	
ilia	12	49	20	47	206	346	680
	(22)	(25)	(7)	(13)	(58)	(46)	(34)
ultronia	7	49	115	25	49	79	324
	(13)	(25)	(39)	(7)	(14)	(11)	(16)
crataegi et al.*	2	14	47	5	36	5	109
	(4)	(7)	(16)	(1)	(10)	(1)	(5)
retecta	–	3	11	30	5	58	107
		(2)	(4)	(8)	(1)	(8)	(5)
antinympha	1	1	15	57	11	19	104
	(2)	(1)	(5)	(16)	(3)	(3)	(5)
gracilis & *sordida*	6	2	11	57	5	10	91
	(11)	(1)	(4)	(16)	(1)	(1)	(5)
cara	1	–	13	2	3	60	79
	(2)		(4)	(1)	(1)	(8)	(4)
concumbens	3	5	19	14	6	29	76
	(5)	(3)	(6)	(4)	(2)	(4)	(4)
relicta	–	21	5	11	3	11	51
		(11)	(2)	(3)	(1)	(1)	(3)
grynea	2	18	10	7	3	10	50
	(4)	(9)	(3)	(2)	(1)	(1)	(2)
amica	3	4	4	30	3	6	50
	(5)	(2)	(1)	(8)	(1)	(1)	(2)
amatrix	–	–	–	–	–	36	36
						(5)	(2)
unijuga	3	3	5	6	6	10	33
	(5)	(2)	(2)	(2)	(2)	(1)	(2)
micronympha	2	4	2	22	–	3	33
	(4)	(2)	(1)	(6)			(2)
epione	1	1	–	6	8	16	32
	(2)	(1)		(2)	(2)	(2)	(2)
andromedae	2	2	3	15	4	4	30
	(4)	(1)	(1)	(4)	(1)	(1)	(1)
praeclara	5	7	6	5	2	4	29
	(9)	(4)	(2)	(1)	(1)	(1)	(1)
similis	4	6	–	11	–	–	21
	(7)	(3)		(3)			(1)
cerogama	–	–	2	3	1	7	13
			(1)	(1)		(1)	(1)
residua	–	–	–	–	–	11	11
						(1)	(1)
palaeogama	–	–	1	–	1	9	11
						(1)	(1)
neogama	–	–	1	3	1	5	10
				(1)		(1)	

TABLE 1. *Continued.*

Species	Numbers of Individuals & (Percent of Yearly Total for All Species)						Totals and Percent of Grand Total for Entire Period
	1964	1965	1966	1967	1968	1969	
habilis	–	–	–	5 (1)	–	3	8
coccinata	–	1 (1)	–	5 (1)	1	1	8
obscura	1 (2)	3 (2)	1	–	–	1	6
briseis	–	1 (1)	2 (1)	–	–	–	3
innubens	–	1 (1)	–	–	–	–	1
piatrix	–	–	1	–	–	–	1
dejecta	–	–	–	–	–	1	1
parta	–	–	–	–	–	1	1
No. Species	16	20	21	21	19	26	33
No. Individuals	55	195	294	366	354	745	2009

* records of *blandula* and *mira* included here

ated in Tables 1 and 2 respectively. In both cases, the species are listed in a descending order of overall abundance. Examination of these tables reveals some differences between results from the two areas. *Catocala* numbers, in terms of both species and individuals, are greater from Area 2. In part, this difference must be due to the longer daily and seasonal collecting periods in Area 2, and perhaps to a greater efficiency of the Robinson trap, when compared to bait, as a collecting device. However, further consideration indicates that those species that are markedly more abundant in Area 2 are almost invariably hickory and walnut (Juglandaceae) feeders. Accordingly, the data were reanalysed with reference to the known foodplants of the various *Catocala* species (Forbes, 1954), and this procedure revealed that remarkably more hickory-walnut feeders, both in terms of species and individuals, were taken in Area 2 (Table 3).

This disparity in records of feeders on the Juglandaceae seems to reflect something more than the previously listed differences in collecting procedures between the two areas. It seems more likely that differences in the frequency of hickories and walnuts are important. In this regard, the presence of Butternut (*Juglans cinerea* L.) as a common tree in the woodlands near the collecting site in Washington, and its virtual absence in all collecting areas near Amherst, seems most suggestive. It could be that

TABLE 2. *Catocala* spp. recorded in Washington, Conn., 1961–65, –67, –69.

Species	Numbers of Individuals & (Percent of Yearly Total for All Species)							Totals and Percent of Grand Total for Entire Period
	1961	1962	1963	1964	1965	1967	1969	
palaeogama	194	487	12	40	33	81	48	895
	(15)	(34)	(4)	(8)	(6)	(7)	(8)	(15)
residua	216	345	45	53	54	135	39	887
	(17)	(24)	(15)	(10)	(10)	(12)	(7)	(15)
habilis	121	79	63	119	78	159	34	653
	(9)	(6)	(21)	(22)	(14)	(14)	(6)	(11)
amica	85	78	10	27	27	89	50	366
	(7)	(6)	(3)	(5)	(5)	(8)	(9)	(6)
antinympha	52	26	13	13	16	182	27	329
	(4)	(2)	(4)	(2)	(3)	(16)	(5)	(6)
neogama	97	36	23	38	39	68	28	329
	(8)	(3)	(8)	(7)	(7)	(6)	(5)	(6)
concumbens	14	12	21	59	68	75	60	309
	(1)	(1)	(7)	(11)	(12)	(6)	(10)	(6)
retecta	83	55	19	29	34	55	19	294
	(7)	(4)	(6)	(5)	(6)	(5)	(3)	(5)
grynea	72	30	8	19	35	39	56	259
	(6)	(2)	(3)	(4)	(6)	(3)	(10)	(4)
ultronia	41	38	14	24	32	45	37	231
	(3)	(3)	(5)	(5)	(6)	(4)	(6)	(4)
epione	69	37	14	6	19	24	15	184
	(5)	(3)	(5)	(1)	(3)	(2)	(3)	(3)
andromedae	40	30	7	8	26	10	18	139
	(3)	(2)	(2)	(1)	(5)	(1)	(3)	(2)
obscura	27	17	3	17	9	26	25	124
	(2)	(1)	(1)	(3)	(2)	(2)	(4)	(2)
micronympha	38	43	5	11	4	6	15	122
	(3)	(3)	(2)	(2)	(1)	(1)	(3)	(2)
serena	3	–	–	8	12	52	28	103
				(1)	(2)	(5)	(5)	(2)
gracilis & *sordida*	16	7	12	15	10	7	8	75
	(1)		(4)	(3)	(2)	(1)	(1)	(1)
mira	4	14	8	11	9	2	20	68
		(1)	(3)	(2)	(2)		(3)	(1)
badia	9	7	3	2	8	21	7	57
	(1)		(1)		(1)	(2)	(1)	(1)
cara	15	12	3	6	2	5	4	47
	(1)	(1)	(1)	(1)			(1)	(1)
dejecta	10	7	1	2	3	15	1	39
	(1)				(1)	(1)		(1)

TABLE 2. *Continued.*

Species	Numbers of Individuals & (Percent of Yearly Total for All Species)							Totals and Percent of Grand Total for Entire Period
	1961	1962	1963	1964	1965	1967	1969	
ilia	9 (1)	4	1	5 (1)	9 (2)	4	5 (1)	37 (1)
judith	1	–	–	–	1	9 (1)	24 (4)	35 (1)
subnata	9 (1)	19 (1)	2 (1)	2	1	1	–	34 (1)
parta	9 (1)	2	6 (2)	3 (1)	4 (1)	7 (1)	2	33 (1)
unijuga	7 (1)	5	3 (1)	6 (1)	4 (1)	8 (1)	–	33 (1)
similis	7 (1)	7	1	–	1	4	–	20
flebilis	10 (1)	2	1	–	1	4	1	19
coccinata	7 (1)	4	1	2	1	2	2	19
praeclara	1	–	1	1	4 (1)	6 (1)	4 (1)	17
relicta	6	–	1	1	5 (1)	2	1	16
blandula	–	6	3 (1)	1	2	2	–	14
crataegi	1	2	1	1	–	2	1	8
innubens	1	–	–	–	2	1	–	4
amatrix	–	1	1	–	–	–	–	2
briseis	–	–	–	–	–	2	–	2
piatrix	1	–	–	–	–	–	–	1
cerogama	–	–	–	–	–	1	–	1
vidua	–	–	–	1	–	–	–	1
No. Species	33	29	31	30	32	35	28	39*
No. Individuals	1275	1412	306	530	553	1151	579	5806

* During the period 1952–60, one additional species was noted in this area—*C. robinsonii*, 15 September 1956, one specimen.

TABLE 3. Foodplants of the *Catocala* spp. from two localities.

Foodplants	Amherst, Mass.		Washington, Conn.	
	No. Species	% Total Individuals	No. Species	% Total Individuals
Salicaceae[1] Willow (*Salix*); Poplar (*Populus*)	7	13.9	7	7.6
Myricaceae[2] Bayberry (*Myrica*); Sweet Fern (*Comptonia*)	1	5.2	2	6.7
Juglandaceae[3] Walnut (*Juglans*); Hickory (*Carya*)	9	9.3	14	62.0
Fagaceae[4] Oak (*Quercus*)	5	39.4	5	9.7
Rosaceae[5] Apple (*Pyrus*); Thorn (*Crataegus*); Cherry (*Prunus*)	5	24.0	5	10.0
Ericaceae[6] Blueberry (*Vaccinium*); Andromeda (*Andromeda*)	3	6.0	3	3.7
Others[7]	3	2.1	3	0.4

Catocala species included:

[1] *relicta, parta, briseis, unijuga, cara, concumbens, amatrix*
[2] *antinympha, badia*
[3] *piatrix, epione, habilis, serena, judith, flebilis, obscura, residua, retecta, dejecta, vidua, palaeogama, subnata, neogama*
[4] *ilia, coccinata, similis, micronympha, amica*
[5] *ultronia, crataegi, mira, blandula, grynea*
[6] *gracilis, sordida, andromedae*
[7] *innubens* (*Gleditsia*), *cerogama* (*Tilia*), *praeclara* (*Quercus* ?, *Crataegus* ?).

Area 1 is near or beyond the northern limit of some of these *Catocala* species, due perhaps to a sparse distribution of certain foodplants, or to climatic marginality for the insects themselves.

The presence and absence of a foodplant seems to explain the single remaining difference in species between Areas 1 and 2 (i.e. bayberry, *Myrica pensylvanica* Loisel, the foodplant of *C. badia*, is present only in Area 2).

It is also possible, of course, that some differences in records from the two areas are due to differences in collecting procedures, which reflect, in turn, behavioral differences among the *Catocala* species. For example, *C. ilia* has been taken much more often at bait than at lights (96% of 371 captures in Leverett, 1967–69), and this fact may well explain its apparently higher numbers in Area 1 (and the consequent higher percentage of feeders on the Fagaceae). In contrast, *C. antinympha* has been more prevalent at lights than at bait (88% of 74 captures in Leverett, 1967–69),

TABLE 4. Early occurrence of several common *Catocala* species in two localities.

Species	Extreme Early Date Month/Day		Median Early Date Month/Day	
	Amherst	Washington	Amherst	Washington
antinympha	7/11	7/11	7/22	7/17
retecta	8/2	7/30	8/11	8/10
concumbens	7/21	7/23	7/31	7/31
ultronia	7/11	7/13	7/20	7/20
grynea	7/14	7/12	7/22	7/21
amica	7/2	7/12	7/25	7/21

and this could account for its apparently higher frequency in Area 2. Differences of this sort, as well as differences in the time of flight of the various species during the night, are being carefully studied, and will form the basis of further papers in this series.

Changes in Abundance. The records presented here do not cover a sufficient number of years to allow extended analyses of changes in abundance. However, the variations and trends in annual numbers of certain species warrant brief comment.

Several species exhibited wide fluctuations in annual abundance (e.g. *C. ilia* and *C. ultronia* in Area 1, *C. palaeogama* and *C. habilis* in Area 2, and *C. antinympha* in both areas). Two species in Area 1, *C. amatrix* and *C. residua*, were never recorded until 1969, and then both were relatively common. These fluctuations indicate that detecting long-term trends in *Catocala* abundance may often require longer series of annual records than those considered here.

The records from Area 2, together with notes of S. A. Hessel extending back to 1952, do indicate that two species, *C. serena* and *C. judith*, have recently become remarkably more common in that area. Although neither of these species was collected in Area 2 prior to 1960, since then 104 *serena* and 35 *judith* have been collected. These results could be due to erratic long-term oscillations in the abundance of these species, or might represent their recent range extension from more southern regions into Area 2. If these two species are presently extending their ranges, then we might eventually expect to take specimens in Area 1, where neither has yet been taken.

In all of the records from both areas, only one species, *C. subnata*, seems to be showing any evidence of a recent decline in numbers. This species is known as one which exhibits long-term fluctuations in abundance (Forbes, 1954).

TABLE 5. Seasonal occurrence of *Catocala*.

Species[1] (N)	Percent Occurrence							
	July		August		September		October	
	1–15	16–31	1–15	16–31	1–15	16–30	1–15	16–31
blandula (18)	61	28	6	6				
coccinata (27)	30	30	33	7				
similis (41)	12	68	17	2				
micronympha (155)	25	47	22	5	1			
ilia (717)	1	47	35	12	4			
ultronia (555)	1	41	39	17	1	–		
mira (69)	3	41	42	14				
epione (216)	2	37	46	15				
andromedae (169)	2	37	39	21	1			
antinympha (433)	4	34	43	15	3	1		
grynea (309)	1	29	42	27	2			
praeclara (46)	2	24	59	15				
gracilis & *sordida* (166)	6	29	29	35	1			
unijuga (66)	8	36	18	12	15	6	5	
amica (416)	1	25	35	27	10	1		
palaeogama (906)		34	25	20	13	8	–	
dejecta (40)		35	43	20	2			
badia (57)		37	49	11	3			
relicta (67)		36	40	19	3	1		
subnata (34)		26	32	24	18			
judith (35)		6	80	14				

[1] Species with less than 10 records not included.

TABLE 5. *Continued.*

Species[1] (N)	Percent Occurrence							
	July		August		September		October	
	1–15	16–31	1–15	16–31	1–15	16–30	1–15	16–31
serena (103)		10	36	29	24	1		
residua (898)		5	37	30	19	8	1	
concumbens (385)		2	30	36	21	9	2	
retecta (401)		1	16	42	24	13	3	
cerogama (14)		7	7	71	14			
parta (34)		3		35	21	32	9	
obscura (130)		1	8	32	39	17	3	1
cara (126)			18	36	29	9	9	
flebilis (19)			11	58	11	21		
neogama (339)			10	34	32	19	5	
amatrix (38)			26	18	55			
habilis (661)			–	15	36	41	7	1

[1] Species with less than 10 records not included.

The wide annual variation in total *Catocala* individuals taken at any one locality seems largely due to dramatic fluctuations in the abundance of a very few common species (e.g. *C. ilia* and *C. ultronia* in Area 1; *C. palaeogama*, *C. residua*, and *C. habilis* in Area 2). Weather is another factor which undoubtedly influences records of annual abundance. It is well known among collectors that *Catocala* are more frequently taken on warm, humid nights; and thus the number of such nights during a summer will affect the total number of *Catocala* recorded. Data on temperature and humidity with respect to *Catocala* abundance will be obtained in our areas in subsequent years.

Seasonal Occurrence. The seasonal appearance of adult *Catocala* in Areas 1 and 2 seemed virtually identical. For example, of the 30 species common to both areas, 17 had earliest records of capture from Washington, and 12 had such records from Amherst (in one species the earliest re-

corded date was the same in both areas). Data on the early occurrence of the six species for which there are 50 or more records from each area are summarized in Table 4. (Late occurrences of the species could not be as meaningfully compared across areas because late season collecting was much less complete in Area 1 than in Area 2.)

A summary of the seasonal occurrence of the *Catocala* species is presented in Table 5. These data were obtained by summing across years and areas, a procedure which tends to extend the apparent season of each species to some extent. Nonetheless, it is clear that seasonal isolation alone is insufficient to separate most of the *Catocala* species from one another (all of the species, for example, may occur during the latter half of August). Some species may occur over the entire summer (e.g. *C. unijuga*, with extreme dates of 8 July and 9 October), and these certainly must be isolated from other species by factors other than seasonal occurrence. However, it seems equally clear that seasonal offset may coact with other factors in effectively isolating certain closely related pairs of species (e.g. *blandula* and *mira*, *serena* and *habilis*, *dejecta* and *retecta*, *subnata* and *neogama*).

Summary

Daily records of adult *Catocala* have been kept over several years at two localities in southern New England. For the period 1961–1969, nearly 8,000 individuals of 39 species were recorded. These data have been summarized here in an attempt to establish the abundance, and fluctuations in abundance, as well as the seasonal limits, of the species. In addition, suggestions relating to the differences in species composition at the two localities have been advanced.

Acknowledgments

This report was written while the first author was a visiting fellow in the laboratory of Dr. Charles L. Remington at Yale University. The stimulation of discussions with Dr. Remington, and his suggestions regarding this manuscript, are gratefully acknowledged.

Some of the *Catocala* records from the Amherst area were contributed by Dr. Ronald R. Keiper (1967–68) and Charles G. Kellogg (1969), and their cooperation and assistance is greatly appreciated.

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COMMUNAL ROOSTING IN *COLIAS* AND *PHOEBIS* (PIERIDAE)

HARRY K. CLENCH
Carnegie Museum, Pittsburgh, Penna.

Two instances of communal roosting in coliadine pierids have recently come to my attention. They have to do with different genera, of considerably different body size, and occurring in different major environments, but there are several striking similarities and I believe a common explanation may satisfy both.

Colias eurytheme Boisduval

In an open meadow near Pittsburgh, Pennsylvania, at about 5:30 PM, EST, on 18 September 1969, I saw *Colias eurytheme* in fairly large numbers preparing for the night. A few of them were still active, but most had already sought roosts. The sun was within 15–20° of the true horizon, but was destined to disappear a little prematurely behind a low, tree-covered hill, and the field was already partly shaded.