With Ferguson's outstanding book for guidance, much more can be learned about *Hemileuca* through rearing and experimentation.

I wish to extend my sincere thanks to Christopher Henne, of Pearblossom, California, for his encouragement and eduction in life history work, and his kind review of this paper.

LITERATURE CITED

FERGUSON, D. C. *in* DOMINICK, R. B. et al., 1971. The Moths of America North of Mexico. Fasc. 20.2A, *Bombycoidea*, (in part), Classey, London, p. 101–153.

MELANISM IN MOTHS OF CENTRAL MASSACHUSETTS (NOCTUIDAE, GEOMETRIDAE)

THEODORE D. SARGENT
Department of Zoology, University of Massachusetts,
Amherst, Massachusetts 01002

The relative dearth of information on the incidence of melanism in North American moths has been recently noted (Kettlewell, 1973). Since the reviews of Owen (1961, 1962) called attention to increasing melanism in various bark-like noctuids and geometers, little else on North American species has been published. Owen & Adams (1963) analysed the occurence of melanism in *Catocala ilia* (Noctuidae) in Michigan, and Klots (1964, 1966, 1968a, b) briefly noted increases in the frequencies of the melanic forms of *Charadra deridens* and *Panthea furcilla* (Noctuidae) in Connecticut. More recently, Sargent (1971) provided data on melanism in *Phigalia titea* (Geometridae) in central Massachusetts. The present data, acquired in the course of collecting moths for other studies in central Massachusetts from 1968–1973, are presented in hopes of stimulating others to acquire and publish similar data. Accumulated records, from different areas and at different times, may permit some meaningful geographic and historical comparisons, and so may contribute eventually to a thorough analysis of melanism in North America. Certainly every effort should be made to take advantage of our opportunity to study this phenomenon as it unfolds, for this opportunity may now be lost elsewhere in the world (Kettlewell, 1973).

TABLE 1. The numbers of typical and melanic individuals of *Panthea furcilla* taken in Leverett, Massachusetts (1970–1973).

Forms	Years				Totals
	1970	1971	1972	1973	
Typical	29	47	28	43	147
Melanic	35	94	40	73	242
% Melanic	54.7	66.7	58.8	62.9	62.2

METHODS

The records included here involve only those species which have been substantially sampled, as my experience indicates that general impressions from limited samples are unreliable as indicators of melanic frequencies. The six species on which I report were collected *in toto* over their entire flight seasons during the years indicated, and virtually all of the specimens have been retained in my collection.

Five of the six species considered were taken exclusively at light sources (incandescent, flourescent black light, and mercury vapor). Most of these specimens were obtained in a Robinson trap (mercury vapor) which operated from dusk to dawn, and, as expected, most of the specimens from light sources were males. One species, *Catocala ultronia*, was taken at both lights and bait, but there were no differences between the two samples, or between the sexes in the bait sample, in terms of melanic frequencies in this case.

All specimens, unless otherwise indicated, were taken at my home in Leverett, Massachusetts. This collecting site is located in an extensive mixed deciduous woodland, most of which has grown up since a logging operation about 30–35 years ago. The dominant trees are oaks (*Quercus velutina* and *Q. alba*), with substantial representation of birches (*Betula papyrifera* and *B. lenta*), hickories (*Carya glabra* and *C. ovata*), pine (*Pinus strobis*), and hemlock (*Tsuga canadensis*). Some of the nearby area is more recently abandoned pasture, and is now in an intermediate stage of succession (sweet fern, *Comptonia peregrina*; juniper, *Juniperus virginiana*; gray birch, *Betula populifolia*; etc.).

Leverett is located some 75 air-miles west of Boston, 25 air-miles north of Springfield, and 66 air-miles east of Albany, New York. The collecting area shows little visible evidence of air-borne pollution, as lichens abound on tree trunks which are not noticeably darkened by soot. I have previously referred to the area as "ostensibly rural" (Sargent, 1971), in an attempt to give recognition to both its visible appearance and its location in the heavily industrialized northeastern United States.

TABLE 2. The numbers of non-melanic and melanic individuals of *Catocala ultronia* taken in Leverett, Massachusetts (1968–1973).

Forms	Years						Totals
	1968	1969	1970	1971	1972	1973	
Non-melanic	41	22	163	192	20	32	470
Melanic	7	7	22	47	5	10	98
% Melanic	14.6	24.1	11.9	19.7	20.0	23.8	17.3

RESULTS

Noctuidae

Panthea furcilla (Packard). The melanic form of this species, **atrescens** McDunnough, is easily distinguished from its typical counterpart by the black ground of the wings, though melanics do vary considerably in the extent of their white lines (see figures in Ginevan, 1971). The genetic basis of melanism has been studied (Ginevan, 1971), but further work is required, particularly to determine whether heterozygote and homozygote melanic males can be distinguished reliably by visual inspection. The numbers of typical and melanic individuals taken in Leverett from 1970–1973 are presented in Table 1.

Catocala ultronia Hübner. This highly polymorphic species has a strongly melanic form, **nigrescens** Cassino, with uniform, deep black forewings. This melanic was illustrated in Cassino's paper (Lepidopterist 1: 79, pl. vi), but is not shown in more popular works, such as Barnes & McDunnough (1918). The most common form of this species in Leverett is **celia** Hy. Edwards (Barnes & McDunnough, 1918: pl. VII, 18), but all of the non-melanic forms are considered together in the tabulation of collecting results (Table 2).

Catocala connubialis (Guenée). This generally rare moth has a "partly melanic" form, **pulverulenta** Brower, with nearly uniform grayish forewings; and a strongly melanic form, **broweri** Muller, with uniform, deep green-black forewings (see figures in Muller, 1960). Most of the

TABLE 3. The numbers of individuals of each form of *Catocala connubialis* taken in central Massachusetts (1970–1973).

Forms	Locations		Totals (%)
	Leverett	West Hatfield	
sancta	1	–	1 (3.3)
cordelia	2	3	5 (16.7)
pulverulenta	4	9	13 (43.3)
broweri	3	8	11 (36.7)

TABLE 4. The numbers of typical and melanic individuals of *Nacophora quernaria* taken in Leverett, Massachusetts (1971–1973).

Forms	Years			Totals
	1971	1972	1973	
Typical	3	10	11	24
Melanic	3	12	17	32
% Melanic	50.0	54.5	60.7	57.1

non-melanic specimens taken in this area are similar to, though darker than, **cordelia** Hy. Edwards (Barnes & McDunnough, 1918: pl. IX, 19), and occasional specimens are close to **sancta** Hulst (Barnes & McDunnough, 1918: pl. IX, 21). Due to the rarity of this species, the numbers of specimens of the various forms are summed for the years 1970–1973, and I have included specimens taken in a Robinson trap at West Hatfield, Massachusetts (7.5 air-miles from Leverett) by Charles G. Kellogg (Table 3).

Geometridae

Nacophora quernaria (Abbot & Smith). The melanic form of this species, **atrescens** Hulst, is jet black, with only occasional traces of faint whitish along the ordinary lines. Specimens splotched with white on a blackish ground were considered typical, as were all brownish specimens. This species is generally uncommon in Leverett, but the frequency of melanic individuals has been consistent (Table 4).

Biston cognataria (Guenée). Typical specimens of this species in Leverett are rather dark gray, being close to the **insularia**[4] category of *Biston betularia* in England (Kettlewell, 1973: pl. 9.1, no. 2, left). The melanic form, **swettaria** Barnes & McDunnough, is nonetheless easily distinguished, being uniformly black over the entire wing surfaces (Kettlewell, 1973: pl. 9.1, no. 3, right). The numbers of typical and melanic specimens taken in Leverett from 1971–1973 are presented in Table 5.

TABLE 5. The numbers of typical and melanic individuals of *Biston cognataria* taken in Leverett, Massachusetts (1971–1973).

Forms	Years			Totals
	1971	1972	1973	
Typical	23	22	84	129
Melanic	–	1	5	6
% Melanic	–	4.3	5.6	4.4

TABLE 6. The numbers of typical and melanic individuals of *Phigalia titea* taken in Leverett, Massachusetts (1968–1973).

Forms	Years						Totals
	1968	1969	1970	1971	1972	1973	
Typical	125	135	131	189	117	123	820
Melanic	44	26	30	41	32	34	207
% Melanic	26.0	16.1	18.6	17.8	21.5	21.7	20.2

Phigalia titea (Cramer). The records presented here (Table 6) will up-date those previously reported for Leverett (Sargent, 1971). The typical and melanic form, **deplorens** Franclemont, of this species are illustrated in Remington (1958). Melanism in this species is very clear-cut; well over 1000 specimens have been taken, and only one or two of these were difficult to assign to either the typical or melanic form.

DISCUSSION

All of the species considered here presumably show industrial melanism, in the broad sense of that phrase. The melanics in these cases were extremely rare or absent in collections made prior to 1930 or 1940, and now they comprise substantial proportions of the existing populations. However, the generally held explanation of industrial melanism, as developed by Kettlewell through studies on *Biston betularia* in England (Kettlewell, 1958), seems not completely applicable to the present results. This explanation stresses the cryptic advantage of melanics on darkened tree trunks, but the trees in the Leverett study area are not noticeably devoid of lichens or blackened by soot. Many of the melanics taken there are extremely dark, nearly jet black, and would seem to be cryptic on only the darkest trees in heavily polluted areas. Furthermore, the apparent tendency of some of these melanics to prefer light backgrounds, like their typical counterparts (Sargent, 1969), makes an explanation for their occurrence based on cryptic advantage even less likely.

It is interesting to note that the frequency of melanics in *Biston cognataria* is quite low in Leverett, much lower, for example, than that occurring in New Haven, Connecticut (C. L. Remington, pers. comm.), or in the areas in Michigan sampled by Owen (1961). Perhaps *Biston* spp. are industrial melanics in much the sense that Kettlewell has proposed (1958), but recent data cast some doubt on the completeness of a cryptic advantage explanation for even *B. betularia* (Bishop, 1972; Lees, Creed & Duckett, 1973).

An activity of man which may have resulted in certain darkened backgrounds, and thus had an influence on at least one of the species considered here, is logging. This activity has been carried out periodically over most of New England since Colonial days, and one of the most prized timber trees throughout this period has been white pine, *Pinus strobis*, the foodplant of *Panthea furcilla*. If this moth tends to rest on the trunks of this tree, then a tendency of loggers to take the larger trees (with lighter, furrowed bark), and leave the younger trees (with darker, smooth bark), may have provided an ecological opportunity, in the form of more appropriate resting substrates, for melanic individuals.

Certain other species, notably *Phigalia titea* and *Nacophora quernaria*, which have rather high melanic frequencies in Leverett, suggest that various factors associated with industrialization, other than observable environmental darkening, should be investigated with respect to the incidence of melanism. For example, air pollution affects the physical and chemical characteristics of vegetation, and perhaps the larvae of melanics are better able than the larvae of typicals to tolerate such changes. Certainly, melanics have exhibited superior viability in a number of physiological tests (Ford, 1937, 1940). Industrialization has undoubtedly also had deleterious effects on the predators of insects, and perhaps relaxed selection pressures have allowed melanics to survive where they previously could not have survived.

All of the species considered here are bark-like cryptic species, and melanism in moths, particularly that associated with industrialization, has been largely restricted to such species. It is also generally true that melanism in those species studied is controlled by a single gene, with the allele for black being dominant to that for pale or typical coloration. These observations, together with our knowledge that the frequency of melanics may increase rapidly in a population, encourage some highly speculative ideas, which I will discuss very briefly.

Perhaps many bark-like species have been exposed throughout their histories to recurring situations where melanism has been advantageous. If so, these species may have evolved mechanisms which enable them to change quickly from prevailingly pale to prevailingly dark populations. Such changes might be effected through conditional genes for melanism, i.e. genes which are expressed only under conditions that are associated with environmental darkening. Among such conditions might be the chemical or physical effects of forest fires on the insects or their foodplants. The ability of a species to respond to these effects by producing adult melanics, which would then be cryptic on blackened backgrounds, could give it a clear selective advantage. Perhaps then,

industrialization is creating conditions which are similar, or identical, to conditions created historically by forest fires. Melanic forms, in this event, would be somewhat analagous to the various seasonal forms which characterize many lepidopteran species.

Much of this discussion is clearly fanciful speculation, but perhaps some excesses of this sort may be excused, if the result is to suggest that our understanding of industrial melanism is far from complete.

SUMMARY

Six species of bark-like moths with melanic forms were extensively sampled in central Massachusetts between 1968 and 1973. These species, and the percentages of melanic individuals in the sampled populations, are: *Panthea furcilla* (62.2%), *Catocala ultronia* (17.3%), *Catocala connubialis* (36.7%), *Nacophora quernaria* (57.1%), *Biston cognataria* (4.4%), and *Phigalia titea* (20.2%). These results are discussed with reference to various theoretical and speculative views on the phenomenon of industrial melanism.

ACKNOWLEDGMENT

I thank Charles G. Kellogg for allowing me to use his unpublished data on *Catocala connubialis*.

LITERATURE CITED

BARNES, W. & J. MCDUNNOUGH. 1918. Illustrations of the North American species of the genus *Catocala*. Mem. Amer. Mus. Nat. Hist. 3, pt. 1.

BISHOP, J. A. 1972. An experimental study of the cline of industrial melanism in *Biston betularia* (L.) (Lepidoptera) between urban Liverpool and rural North Wales. J. Anim. Ecol. 41: 209–243.

FORD, E. B. 1937. Problems of heredity in the Lepidoptera. Biol. Rev. 12: 461–503.

———. 1940. Genetic research in the Lepidoptera. Ann. Eugen., Lond. 10: 227–252.

GINEVAN, M. E. 1971. Genetic control of melanism in *Panthea furcilla* (Packard) (Lepidoptera: Noctuidae). J. N. Y. Entomol. Soc. 79: 195–200.

KETTLEWELL, H. B. D. 1958. Industrial melanism in the Lepidoptera and its contribution to our knowledge of evolution. Proc. 10th Int. Congr. Entomol. (1956) 2: 831–841.

———. 1973. The Evolution of Melanism, The Study of a Recurring Necessity, With Special Reference to Industrial Melanism in the Lepidoptera. Clarendon, Oxford. xxiv + 424 p.

KLOTS, A. B. 1964. Notes on melanism in some Connecticut moths. J. N. Y. Entomol. Soc. 72: 142–144.

———. 1966. Melanism in Connecticut *Panthea furcilla* (Packard) (Lepidoptera: Noctuidae). J. N. Y. Entomol. Soc. 74: 95–100.

———. 1968a. Melanism in Connecticut *Charadra deridens* (Guenée) (Lepidoptera: Noctuidae). J. N. Y. Entomol. Soc. 76: 58–59.

———. 1968b. Further notes on melanism in Connecticut *Panthea furcilla* (Packard) (Lepidoptera: Noctuidae). J. N. Y. Entomol. Soc. 76: 92–95.

LEES, D. R., E. R. CREED & J. G. DUCKETT. 1973. Atmospheric pollution and industrial melanism. Heredity 30: 227–232.
MULLER, J. 1960. A new melanic form of *Catocala connubialis* from New Jersey (Noctuidae). J. Lepid. Soc. 14: 177–178.
OWEN, D. F. 1961. Industrial melanism in North American moths. Amer. Nat. 95: 227–233.
———. 1962. The evolution of melanism in six species of North American geometrid moths. Ann. Entomol. Soc. Amer. 55: 695–703.
——— & M. S. ADAMS. 1963. The evolution of melanism in a population of *Catocala ilia* (Noctuidae). J. Lepid. Soc. 17: 159–162.
REMINGTON, C. L. 1958. Genetics of populations of Lepidoptera. Proc. 10th Int. Congr. Entomol. (1956) 2: 787–805.
SARGENT, T. D. 1969. Background selections of the pale and melanic forms of the cryptic moth, *Phigalia titea* (Cramer). Nature, Lond. 222: 585–586.
———. 1971. Melanism in *Phigalia titea* (Cramer) (Lepidoptera: Geometridae). J. N. Y. Entomol. Soc. 79: 122–129.

BIOLOGY AND IMMATURE STAGES OF *SCHINIA MITIS* (GROTE) (NOCTUIDAE)[1]

D. H. HABECK,[2] R. T. ARBOGAST[3] AND L. D. CLINE[3]
Department of Entomology and Nematology,
University of Florida, Gainesville, Florida 32601

Schinia mitis (Grote) occurs from central Florida, north to Georgia, and west to eastern Texas (Hardwick, 1958). Most of the specimens Hardwick examined were collected in April, May, and June, but a few were collected in September and November. Kimball (1965) listed Florida records from March to June. Forbes (1954) gave the foodplant as *Sitilias caroliniana* Walt. [= Carolina false dandelion, *Pyrrhopappus carolinianus* (Walt.)DC]. Hardwick (1958) figured the lateral aspect of the egg and design of the chorion and gave a description and dimensions based on eggs dissected from preserved or dried females. Ganyard & Brady (1972) reported that males were attracted to virgin females of Indian meal moth, *Plodia interpunctella* (Hübner); almond moth, *Cadra cautella* (Walker); and fall armyworm, *Spodoptera frugiperda* (J. E. Smith), in field studies at Watkinsville, Georgia. No other published information was found on this species.

[1] Florida Agricultural Experiment Station Journal Series No. 5035. Received for publication.
[2] Research Associate, Florida State Collection of Arthropods.
[3] Present address: USDA, Stored-Product Insects R & D Laboratory, Box 5125, Savannah, Georgia 31403.