Melanism in Connecticut *Panthea furcilla* (Packard) (Lepidoptera: Noctuidae)

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Abstract: Counts are given of melanic, melanistic, and normal individuals in the total catch of this moth in Connecticut in 1962–1965. Counts of these types are also given in families reared from wild-caught melanic, melanistic, and normal females. Larval melanism occurs, not linked to adult melanism. Adult melanism is dominant and apparently multifactorial. Environmental effects on the polymorphism are discussed.

In a previous article (1964, Jour. N. Y. Ent. Soc. **72**: 142–144) I recorded the counts of my total catch (unbiased by collector selection) of *Panthea furcilla* and other moths at Putnam, Windham County, Connecticut. In the summers of 1962–1965 similar catches were made at the same spot. In 1964 and 1965 six batches of eggs were obtained from wild-caught females, and from these 95 adults were reared which show several degrees of melanism.

Panthea furcilla was chosen for special work because of the large numbers of this species that come to an ultraviolet "black light," the same described in the previous article, from a nearby grove of white pine (*Pinus strobus*), the food plant. It may be noted that this is the true *P. furcilla* Packard, and not the more southern, "hard" pine feeder that some authors have confused with this species.

WILD-CAUGHT SERIES

In the wild-caught series the partially melanic, or "melanistic," individuals form a nearly continuous spectrum of variation from almost totally melanic to very close to the normal, light grey, so that dividing them into a small number of groups is somewhat arbitrary. However, the series is here classified in four groups instead of the three used in sorting the 1961 catch. The category of "melanistic" is divided into: "slightly to strongly melanistic" and "very strongly melanistic." Admittedly, there are many borderline specimens that might as well be sorted one way as another. How much of the variation is genetically based will certainly never be known without a great deal of controlled, experimental work. Probably a number of factors are involved.

The wholly melanic individuals are not all black, the hairs and scales that in the normal form are light grey or white being a very dark, sooty brown against which the normal black markings are discernible. The vestiture of the head and thorax is perhaps as useful as the wing scales for deciding which moths are to be classified as very strongly melanistic, all of these having this vestiture

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extremely dark with only a slight mixture of light hairs and scales. Within the very strongly melanistic group are numerous specimens that have the white scale hairs of the thorax sharply limited to the tips of the tegulae and the area posterad to these, forming sharp, transverse white bars. The wings of such specimens are almost wholly dark except for the white lines that outwardly margin the transverse black markings; these are sharp and clear. Perhaps these sharply and contrastingly marked individuals represent something genetically distinct from the more common, rather smudgy melanistic ones.

Only 13 females were caught at the light, compared with 273 males, although this sex flies strongly enough at times. In 95 reared individuals there were 52 females.

Wild-caught Moths, 1962–1965 inclusive

Wholly melanic	51	= 17.8%
Very strongly melanistic	120	= 42.0%
Slightly to strongly melanistic	56	= 19.6%
Normal	59	= 20.6%
Total	286	

For combination with the 1961 catch, which was sorted in only three categories (all melanistics being grouped together), the same is done for the 1962–1965 catch. The 1961 figures are given in parentheses.

Wild-caught Moths, 1961–1965 inclusive

Melanic	51 + (19)	=	70	= 18.8%
Melanistic	176 + (47)	=	223	= 60.0%
Normal	59 + (20)	=	79	= 21.2%
Totals	286 + (86)	=	372	

REARINGS

1964, ♀ Pf N-1, a normal, light grey mother. A total of 49 pupae was obtained, of which 16 died during hibernation. The 33 adults obtained were as follows: strongly melanistic, 11; normal, 22. The larvae showed strong dimorphism; 16 were melanic, with the long hair pencils white; 17 were normal, i.e., dull brown to bright orange-brown, with the long hair pencils black. These larvae developed into moths as follows:

16 melanic larvae: strongly melanistic moths, 4; normal moths, 12.

17 normal larvae: strongly melanistic moths, 7; normal moths, 10.

1964, ♀ Pf N-2, a normal, light grey mother. All larvae were normal. A total of 61 pupae was obtained, of which 38 died during hibernation. The 23 adults obtained were as follows: slightly melanistic, 11; normal, 12.

1964, ♀ Pf Ms-1, a strongly melanistic mother. All larvae were normal. A total of 56 pupae was obtained, of which 50 died during hibernation. The 6 adults obtained were as follows: fully melanic, 4; slightly melanistic, 1; normal, 1.

1964, ♀ **Pf M-2,** a fully melanic mother. All larvae were normal. A total of 40 pupae was obtained, of which 35 died during hibernation. The 5 adults obtained were as follows: fully melanic, 1; slightly melanistic, 3; normal, 1.

1964, ♀ **Pf Ms-3,** a strongly melanistic mother. All larvae were normal. A total of 83 pupae was obtained, of which 71 died during hibernation. The 12 adults obtained were as follows: fully melanic, 8; strongly melanistic, 3; normal, 1.

1965, ♀ **Pf M-1,** a fully melanic mother. A total of 22 pupae was obtained, of which 6 died during hibernation. All larvae were normal. The 16 adults obtained were as follows: fully melanic, 5 (all ♂♂); slightly melanistic, 11 (all ♀♀).

Totals of Reared Moths, 1964–1965

Melanic	18 (11 ♂, 7 ♀)	= 18.9%
Very strongly melanistic	14 (10 ♂, 4 ♀)	= 14.7%
Slightly melanistic	26 (3 ♂, 23 ♀)	= 27.4%
Total of melanistics	40 (13 ♂, 27 ♀)	= 42.1%
Normal	37 (19 ♂, 18 ♀)	= 39.0%
Total	95 (43 ♂, 52 ♀)	

DISCUSSION

The total wild-caught series of 1961–1965 shows an approximate proportion of 1 melanic to 3 melanistic to 1 normal. This is indicative of a condition of dominance of melanism with the probability of melanistics being heterozygotes. The wide spectrum of variation in the melanistics suggests that there is more than one gene controlling this. The sharpness and contrast of the markings of some very strong melanistics, compared with the diffuse, smudgy appearance of others equally dark, may be the result of a different gene, perhaps even at a different locus, or may result from some modifying factor expressing itself differently in different environments or under different physiological conditions. Although their numbers are small the melanistics of the reared series buttress the idea of the melanistic condition in general being multifactorial, since 14.7% (n = 95) were strongly melanistic and 27.4% were slightly melanistic; but there were none of the wide range of intermediate melanistics that form the majority of the wild-caught individuals.

It may be noted here that a population sample such as this, no matter how extensive, cannot be regarded as representative of the wild population as a whole. It is probably safe to assume that the differences in coloration ranging from normal, light grey to wholly melanic have different survival values with respect to bird predation, although admittedly this remains to be shown for *P. furcilla*. The population that arrives at the collecting light ranges from very freshly emerged individuals to ones that have evidently been flying for several nights. Many have probably been subjected to the attention of predators, but escaped. Many others probably did not escape, and so never came to the light. The caught series, then, represents a probably biased sample of an original population from which more of the less cryptic individuals may have been

eliminated than of the more cryptic ones. We would expect it to show a higher proportion of cryptic or otherwise protected individuals than the entire, unselected population.

It may also be noted that *P. furcilla* flies in a wide range of local environments, as a result of which there is probably a strong selection for the more or less intermediate, presumably heterozgous, melanistics. Immediately adjacent to my collecting light is a dense and heavily shaded grove of white pine about 30 years old, the trees having very dark bark free from lichens. Here the wholly melanic moths can enjoy the full advantage of their crypsis, while the lighter melanistic and normal ones must be at a strong disadvantage. But within a quarter of a mile are far greater areas of mixed pine–deciduous and mixed deciduous forests, as well as of fields and pastures being invaded by trees and shrubs, many of which are young pines. There are also a number of very old pines, with rough, grey–brown bark, that have lost their lower limbs and have well-lit trunks. The area shows little, if any, sign of industrial pollution; corticolous lichens are still abundant. In this highly mixed environment there are plenty of areas within the flight range of even a heavy female *P. furcilla* where any phenotype shown by the species can be benefited by its crypsis. In the heavily shaded pine groves the melanics would be favored; and in areas predominantly occupied by grey-barked ashes, American elm, and white oak, selection would favor the normal, light grey moths. Such an environment occurs very widely in much of the northeast today where there has not been industrial pollution. Where there has been such pollution, of course, everything is much darker and duller.

Yet, this highly mixed environment is changing. In the relatively stabilized pre-Columbian forest *P. furcilla* must have evolved a relatively stable, balanced polymorphism. Very likely it had a rather dark population; it may be, in fact, that what we call "normal" today was, at least in many areas, a relatively rare thing. In the 17th century man began removing the dense, almost unbroken forest and continued to do so at an ever accelerating rate until by the late 19th century little of the original forest remained and most forest areas had been cut over more than once. Agricultural land was then at its maximum. In this open environment *P. furcilla* must have responded by greatly decreasing its melanism, the light grey form becoming the "normal."

By the beginning of the 20th century, however, a reversal had set in as eastern agriculture, especially in New England, began a rapid decline. Fields and pastures were abandoned to the encroachment of the forest, which was far less cut for fuel. Small, but dense, groves of white pine sprang up everywhere. That on the edge of which the present *P. furcilla* work is being done was open, grassy meadow in 1939. Even local, small lumbering operations declined, as lumber was shipped in from the West; most sawmills were abandoned (many because of the loss of the American chestnut) and old stone

walls, marking former field boundaries, can be found everywhere running through young, but dense, forest. This reforestation is likely to continue. In much of its range, therefore, *P. furcilla* must again be in a transient state, responding, in a reversal of what it did three centuries ago, to the again changing environment.

The above, of course, deals with what for lack of a better term we call "nonindustrial melanism." Certainly this is largely what now occurs at Putnam. In and about the great industrial areas of eastern North America, however, where atmospheric pollution is extremely heavy, *P. furcilla* is undoubtedly "industrially melanic" although we have no proof of this. Selection pressures in polluted areas, however, are far from identical with those in an unpolluted forest area; for not only are the larvae, which must feed on polluted foliage, subject to selection by physiological factors (which may be melanism-linked) that very seasonally as pollution builds up, but also in the environment there is a general darkening of everything that causes selection for dull, smudgy melanistic phenotypes, and against more contrastingly marked ones. Quite different genes or gene combinations may thus be selected for in industrially polluted and nonpolluted areas, even though in both the apparent general effect is one of environmental darkening. In addition, in many areas where little or no industrial pollution exists there may well be something of an inflow of genes from nearby industrially polluted areas.

DISCUSSION OF REARINGS

The rearings were highly disappointing because of an accidental mortality of pupae during the winter of 1964–1965. Consequently, relatively few adults were secured, and the ratios are mathematically unreliable. Furthermore, since nearly all of the adults that were secured were ones that emerged during October, not going into diapause, there is the strong possibility that, representing a physiologically selected group, they may also be melanically selected. The uniformity of the rearing conditions (in screen cages indoors) may also have biased the results by eliminating varying factors that affect wild-reared individuals. Of course, the lack of knowledge of male parents is a great handicap, and the possibility of multiple insemination of wild-caught females by more than one male is something that can never be entirely ignored. Despite such shortcomings, however, the rearings give some valuable information.

The breakdown into phenotypic groups of the reared individuals is interesting when compared with that of the wild-caught ones. The proportions of wholly melanic individuals agree very closely (reared 18 = 18.9%; wild-caught 51 = 18.8%). In the melanistics, however, the figures for the reared and wild-caught groups differ greatly, being: 40 = 42.1% for the reared moths, but 223 = 60% for the wild-caught. Breaking these figures down further: only 14 = 14.7% of the reared moths are very strongly melanistic, compared with

120 = 42% of the wild-caught ones (1962–1965). Furthermore, the reared series contains no intermediately melanistic individuals, having a great hiatus between very strongly and slightly melanistic. This may have resulted from the absence of the proper genetic factors for the intermediate conditions, due to the inadequacy of the sample represented by the parents of the reared group; but it could also result from the rearing conditions or the differential pupal mortality.

The offspring of 1964 Pf N-1 are significant in showing the genetic nature of the larval dimorphism, and in the apparent independence of this from the adult melanism. This is quite in line with findings in many moths in England where larval melanism is scarcely ever linked to adult melanism. Exceptions are *Arctia caja f. fumosa*, in which black larvae always produce black moths; and *Lasiocampa quercus* subsp. *callunae*, in which a high proportion of black larvae produce black moths, indicating linkage (H. B. D. Kettlewell, in litt.).

The numbers of adults secured are too small to have significance, but the fact that of the offspring of 1964 Pf Ms-1 all 5 wholly melanics are males, and all 11 slightly melanistics are females, suggests a possible sex linkage. Also bearing on this is the fact that of the total of 32 reared melanic and strongly melanistic moths (from 5 different mothers) 21 = 66% are males and 11 = 34% are females. A vast preponderance of the slightly melanistic moths (23/26) are females, while the normals run nearly even (19 ♂♂/18 ♀♀) and for the entire reared group the proportions are 43 ♂♂/52 ♀♀. As noted before, the sex ratio of wild-caught moths means nothing here, since very few females come to the collecting light.

One additional feature deserves mention. In some of the reared groups a definite dimorphism of silk color was noted, the silk of some larvae being dark brown while that of others was white. Unfortunately, this was not noticed until too late for full records. However, it occurred only among the offspring of the two very strongly melanistic mothers, 1964 Pf Ms-1 and 1964 Pf Ms-3; all larvae from all other mothers spun brown silk. One larva of 1964 Pf Ms-3 that spun white silk developed into a very strongly melanistic male. At least 10 larvae of 1964 Pf Ms-1 spun white silk; of these 4 developed into wholly melanic moths (1 ♂ and 3 ♀♀) and the others died in pupa; the single slightly melanistic female and the single normal male of this group developed from larvae that spun brown silk. These data merely suggest future observation.

There was no observable correlation between either larval or adult melanism and the rate of larval development or of adult eclosion.

These rearings point beyond this only to the dominance of melanism, and suggest that it is multifactorial. It is hoped, however, that the data here recorded may be of some use as a background, and perhaps a stimulus, for badly needed work on moth melanism in North America.

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