SPECIES DIVERSITY IN *CATOCALA* (NOCTUIDAE) IN THREE LOCALITIES IN NORTH AMERICA

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Moths of the genus *Catocala* (Noctuidae) are abundant in deciduous woodland in many parts of North America, and in some localities between 30 and 40 species may occur together. The larvae of almost all the species of *Catocala* feed on the leaves of trees, especially trees belonging to the Salicaceae, Juglandaceae, Fagaceae, and Rosaceae. Each species of moth tends to be confined to a rather small range of tree species. Many species of *Catocala* are extremely similar, but there appears to be no evidence of natural hybrids (Sargent & Hessel, 1970). The most obvious difference between species is the color and pattern of the hindwing which, at least during daylight, is only apparent when a moth is startled from its resting place on a tree trunk. It would seem likely that the diversity in the pattern of the hindwing is in some way related to the predatory behaviour of birds, although exactly how this is achieved is not known (Sargent, 1969).

Sargent & Hessel (1970) have published information showing the relative abundance of species of *Catocala* at two localities in the United States. In 1961 I obtained a rather similar sample from a single locality in Michigan, and my aim in this paper is to compare the diversity of species in the three samples. But before discussing the estimates of diversity it is necessary to outline briefly the different methods used to obtain the three samples:

Sample 1 consists of 2009 moths obtained at several localities in Franklin and Hampshire Counties in north-central Massachusetts. Specimens taken at bait (a mixture of brown sugar and beer painted on tree trunks) comprise 84% of the sample, while 12% were taken at light, and the remaining 4% were found resting on tree trunks. The specimens were obtained in the summers of 1964–69, baited and light-trapped specimens being obtained mostly before midnight. Very few specimens were collected after early September, a month in which many species of *Catocala* are common. Possibly some individuals were recorded more than once as most of the moths were released after being examined, although Sargent & Hessel (1970) are of the opinion, on the basis of recaptures of color-marked individuals, that recaptures were few.

Sample 2 consists of 5806 specimens from a single site in Litchfield County, west central Connecticut, about 65 miles south-west of Amherst,

TABLE 1. Estimates of species diversity in three samples of *Catocala*.

Sample	N	S	α and Standard Error
1. Franklin and Hampshire Counties, Mass.	2009	33	5.61 ± 0.40
2. Litchfield County, Conn.	5806	39	5.62 ± 0.33
3. Livingston County, Mich.	1331	30	5.45 ± 0.43

Massachusetts. All specimens were taken at lights, mostly from a single mercury vapor trap operated from dusk to dawn in the summers of 1961–65, 1967, and 1969. Trapping continued through September, and there is again the possibility that a few individuals may have been recorded more than once.

Sample 3 consists of 1331 specimens taken at a mercury vapor light operated on the Edwin S. George Reserve, Livingston County, Michigan, during the summer of 1961. The light was operated on almost every suitable night throughout the season and all specimens captured were killed. The light was not normally operated after about 1 a.m.

All three samples are from areas of deciduous woodland mixed with farmland and abandoned farmland. The essential point about the three samples is that number 1 differs markedly from numbers 2 and 3 by the method used to obtain the moths. The three localities are geographically separate from one another, but in view of the distribution and abundance of *Catocala* in North America it is likely that in at least some of the species there is gene flow between the areas.

Numerical estimates of species diversity are possible when both the number of species and the number of individuals per species are known. In estimating species diversity in the three samples I have used the method proposed by Fisher, Corbet & Williams (1943), amplified in Williams (1964). The method involves the assumption, which can be tested, that the distribution underlying the number of species represented by different numbers of individuals is approximately a logarithmic series. The distribution is defined by two parameters: x, a property of sample size only, and α, a property of the populations sampled, which can be regarded as a measure of diversity. The method of estimating α and its standard error is given in Fisher, Corbet & Williams (1943), and rough estimates can be read from the nomogram given in Williams (1964). Observed values of N, the number of individuals, and S, the number of species, are required.

TABLE 2. The three commonest species of *Catocala* in three different localities.

Locality	Species	% of Total Sample
1	*ilia*	34
	ultronia	16
	*crataegi**	5
2	*palaeogama*	15
	residua	15
	habilis	11
3	*amica*	31
	epione	12
	concumbens	6

* This includes records of *Catocala blandula* and *Catocala mira*.

The results for each of the three samples are given in Table 1. The three computed values of α are similar and the standard errors are small. There is no significant difference between them, and the result is thus in accordance with the view that species diversity within a group of organisms is an intrinsic property of the environment. The three samples differ in the way in which they were obtained (the difference being greatest between sample 1 and samples 2 and 3) but this does not appear to have affected the value of α. Many of the species taken are common to all three samples, but the relative frequency of most of the species in each locality is quite different. All three samples are characterised by a small number of abundant species and many relatively rare species, but a rare species in one sample is sometimes among the commonest in another. Table 2 shows the three most abundant species in each of the three samples. With the possible exception of *Catocala crataegi*,[1] which was not positively identified in sample 3, each of the species shown in Table 2 occurred at all three localities, but in each case the three most abundant species are different in each of the three samples. These differences are presumably associated with local ecological conditions, possibly with the relative availability of larval foodplants in the three localities, but the important point is that in each locality only three species comprise 55%, 41%, and 49%, respectively, of the total samples. This is the familiar result obtained whenever a group of species is sampled. But despite the variations in abundance of the species in the three localities, almost identical values of species diversity are obtained. This suggests that species of *Catocala* are partitioned out by the local environment in such a way that a constant diversity is maintained. It would be of considerable interest to know exactly how this is achieved.

[1] *Catocala mira*, which was tentatively identified in sample 3, is easily confused with *Catocala crataegi*, and it is possible that what I have called *mira* is in reality *crataegi*.

SUMMARY

Samples of moths of the genus *Catocala* from three localities in the United States have values of species diversity that are not significantly different. It is suggested that this result supports the view that diversity is an intrinsic property of the environment and that although the individual species differ in their relative abundance in different places, an essentially identical pattern of diversity occurs in three widely separated yet ecologically similar localities.

LITERATURE CITED

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McFARLAND MOTH COLLECTION DONATED TO THE NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY

Noel McFarland has been one of the more prominent students of North American moths for many years. When he moved to Australia he donated his splendid collection of 8,420 specimens to the Natural History Museum of Los Angeles County.

By far the most significant portion of the collection is 3,315 beautifully preserved larvae, in alcohol, and the accompanying copious notes on foodplants, behavior, and larval descriptions. The larvae of many species, such as *Saturnia albofasciata*, are represented in few, if any, other collections.

In addition to the larvae, there are 5,105 adult moths, many of which bear distinctive labels to associate them with rearing notes and preserved larvae. Included are most of the 278 species of moths taken during extensive collecting in Los Angeles County that resulted in "The moths (Macroheterocera) of a chaparral plant association in the Santa Monica Mountains of Southern California," (1965, J. Res. Lepid. 4: 43–74). In addition, there are a number of specimens from Kansas, and numerous moths from the edge of the Mojave Desert adjacent to the San Gabriel Mountains.

Earlier, in 1963, McFarland donated to the Museum 860 specimens of moths from Benton County, Oregon. These represent a large portion of the 360 species that he collected during a 20-month study that was the basis of his unpublished 1963 Master of Science thesis at Oregon State University, "The Macroheterocera (Lepidoptera) of a Mixed Forest in Western Oregon."

These generous donations are a valuable addition to the Museum's extensive holdings of western Lepidoptera, while the larvae will form a strong nucleus for the collection of immatures.

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