How Unusual are Unusual Events?

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. . . and there shall be famines, and pestilences, and earthquakes, in various places. (Matthew 24:7)

In studying living organisms, the laboratory researcher is spared the apparently random, unusual event that affects the organism in its natural environment. Such events include the abiotic (e.g., drought, flood, heat, cold) and the biotic (e.g., high or low predation, a dearth or wealth of prey). My aim is to document the extent to which researchers invoke "unusual" events to interpret data from field studies. Furthermore, I examine how the probability of an unusual event's occurrence varies with study duration, organism studied, habitat, and latitude. If unusual events are purely statistical phenomena, I expected them to occur more frequently in longer studies. Because aquatic environments should be buffered better than terrestrial environments from events like rapid temperature change, I expected fewer unusual events in aquatic studies. However, for many comparisons, such as those between different taxa or between tropical and temperate studies, there were no clear predictions regarding the relative susceptibility to unusual events.

In addition to satisfying a curiosity about whether unusual events are really rare, the results of this study also are significant for several areas of research. In the debate over whether ecological communities are ordered assemblages of species, Wiens (1977) argued that natural environmental variation affecting the distribution and abundance of populations may be commonplace. These "ecological crunches" keep populations below carrying capacity most of the time, thereby making interspecific competition for resources relatively rare and competition relatively unimportant in shaping community composition. Similarly, in a commentary on optimal foraging theory, Myers (1983) suggested that unpredictable selective events may retard the rate at which animal behavior approaches optimality. Thus, although animal behavior may show qualitative concordance with the predicted optimal solutions to various problems, quantitative agreement may be rare. I offer the above examples only to illustrate two areas of investigation to which data on the frequency of unusual events may be relevant. As described below, however, these data were not assembled with the intention of addressing any specific body of research.

METHODS

Rather than examining such data as variation in meteorological features and attempting to interpret their potential biological importance, I pursued a more direct route. Using a literature survey, I relied on the authors of each study to

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determine whether the organism or system they were studying had been subjected to some unanticipated natural phenomenon (i.e., an unusual event) that affected the outcome of the study. This approach allowed wide sampling geographically and taxonomically and would produce biased estimates only if researchers tended to underreport or overreport studies in which unusual events had occurred, a possibility that seems unlikely. It should be noted that none of the studies in which unusual events were recorded were published specifically to report the unusual event. Rather, unusual events were encountered by researchers investigating other phenomena. For a study to qualify as having an unusual event, the authors had to attribute some outcome of their study to that event.

All the information reported on here was drawn from the following sources: *Animal Behaviour* volumes 21, 22, 31, 32; *Ecology* volumes 54 (pp. 1–339), 55, 64, 65; *Evolution* volumes 27, 28, 38; *Behavioral Ecology and Sociobiology* volume 14 (pp. 1–150). The choice of the source material attempted to achieve some breadth in the organisms studied, the conceptual objectives of the studies, and the time at which the studies were done. Every paper from the above sources that involved a study of a free-living population or community was included in the sample of 380 papers. From each paper the following information was recorded: organism(s) studied, environment (terrestrial, aquatic), latitude (temperate, tropical), duration of study, and the nature of any unusual event. Because not every paper contained all the above information, sample sizes for different analyses vary.

RESULTS

The types of unusual events encountered include such things as high mortality of plants due to drought and major shifts in birds' diets because hot, dry conditions changed the usual patterns of prey abundance. In fact, the breakdown of unusual events by category (fig. 1) reveals that most were abiotic, with atypical precipitation, temperature, or both accounting for most of the observations. The "other" abiotic events included unusual precipitation and temperature combined with high winds, or flooding from causes other than precipitation. Unusual biotic events were rare and included changes in food availability, fungal infection, and the abundance of species present in a study location.

The relationship between study duration and the probability of an unusual event was less clear-cut than expected (fig. 2). Generally, the frequency of unusual events increased in studies lasting up to 6 yr, but for longer studies (up to 15 yr) unusual events were less common. Overall, one study in 10 can expect to record at least one unusual event. Interestingly, even a one-year study can be unusual. In these cases, unusual refers to some background information such as weather records for the location where the study was conducted. In longer studies, unusual can refer to background information or to other years of the same study.

The overall occurrence of unusual events by taxonomic group and ecosystem was surprisingly uniform (table 1). Studies conducted in the tropics were almost as likely to encounter unusual events as studies in temperate regions. Plants and animals were equally likely to experience unusual events, and among the animals, only fish experienced no unusual events in 20 studies. However, the pattern for

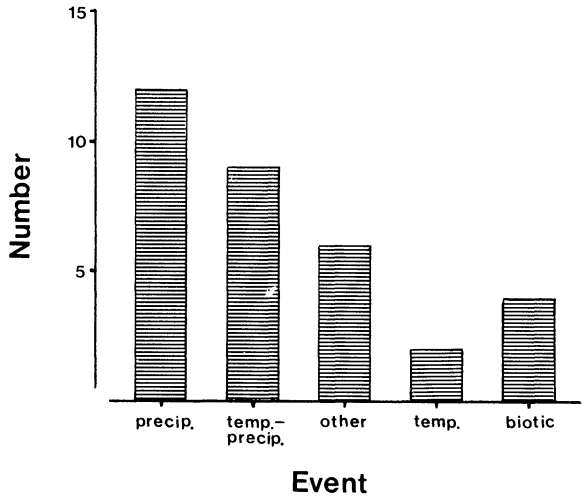

FIG. 1.—The frequency distribution of different types of unusual events.

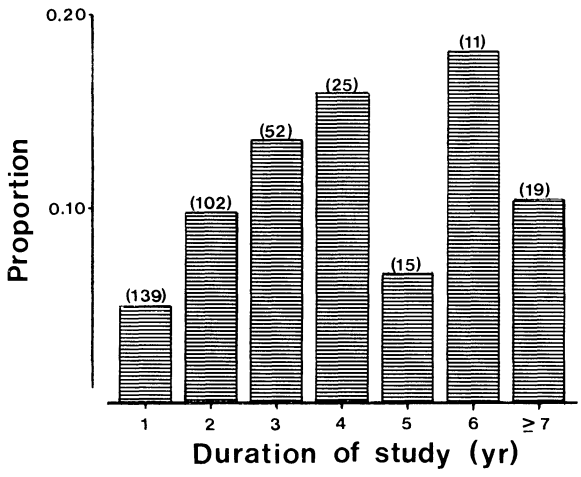

FIG. 2.—The proportion of studies of different duration in which at least one unusual event was reported. Sample sizes are given in parentheses.

fish may be due in part to the shorter average duration of fish studies (table 1; a Kruskal-Wallis test shows that mean study duration differs between taxa, $\chi^2 = 15.1$, $P = 0.04$). The pattern for fish appears not to reflect inherently greater stability in aquatic environments because, of 35 studies of aquatic organisms other than fish, 4 (11.4%) recorded unusual events, a level similar to that recorded in terrestrial environments. Finally, an interesting difference, based solely on the type of journal in which the study was published, was found between broad types of research. Unusual events were encountered in only 3.0% of 135 behavioral

TABLE 1

PERCENTAGE OF STUDIES WITH AT LEAST ONE UNUSUAL EVENT (SAMPLE SIZES IN PARENTHESES)

TAXONOMIC GROUP	ECOSYSTEM			TOTAL	MEAN DURATION OF STUDIES ± SD (YR)
	Temperate	Tropical	Desert		
Bird	9.6 (73)	14.3 (14)	0 (2)	10.1 (89)	2.80 ± 1.96
Mammal	9.1 (22)	6.7 (15)	0 (8)	6.7 (45)	2.80 ± 2.55
Fish	0 (6)	0 (14)	—	0 (20)	1.74 ± 1.20
Reptile	0 (6)	16.7 (6)	50.0 (2)	14.3 (14)	2.13 ± 1.36
Amphibian	22.2 (9)	0 (7)	0 (1)	11.8 (17)	2.41 ± 1.28
Insect	5.3 (38)	12.5 (8)	25.0 (8)	9.3 (54)	1.95 ± 1.40
Other invertebrates	11.1 (18)	0 (7)	0 (2)	7.4 (27)	2.28 ± 1.57
Plant	12.2 (49)	10.0 (10)	0 (7)	10.6 (66)	2.87 ± 2.81
Total	9.5 (221)	7.4 (81)	10.0 (30)	9.0 (332)	

studies, contrasting with 11.0% of ecological studies ($N = 214$) and 16.1% of evolutionary studies ($N = 31$). These differences are not the result of study duration, which averaged approximately 2.5 yr in all three groups.

DISCUSSION

In biological research, one possibility in 20 of an event's occurring by chance might be considered an existing way of defining unusual, since that is the accepted standard used in interpreting statistical analyses. That being so, the answer to the question posed in the title must be that unusual events are perhaps more usual than has been previously recognized, given a probability that they will occur in one study in ten. However, the curious relationship between the likelihood of an unusual event and the duration of a study suggests that we cannot treat these events as only statistical phenomena. For example, given a 5% probability of an unusual event in a 1-yr study, one should expect a 35% probability of such an event in a 7-yr study. However, studies lasting 7 yr or longer had less than a 10% likelihood of including an unusual event.

The key to this paradox may lie in the fact that I relied on the authors of each paper to designate whether an unusual event affected the outcome of their study. In a 2-yr study of some aspect of an animal's reproductive biology, a drought that reduces reproductive output in one of the years may appear of greater importance than a 1-yr drought in a 10-yr study. One extreme value in ten points will have less effect on analysis and interpretation than will one extreme value in two points. Thus, unusual events may be encountered at the same rate in long and short investigations, but the researchers in long investigations may less often consider them important.

Wiens (1977) suggested that short-term studies could lead to erroneous conclusions because they were likely to miss infrequent but important random events. However, the interpretation I propose above implies that, in fact, the danger of short-term studies may be that they experience too many unusual events. The

reason for this unexpected conclusion may be that we tend to overestimate the importance of some unusual events when we lack the benefit of the perspective provided by a longer study.

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