Table 2. COMPARISON OF *Erebia epipsodea* AND *Euphydryas editha*

	Euphydryas editha	*Erebia epipsodea*
Microdistribution	Isolated local populations	Nearly ubiquitous at suitable altitude
Degree of isolation of populations	Almost no exchange of individuals and even less gene flow between many small populations in close geographic proximity	Isolation by distance, but "neighbourhood" size extremely large
Gene flow within population	Effectively panmictic within small local populations	Effectively panmictic over a very large geographical area
Reaction to "barriers"	Intrinsic barriers to dispersal	No intrinsic barriers to dispersal
Dispersion within suitable habitat	Clumped, does not utilize all habitat where food plant of larva grows	Randomly distributed throughout all suitable areas
Annual population fluctuations	Adjacent populations fluctuate independently of each other	Changes in one area are reflected by changes in another 10·5 km away
Frequency of population extinction	Probably high	Probably very low
Suitability for capture–recapture analysis	Highly suitable; much information about population size, survival rates, and number of new animals joining population can be derived from analysis of sequential recapture studies	Much less suitable; analysis provides a fair general indication of density, but due to extensive leakage and re-immigration into and out of study areas, less can be learned about the more detailed properties of the entire population
Phenetic and genetic similarity	Similarity between local populations maintained by similar selective pressures	No differences between widely separated geographic areas due to effective panmixia within a single large population

for annual organisms in a temporally variable environment. It is interesting to note that what selective changes have been detected in *E. editha* populations tended to occur simultaneously in adjacent populations, rather than differentially[5,9]. The differences and similarities of *E. editha* and *E. epipsodea* are summarized in Table 2.

P. F. BRUSSARD

Division of Biological Sciences,
Cornell University,
Ithaca, New York 14850.

P. R. EHRLICH

Department of Biological Sciences,
Stanford University,
Stanford, California 94305.

Received March 31, 1970.

[1] Ehrlich, P. R., *Evolution*, **19**, 327 (1965).
[2] Ehrlich, P. R., *Science*, **134**, 108 (1961).
[3] Brussard, P. F., and Ehrlich, P. R., *Ecology* (in the press).
[4] Ehrlich, P. R., *Univ. Kans. Sci. Bull.*, **37**, 175 (1955).
[5] Ehrlich, P. R., and Mason, L. G., *Evolution*, **20**, 165 (1966).
[6] Li, C. C., *Population Genetics* (University of Chicago, 1955).
[7] Dowdeswell, W. H., Fisher, R. A., and Ford, E. B., *Ann. Eugen.*, **10**, 123 (1940); Dowdeswell, W. H., Fisher, R. A., and Ford, E. B., *Heredity*, **3**, 67 (1949); Sheppard, P. M., *Heredity*, **5**, 349 (1951); Turner, J. R. G., *Proc. Roy. Entomol. Soc.*, **38**, 101 (1963); Keller, E. L., Mattoni, R. H. T., and Seiger, M. S. B., *Anim. Behav.*, **14**, 197 (1966).
[8] Ehrlich, P. R., and Raven, P. H., *Science*, **165**, 1228 (1969).
[9] Mason, L. G., Emmel, T. C., and Ehrlich, P. R., *Evolution*, **22**, 46 (1968).

GENERAL

Likelihood

BIRNBAUM[1,2] has retracted his former support[3] for the likelihood approach to scientific inference[4] after considering an example in which the approach would, it seems, always lead to the wrong conclusion. The import of this example[2] is that there exists a hypothesis of higher likelihood than any statistical hypothesis one cares to contemplate, namely the determinist hypothesis which asserts that what was observed happened because there was no alternative, and hence has a likelihood of 1. Indeed, if the sample space is supposed continuous, this hypothesis has an infinite likelihood ratio in its favour.

This criticism belies a misunderstanding of the nature of a scientific hypothesis. If two hypotheses are both compatible with the data, in what sense can either be said to be wrong? On drawing a card at random from a pack of fifty-two playing cards and finding it to be the ace of diamonds, the likelihood of the hypothesis "all fifty-two cards are aces of diamonds" is fifty-two times that of the hypothesis "the pack is normal". If I use this as a criterion for accepting or rejecting packs of cards from a production line, I am indeed behaving foolishly[4]; but as a scientific theory the first hypothesis is admirable as far as it goes and on the information available, for it is extremely simple and accounts for the observation. The fact that drawing a second card will destroy it is irrelevant; we are considering an induction based on a single card. A Martian faced with this problem would find the first hypothesis most appealing; are not all the cards identical in size and shape, with identical patterns on the side exposed to view? How natural, then, that they should all have the same design on the other side. But we find the hypothesis absurd, not because it does not account simply for the observation—it does that very well—but because we have strong prior opinions. These may be expressed by prior likelihood or prior probability, as appropriate[4].

On finding six pennies on a table in the sequence HHTHTT, how are we to compare the hypothesis that they were placed thus intentionally (likelihood 1) with the hypothesis that they were each placed head or tail up at random (likelihood 1/64)? The determinist hypothesis is attractive, but whether our prior opinions outweigh the evidence provided by the likelihood ratio depends on whether the table is in a gambling hall or a numismatic exhibition.

To use the confidence concept[1,2] in science is to behave as though we are playing a game with the Creator, who keeps a list of true theories, rewarding us with a fixed prize whenever we get one right. This is fine as a model for industrial quality control, but hardly appealing to natural scientists. The fact that Newton failed to collect a prize for his theory of gravitation is discouraging, to say the least.

Napoleon accused Laplace of leaving the Creator out of the *Mécanique Céleste*, to which the Marquis replied, "I had no need of that hypothesis", even though, as Lagrange afterwards commented to Napoleon, "it is a fine hypothesis—it explains so many things". We, like Laplace, admit other criteria: "we choose (other things being equal) the simplest system, and (other things being equal) we choose the system which gives the highest chance to the facts we have observed. This last is Fisher's 'Principle of Maximum Likelihood', and gives the only method of verifying a system of chances"[5]. The inequality of "other things" may be expressed by prior likelihood[4].

In my view it would be unfortunate if the likelihood method, which is a natural and simple quantification of our desire to adopt hypotheses which best fit the facts, were to be neglected by scientists in favour of "the incompletely formalized synthesis of ingredients borrowed from mutually incompatible theoretical approaches" advocated by Birnbaum[1].

I thank Professor L. L. Cavalli-Sforza and Professor M. Fraccaro for hospitality in their departments during a visit to the University of Pavia, when this was written.

A. W. F. EDWARDS

Gonville and Caius College,
Cambridge.

Received April 13, 1970.

[1] Birnbaum, A., *Nature*, **225**, 1033 (1970).
[2] Birnbaum, A., in *Philosophy, Science, and Method* (edit. by Morgenbesser, S., Suppes, P., and White, M.) (St Martin's Press, New York, 1969).
[3] Birnbaum, A., *J. Amer. Stat. Assoc.*, **57**, 269 (1962).
[4] Edwards, A. W. F., *Nature*, **222**, 1233 (1969).
[5] Ramsey, F. P., *The Foundations of Mathematics and other Logical Essays* (Routledge and Kegan Paul, London, 1931).