Empirical Test of Lotka-Volterra

(from *Ecology, The Experimental Analysis*
of Distributions and Abundance, 3rd Edition,
by Charles J. Krebs, Harper and Row, NY, 1985)

Stable Oscillations of predator-prey interactions have been obtained in several laboratory systems. Utida (1957) maintained a system of the azuki bean weevil as a host (prey) and a wasp parasitic on the larvae of the weevil as a parasite (predator) in a petri dish 1.8 cm high by 8.5 cm in diameter. Systems of this type show oscillations (Figure 1), which Utida followed for a maximum of 112 generations (14 complete oscillations). The oscillations were gradually damped in amplitude (convergent oscillations), and Utida noted that a long-term trend was imposed on the cycle; the host population gradually increased in density, and the parasite population gradually declined. This raised an interesting question: Can there be evolutionary changes in laboratory predator-prey systems during short experiments? Lotka-Volterra, of course, assumed a constant and unchanging prey species and a constant and unchanging predator species, and other ecologists have often followed their lead in assuming that evolution cannot occur on an ecological time scale.

Evolutionary changes in predator-prey systems in the laboratory have been studied most thoroughly by Pimentel and his coworkers at Cornell. In one study, a population system of the house fly (*Musca domestica*) and a wasp parasite (*Nasonia vitripennis*) maintained for 20 generations showed significant evolutionary changes (Pimentel et al. 1963). These changes occurred in both the host flies and the parasite wasps: The host became more resistant to the parasite, and the parasite became less virulent to the host. This is indicated in the population parameters in Table 1. Selection had produced evolutionary changes in a short time to reduce the intensity of interaction between the host and the parasite. Thus the genetic properties of both host and parasite were not constant.

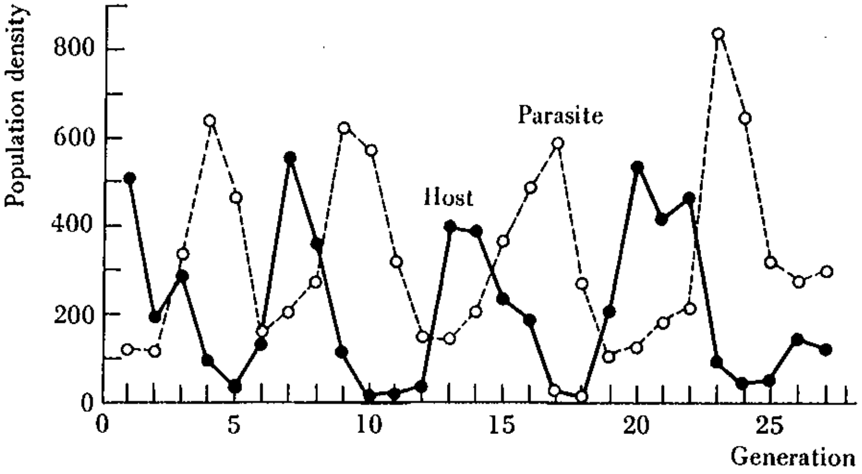

Figure 1. Fluctuations in population density in a host-parasite system of the azuki bean weevil (*Callosobruchus chinensis*) and its larval parasite *Heterospilus prosopidis* (a wasp).

Table 1. Evolutionary Changes in a Host-Parasite System of the House Fly (*Musca domestica*) and a Wasp Parasite (*Nasonia vitripennis*) After 20 Generations of Interaction in the Laboratory

	Reproductive Rate (progeny per female wasp)	Parasite Rate (% fly pupae parasitized)	Longevity of of Female Wasps (days)	Longevity of of Male Wasps (days)
Control wasps on control flies	140	51.7	7.0	1.6
Experimental wasps on experimental flies[a]	46	39.6	4.6	1.4
Control wasps on experimental flies[b]	68	46.0	5.2	1.4
Experimental wasps on control flies[c]	123	52.6	6.6	1.7

[a] Measures evolutionary changes in both hosts and parasites.

[b] Measures evolutionary changes in host resistance.

[c] Measures evolutionary changes in parasite virulence.

The mathematical demonstration by Lotka and Volterra that predator-prey interactions could produce oscillations seems strikingly applicable to some biological systems. The Canada lynx (*Lynx canadensis*) eats snowshoe hares (*Lepus americanus*) and shows dramatic cyclic oscillations in density with peaks every 9 to 10 years (Figure 2). Charles Elton analyzed the records of furs traded by the Hudson Bay Company in Canada for over 200 years and showed that the cycle is a real one that has persisted unchanged for at least 200 years (Elton and Nicholson 1942).

This lynx-hare cycle has been interpreted as an example of an intrinsic predator-prey oscillation, but this is apparently not correct. Keith (1983) has shown that a food shortage during the winter initiates the decline in hare numbers, and predators play a secondary role in prolonging the decline to low numbers. Although lynx depend on snowshoe hares, the hares fluctuate in numbers because of interactions with their food plants. *No one has yet found a classic predator-prey oscillation in field populations!*

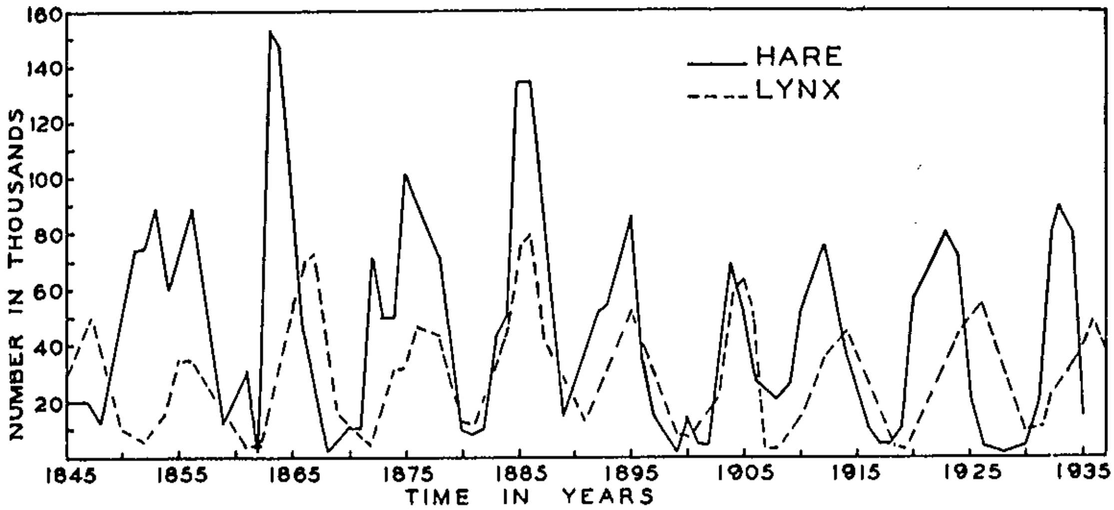

Figure 2. Changes in the abundance of the lynx and the snowshoe hare, as indicated by the number of pelts received by the Hudson Bay Company. (From Odum 1983, redrawn from MacLulich 1937.)

References

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