Delayed density-dependence

SIR — Population ecologists have frequently failed to detect significant density-dependence, the pivotal prediction of the theory of population dynamics, in natural populations of animals. Various statistical techniques for demonstrating density-dependence have been described and tested (for example see refs 1, 2), but many difficulties still remain[3,4]. Turchin has pointed out[5] that most current techniques are unsuitable for detecting delayed density-dependence. Therefore, if population regulation with time lags is common, the overall level of density-dependence may be underestimated.

Turchin demonstrated this problem with an analysis of 14 sets of time-series data on forest insects, eight of which showed clear evidence of delayed density-dependence. We have analysed a large set of time-series data on annual abundances of moths and aphids using the light-and suction-trap networks of the Rothamsted insect survey[8] (our full analysis will be published elsewhere). We have looked at the occurrence of delayed density-dependence using Turchin's method[5], and present our results in the table.

We counted the fractions of time-series that showed significant delayed density-dependence at 5 and 1% levels. (By chance, one would expect that 5 and 1% of the time-series would show a delayed effect at these levels.) The observed fractions of significant delayed effects match the expected values closely for moths, but we found less delayed density-dependence than expected by chance for aphids (the model is not very appropriate for aphids with several overlapping generations per year).

DELAYED DENSITY-DEPENDENCE IN INSECT POPULATIONS

Taxon	Number of species	Number of series	Significance level	Observed fraction	X^2	P
Moths	357	4,306	0.05	0.045	1.13	0.287
			0.01	0.014	2.84	0.092
Aphids	92	1,405	0.05	0.022	15.62	<0.001
			0.01	0.004	3.22	0.073

Lengths of the time-series are from 10 to 24 years.

We are not suggesting that the delayed density-dependence demonstrated by Turchin is not real or important, but we do suggest that the high incidence detected by him is due to the selection of forest pest species with a tendency towards outbreak dynamics. More generally, the kind of data typically analysed by population ecologists are biased towards the most abundant and outbreak species, which means that the current population-dynamic conclusions based on these data should be viewed with caution[4]. Our data consist of 'ordinary' insect populations, without any bias with respect to their abundance or dynamics.

Our results strongly suggest that delayed density-dependence is rare in these insects and, by implication, in most insect populations. Although delayed density-dependence is uncommon in British moths and aphids, we do find non-delayed density-dependence to be common (manuscript in preparation).

ILKKA HANSKI

Department of Zoology,
University of Helsinki,
P. Rautatiekatu 13,
SF-00100 Helsinki, Finland

IAN WOIWOD

Department of Entomology & Nematology,
Institute of Arable Crops Research,
Rothamsted Experimental Station,
Harpenden, Hertfordshire AL5 2JQ, UK

1. Gaston, K. J. & Lawton, *Oecologie* **74**, 404–410 (1987).
2. Den Boer, P. J. & Reddington, J. *Oecologia* **79**, 143–149 (1989).
3. Murdoch, W. W. & Walde, S. J. in *Toward a More Exact Ecology* (eds Grubb, P. J. & Whittaker, J. B.) 113–140 (Blackwell, Oxford, 1989).
4. Hanski, I. In *Regulation and Relative Abundance of Plants and Animals* (eds May, R. M. & Hassell, M. P.) **330**, 140–150 (Royal Society, London, 1990).
5. Turchin, P. *Nature* **344**, 660–663 (1900).
6. Taylor, L. R. *J. anim. Ecol.* **55**, 1–38 (1986).

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DNA damage in the Antarctic

SIR — The Antarctic ozone hole represents a cycle of annual springtime depletion of stratospheric ozone over the continent and surrounding ocean areas, with consequent increases in levels of ultraviolet-B radiation (UV-B, 280–320 nm)[1]. The ecological impact of this increased radiation is of particular concern for Antarctic marine communities, which depend on the productivity of phytoplankton at the base of short food chains. There has been much speculation about ecological effects based on *a priori* assumptions about unique photobiological properties of Antarctic organisms. A common misconception is that because these organisms inhabit an area of relatively low ambient ultraviolet intensity, Antarctic species may be more sensitive to UV-B exposure than their temperate or tropical counterparts[2]. But Antarctic species are derived from temperate and tropical stocks and should therefore retain a capacity for biochemical protection from ultraviolet exposure[3] and for repair of radiation-induced damage.

During 1987 and 1988 we carried out one of the first on-site evaluations of ultraviolet exposure and photobiological responses of nine phytoplankton species at Anvers Island in the Antarctic[4]. We discovered that biologically effective UV-B can be detected as deep as 20 m during springtime ozone depletion[5] and noted that the morphology of the cells influenced the amount of initial DNA damage[4]. The nine diatom species, which spanned nearly three orders of magnitude in cell volume with considerable variation in surface area: volume ratios, exhibited a nearly 100-fold range in the total number of photoproducts induced. All species investigated showed evidence of both photoreactivation and excision repair at ambient Antarctic temperatures, but with considerable species variation. *Chaetoceros neglectus,* for example, removed 31% of cyclobutane dimers in 6 h but did not repair any (6–4) photoproducts; *Corethron cryophilum* repaired 46% of the dimers induced and 94% of the (6–4) photoproducts[4].

The ozone hole has existed for more than ten years. Obvious catastrophic events have not been noted. Our results indicate that Antarctic phytoplankton have diverse capacities for sustaining and repairing UV-induced damage to DNA and as a group are not defenceless against this environmental stress. Cumulative biological effects of the ozone hole are apparently subtle alterations in species interactions, and it may take longer than a decade for these perturbations to have an observable effect. The UV photobiology of individual species needs to be a key focus in future research efforts.

SENEB KARENTZ
JAMES E. CLEAVER
DAVID L. MITCHELL

Laboratory of Radiobiology and Environmental Health,
University of California,
San Francisco, California 94143, USA

1. Frederick, J. E. & Snell, H. E. *Science* **241**, 438 (1988).
2. Calkins, J. & Thordardottir, T. *Nature* **283**, 563 (1980).
3. Karentz, D. *et al. Marine Biol.* (in the press).
4. Karentz, D., Cleaver, J. E. & Mitchell, D. L. *J. Phycol.* (in the press).
5. Karentz, D. & Lutze, L. H. *Limnol. Oceanogr.* **35**, 549–561 (1990).