tubes, which on closer examination proved to occur always in pairs and to project from the openings of the burrows formed by the shipworms. Plainly the tubes had been formed around the siphons of the Teredo. They were of varying length, depending presumably on the thickness of the deposits, the longest being some two-fifths of an inch. The general appearance of the wood is shown in Fig. 1.

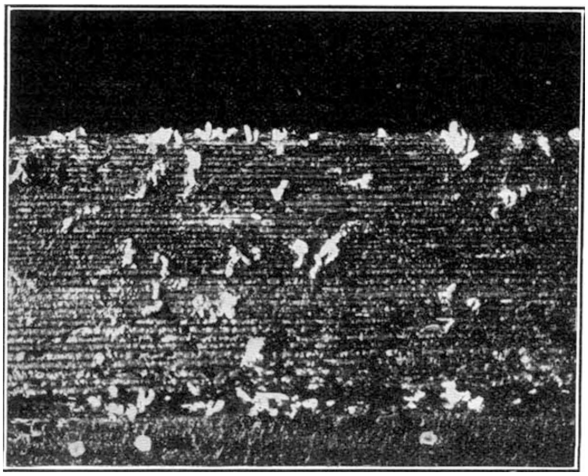

Photo.] [*A. J. Smith.*

FIG. 1.—Portion of wood badly infected with *Teredo norvegica.* The white objects are the protruding calcarerous siphonal tubes which appeared after the fæcal deposits had been washed off. In several cases the paired tubes can plainly be distinguished.

Normally the external openings of the tubes of Teredo are very difficult to distinguish, consisting of a pair of minute openings ringed with calcareous matter out of which project the siphons and within which these are immediately withdrawn on stimulation. The presence of fæcal deposits, which had accumulated to an abnormal degree owing to the lack of water currents to remove them, would tend to obstruct the passage of the siphons and so endanger the life of the animals within. The response of the animals to this abnormal and dangerous state of affairs was to lay down calcareous tubes around the siphons, which by this means were able to maintain free contact with the water.

Dr. W. T. Calman has directed my attention to the fact that the giant shipworm, *Kuphus arenarius*, which lives vertically embedded in the mud of mangrove swamps in the Pacific, normally has the siphons encased in this manner, a fact which was known to Rumphius so far back as 1741, and was figured by him (as *Solen arenarius*) in his " D'Amboinsche Rariteitkamer." This animal lives normally under conditions in which the Teredo in the Plymouth tank lived for some four months, namely, in constant danger of being suffocated by accumulating deposits—in one case of mud, in the other of fæcal matter.

This accidental production of calcareous siphonal tubes in Teredo is therefore of some considerable interest, since it provides a very striking case of an immediate and highly successful response by an animal to changed environmental conditions; a response, moreover, which has taken the form of a permanent adaptation in related animals living under conditions very similar to those accidentally produced.

C. M. YONGE.

Marine Biological Laboratory,
Citadel Hill, Plymouth,
November 15.

Fluctuations in the Abundance of a Species considered Mathematically.

WITH regard to Prof. Volterra's interesting article, " Fluctuations in the Abundance of a Species considered Mathematically," in NATURE of October 16, page 558, I may be permitted to point to certain prior publications on the subject, of which Prof. Volterra seems to be unaware. The general theory as well as a number of special cases have been set forth in " Elements of Physical Biology " (published by Williams and Wilkins, Baltimore, 1925), in which work a considerable number of references to the journal literature are given. Among other things Prof. Volterra's diagram " Fig. 2 " will be found on page 90 of the book cited; the expression for the period of isochronous small oscillations in the case of two species is also found on the same page. Prof. Volterra refers to certain applications of his analysis to problems of sea fisheries, to a passage in Darwin's " Origin of Species," to extinction of species, to pathogenic germs, and to parasitology. An application to sea fisheries is found in the book cited on page 95; to a passage in Herbert Spencer on page 61; to the extinction of species on pages 94, 95; to pathogenic germs on pages 77, 79, 147 *et seq.*; to parasitology on page 83.

The effect of introducing a third species into a system of two species is discussed on page 94; the effect on equilibrium of changing various factors is treated in Chap. xxii., " Displacement of Equilibrium," and, in particular, the effect on equilibrium between food and feeding species is analysed on page 289. The distinction between oscillatory and aperiodic systems, and its relation to certain quadratic forms, is referred to on pages 146, 148, and 159.

It would be gratifying if Prof. Volterra's publication should direct attention to a field and method of inquiry which apparently has hitherto passed almost unnoticed.

ALFRED J. LOTKA.

Metropolitan Life Insurance Company,
New York City, October 29.

In the above letter from Dr. Lotka, which is in accordance with our preceding correspondence, following upon the publication of my article in NATURE, he justly observes that he had obtained the differential equations in the case of two species, one of which feeds upon the other, that he had given, as well as myself, the same diagram of the integral, and also the period in the case of small fluctuations. In this I recognize his priority, and am sorry not to have known his work, and therefore not to have been able to mention it.

I did not even know other publications of the same kind by other authors, for example, the work of Sir Ronald Ross on malaria, which precedes the writings of Dr. Lotka, who has, however, found so many new and important results.

The other observations mentioned in the above letter refer to points which I have not treated; but as to the sea-fisheries, while I refer to the laws (which I believe to have been the first to formulate) and principally to the third law, which gives an easy way of calculating the maximum output of fisheries; he, on his part, considers the case of the addition of a third species, which seems to me a different problem.

I also think that the quotation of Darwin's acute intuition referring to my third law, and the quotation from Spencer, which touches only the principle of the existence of fluctuations, are essentially different.

I think that the study of the general case of the convivence of n different species, subject to the hypothesis which permits me to distinguish the case