LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Detection of Birds by Radar

PERMISSION has now been obtained to publish the fact that birds can reflect radio waves with sufficient strength to be detected by radar sets. Evidence of this was given to us in the summer of 1941 by Dr. E. S. Shire, then developing centimetric radar equipment at the Air Defence Research and Development Establishment, Ministry of Supply. Confirmation was obtained by G. C. Varley in September 1941, when echoes observed on an operational centimetric set at Dover were established by visual checks to come from gannets (*Sula bassana*) flying singly above the sea. The facts were published in a secret report of the Army Operational Research Group, Ministry of Supply, in April 1942. Much fuller details, with numerous further records, were published in a secret report dated February 1945.

Since 1941, there have been numerous well-authenticated records of birds being detected by radar, first from England, then from Malta and Gibraltar, and later from New Zealand and the United States of America[1]. Indeed, with the introduction of higher powered transmitters late in 1943, bird echoes became such a menace on British coast-watching equipment that we specially trained radar operators to distinguish them from echoes of operational importance. Confusion has occurred with aircraft; but the latter are usually quickly differentiated by their greater speed. More serious is the possibility of confusion with fast-moving ships. Birds not infrequently travel with a ground-speed similar to that of a fast-moving ship, and at long range the echo from a bird flying fully in the beam of a radar set can be equal in strength to that from a ship which is below the lowest maximum of the vertical polar diagram. Birds have given rise to several E-boat scares and to at least one invasion alarm.

That birds give radar echoes is not surprising when it is realized that heavy rain is also detected. Single birds may give echoes not much smaller than those from metal spheres of comparable size. The species involved have been mainly the larger sea and shore birds, such as gulls (*Larus* spp.) and grey geese (*Anser* spp.). However, when in flocks even birds so small as a starling (*Sturnus vulgaris*) have produced echoes large enough to be a nuisance to radar operators. Experimental proof that birds can produce radar echoes was obtained by Major J. A. Ramsay of Coast and Anti-Aircraft Experimental Establishment, when he suspended a herring gull (*Larus argentatus*) from a captive balloon in such a way that the echo from the bird was clearly separable from that given by the balloon.

As yet, the radar results have produced little of ornithological interest except to show how frequently birds fly at night over the sea. However, the radar stations concerned have rarely been allowed to follow bird tracks once their identity has been established. There are two other serious difficulties: first, that of getting visual confirmation of the source of the echo, and secondly, that of following a bird track continuously on a coastal radar set owing to marked variations in signal-strength, including complete fading, due to the bird passing through successive maxima and minima of the vertical polar diagram.

On January 12, 1945, a long track was obtained on birds which later crossed the East Anglian coast near a Royal Observer Corps post, where they were identified as grey geese from their calls. (The pink-footed goose, *Anser brachyrhynchus*, is much the commonest species of goose in the area concerned.) One R.A.F. radar station plotted the birds for fifty-seven land miles, which the birds covered in 99 minutes, giving a ground speed of 35 m.p.h. Adding the plot from a neighbouring station, they covered another 22 miles in 40 minutes (33 m.p.h.). They were travelling on a bearing of 287° at an approximate height of 5,000 ft. The Air Ministry Meteorological Office state that at the time in question the wind at this height was probably about 40 m.p.h. from 070°. If this wind speed is correct, the geese were travelling with an air speed of about 25 m.p.h., which seems rather slow. This record constitutes much the longest timed track so far available for any bird in flight.

DAVID LACK.
G. C. VARLEY.

Army Operational Research Group
(Ministry of Supply).

[1] Brooks, M., *Science*, 101, 329 (1945).

Autotrophic Flagellates as the Major Constituent of the Oceanic Phytoplankton

ALL plankton surveys record the catches of diatoms and often of peridinians, but as a rule little mention is made of the autotrophic flagellates, though it appears quite possible that they make up the greatest proportion of the oceanic vegetation; being very minute they mostly pass through the finest silk nets. Their importance has been pointed out by Gross[1], who, however, supposes their mass to be much less than that of the diatoms and peridinians.

In 1919, Allen[2] published a fundamental observation, that culture methods gave far higher counts for plankton organisms than did either netting or centrifuging. Since then, the mass of plant material in the annual crop has been calculated from the consumption of carbon dioxide and of phosphate[3] and in addition of nitrate, and silicate[4]. These estimations gave 1,200–1,600 tons wet weight per sq. kilometre for the English Channel for all but silicate. The silica consumption gave only 110 tons, and diatoms alone take up silica. It was supposed that the low figure for silica was due to its being dissolved and used over again several times. This process would have to be relatively rapid, as the phosphate is all used up in the spring, mostly in a few weeks. In fact, however, the siliceous test of the diatoms is extraordinarily insoluble. Diatoms, with their fine markings perfect, are dredged from the ocean depths and are recognizable in geological deposits; they are of much importance in identifying oil-bearing strata. Miss F. A. Stanbury and I have tried to dissolve diatom tests in alkaline solutions, from the alkalinity of sea-water upwards to pH 11, both at air temperature and at about 100° C.; we have not succeeded, even with trials of long duration. Furthermore, Coupin[5] showed that diatoms get the substance of their siliceous valves from the silica of silicates of aluminium, not from vitreous or gelatinous silica.