LETTERS TO THE EDITORS

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Observation of Desert Locust Swarms by Radar

THE possibility of detecting flying locusts by radar was examined theoretically some years ago, using the deduction of Ryde[1] that the intensity of a centimetric radar echo from raindrops is proportional to ΣND^6, where N is the number of drops of diameter D per unit volume. Raindrops do not exceed about 6 mm. in diameter; and recorded rainfall intensities indicate that there can rarely be more than ten such drops per cubic metre in the heaviest precipitation. More than half the weight of a locust is water; from considerations of water-content alone, a swarm averaging ten flying locusts per cubic metre, as recorded in the Kenya Highlands in 1945[2], with each locust containing about 1 c.c. of water, might be expected to give an echo of intensity at least an order of magnitude greater than that given by the very heavy precipitation considered; and it was concluded that recognizable echoes might well be given by much more attenuated swarms. Subsequent field-work[3,4] has suggested that considerably lower volume densities, of the order of 0·1 locust per cubic metre, are in fact more representative of even the denser parts of flying swarms; densities of this order, however, might still be expected to give echoes comparable with those given by heavy precipitation.

Radar equipment was known to be in regular use in the determination of upper winds at a series of meteorological stations within the invasion area of the desert locust (*Schistocerca gregaria* Forsk.), and an approach was accordingly made in 1950 to the Meteorological Office, through the Anti-Locust Research Centre. The co-operation of the Air Ministry stations concerned was at once offered by the Meteorological Office, with the comment that, since the back-scattering of the radiated energy is largely a surface phenomenon, results were likely to be somewhat better than would be indicated by considerations of water-content alone. At the same time it was pointed out that a type of radar giving plan-position-indicator form of presentation would be more suitable for observing locusts than the *GL* III equipment in use at the meteorological stations concerned.

The first radar sighting of a locust swarm was in fact recorded at 17.00 G.M.T. (20.15 local time) on March 22, 1954, at lat. 28° 50′ N., long. 49° 30′ E., in the Persian Gulf about midway between Bushire and Kuwait, by H.M.S. *Wild Goose*. A naval centimetric combined air- and surface-warning radar set was used, with a tilted parabolic cheese aerial. The locusts appeared to constitute a swarm of at least 15 miles radius, and were detected at ranges up to sixty miles, over a sector of up to 80°, giving large 'fluffy' echoes on a plan-position-indicator, similar to the effects of mechanical jamming. Flying locusts were seen at the time in the light of a 10-in. signalling projector, and dead ones were seen next morning floating on the sea, at a density estimated at about a thousand locusts over 40,000 sq. yd. This confirmation of the earlier theoretical conclusion opens up possibilities of securing new information on the structure, density and movement of flying swarms which come within range of suitable radar installations, especially from photographic records of the echoes observed; such data are likely to be of particular value in the further development of aircraft methods of attacking flying swarms[3].

The locusts concerned were mature (yellow) desert locusts, and were recorded as moving very slowly southwards. The wind was light and variable at the time, following a spell of moderate north-westerlies over the northern Persian Gulf during March 21 and the morning of March 22 (data provided by Chief Meteorological Officer, Middle East Air Force). The locusts represented in all probability one of a number of mature swarms which had been present since late February in the Kuwait area, about a hundred miles to the west and north-west of the position of the ship report.

The time of the radar sighting was two hours after sunset and three-quarters of an hour before moonrise; and the report is of considerable interest as evidence of flight in swarm formation in darkness and over the sea, when visual reactions might be expected to have been minimal and auditory reactions[5] may well have been involved in maintaining swarm cohesion. The air temperature recorded at the time at the ship was 69° F., which is several degrees lower than has previously been recorded during the night flight of desert locusts on such a scale[6]. Most of the locusts, flying higher than the level of the ship, are, however, likely to have been experiencing temperatures above 69°; radiosonde observations from Bahrein Island recorded temperatures of 80° at 1,600 ft. at 14.30 G.M.T. the same day and 78° at 950 ft. at 02.05 the following morning, respectively 7 deg. and 11 deg. above the corresponding surface temperatures[7]. The establishment of such a temperature inversion over the Persian Gulf is usual during March[8].

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[1] Ryde, J. W. (1946), in Jones, R. F., *Quart. J. Roy. Met. Soc.*, **76**, 312 (1950).
[2] Gunn, D. L., Perry, F. C., *et al.*, Anti-Locust Bull., No. 3 (1948).
[3] Rainey, R. C., and Sayer, H. J., *Nature*, **172**, 224 (1953).
[4] Waloff, Z., *et al.*, unpublished field data (1951–54).
[5] Pumphrey, R. J., in Kennedy, J. S., *Phil. Trans. Roy. Soc.*, B, **235**, 226 (1951).
[6] Rainey, R. C., and Ashall, C., *Brit. J. Anim. Behav.*, **1**, 136 (1953)
[7] Overseas Supplement to the Daily Weather Report of the Meteorological Office, London, Nos. 1177–1178.
[8] Durst, C. S., Meteorological factors in radio wave propagation, Phys. Soc. and Roy. Met. Soc., p. 193 (1946).

Widespread Diurnal Variations of Effective Slope of the Ionosphere

OVER a period of twelve months, measurements have been made at Seagrove Radio Research Station of the bearing and elevation angles of radio signals received from two transmitting stations at about the same distance but in directions differing by almost 90° from the receiving station. From these measurements the effective slopes of the ionosphere have been found to be related at places about 1,500 km. apart, and the average diurnal variation of these slopes has been measured.