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Weather during Desert Locust plague upsurges

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The vast numbers of swarming locusts needed to bring about a plague upsurge come from breeding following widespread and heavy rains in otherwise arid areas. The causes of such rains are discussed. Locusts can be crowded into swarms by the wind, either while airborne or after landing on scanty feeding or egg-laying sites. Wind systems at the time of crowding are touched upon.

1. Introduction

A plague upsurge may be defined as a progressive growth, from generation to generation, in the number of locusts in swarms. How do numbers grow, and how do they come to be in swarms? These two questions will be touched upon in so far as the weather plays a part.

2. Rains

Waloff (1966), in her studies of plague upsurges of the Desert Locust (*Schistocerca gregaria*) in 1925–6, 1940–1 and 1949–50, gives strong evidence to suggest that locust plagues have come about through successful breeding in complementary seasonal areas connected by migration of adults. Now the heavy and widespread rains needed for such breeding are rare in the normally arid places where the Desert Locust lives. Moreover, it is not clear how heavy and widespread the rains must be to lead to a plague. Case studies have shed light on the kinds of atmospheric disturbances that can lead to desert rains; hence early recognition of a disturbance as it develops, and the timing and extent of associated rains, are clearly of value in forecasting the outcome of breeding, and hence in planning control strategy. These rainy disturbances of the Desert Locust area are of kinds well-known from other parts of the world. They have the common property of letting deep convective clouds grow where such clouds would not normally form because of the widespread, slow sinking of warm, dry air in the subtropical anticyclones. Each disturbance leads to a spell of up to a few days when there is slow ascent of air favouring deep clouds, the more so over highlands and where there is moist air near the ground. These disturbances may be put into two groups: those in the north of the Desert Locust area (giving a rainy season from about October to May), and those in the south (with a rainy season from about May to October). Over East Africa, however, the latter rains cross the equator seasonally to reach about 10° S by January; and over the far east of the Desert Locust area, rain falls in both seasons.

Case studies of northern rains (for example, Jalu & Damotte 1967, Kumar & Saxena 1969, Mayençon 1961, Ramamurthy 1964, Swaminathan 1969, Tantawy 1964) show they are associated with disturbances that are more strongly developed in the middle and upper troposphere (heights of about 3–12 km) than near the ground. They take the form of large lateral waves in the west winds at those heights, the more so in the narrow band of very strong winds,

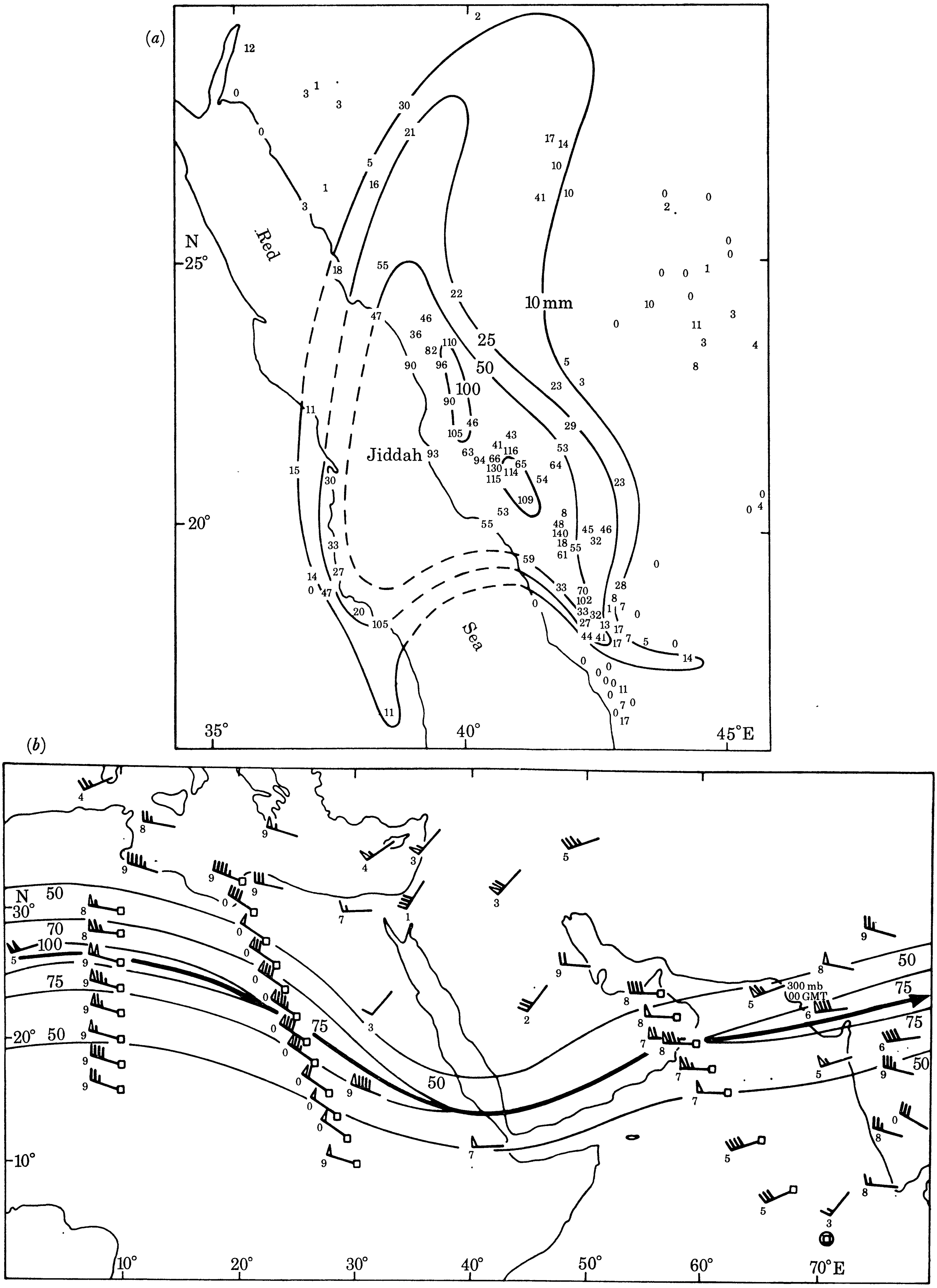

FIGURE 1. An example of widespread heavy rains over northwest Arabia. (a) Total fall (mm) during the five days from 09.00 G.M.T., 15 April to 09.00 G.M.T., 20 April 1968. (b) Weather map for 12.00 G.M.T., 17 April 1968 at 250 mbar (about 10 km above sea level). After Pedgley (1970). Reproduced by permission of the American Meteorological Society.

centred near 12 km, known as the subtropical jet stream. Deep, cloudy convection is most likely on the east side of a wave trough, or beneath the right entrance or left exit of a speed maximum in the jet, which is usually at the crest of a wave ridge. Figure 1 shows an example of widespread heavy rains over northwest Arabia in April 1968 beneath the left exit of a jet maximum, where moist southeast winds near the ground fed the convective clouds (Pedgley 1970). These rains fostered the widespread spring breeding in 1968, and helped bring about the plague upsurge of 1966–8. Accurate placing of such upper atmospheric disturbances by meteorological services is hampered by lack of data, but should become easier with the growing application of satellites to remote sensing of the atmosphere.

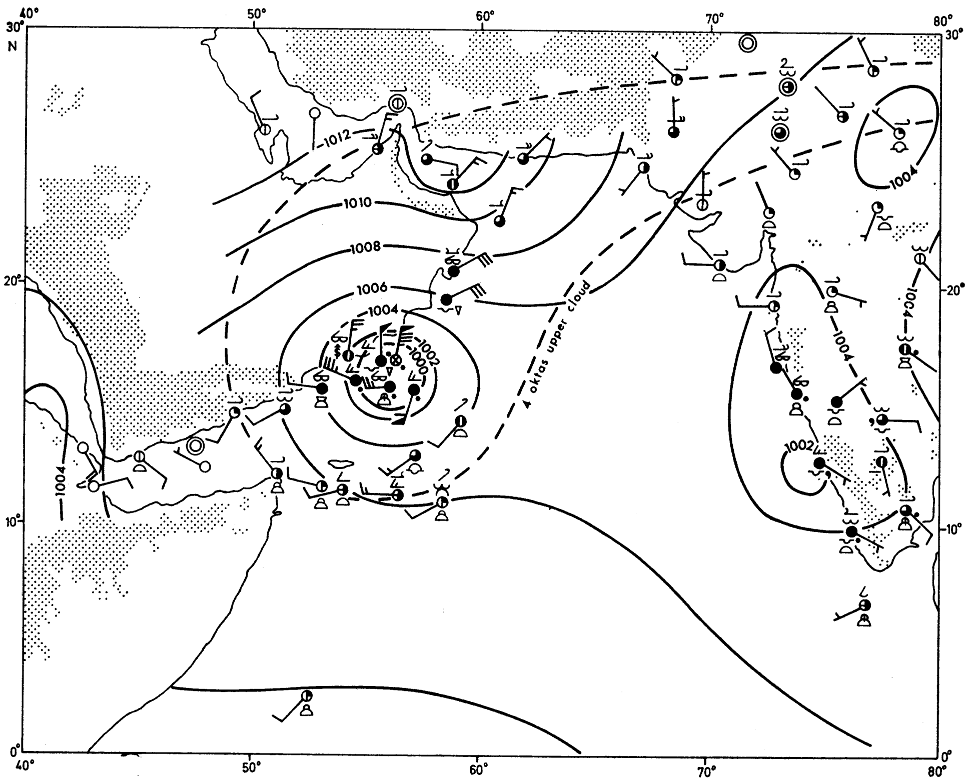

FIGURE 2. Surface weather map for 12.00 G.M.T., 11 November 1966. Isobars are at 2 mbar intervals, but omitted for pressures less than 1000 mbar. (1 mbar = 10^2 Pa.) After Pedgley (1969).

The origins of rains over West Africa are less well understood. They come mostly in the form of westward-moving storms some hundreds of kilometres across, easily seen as bright cloud clusters on satellite photographs, but whose relation to larger scale atmospheric disturbances, such as waves in the east winds above the surface monsoon, is still uncertain. Over East Africa, the incidence and extent of rains seem to be largely controlled not so much by moving waves as by day-to-day changes in the size, strength and position of the subtropical anticyclones in mid troposphere (say, at heights of 3–10 km), but they have been little studied. Over northwest India and Pakistan, case studies of monsoon rains show they are associated with various kinds of cyclonic disturbance in the lower and middle troposphere (see, for example, Miller & Keshavamurthy 1968; Rao & Rajamani 1970; Rao, Srinivasan & Raman 1970). In some years there are severe cyclones in the pre- and post-monsoon seasons that can bring torrential rains

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to countries bordering the Arabian Sea. Such rains over south Arabia in October 1948 and November 1966 (figure 2) helped to bring about locust upsurges. Developments in tropical meteorology, particularly through the use of numerical models, are likely to throw more light on the nature of rainy disturbances and hence on when and where locust breeding is possible.

3. Winds

Whereas rains leading to widespread breeding are rare, winds that can move flying locusts about are almost always blowing. Moreover, large-scale wind fields can be described with some confidence for most of the Desert Locust area. While moving locusts about, winds can also crowd them together or drive them apart. Two kinds of crowding into swarms have been recognized: in the air and on the ground. Airborne crowding takes place in converging winds but, whereas there is no doubt from extensive biogeographical analysis that swarms have been shown frequently to come together in areas of persistent convergence (see, for example, Rainey 1963), there is only circumstantial evidence that swarms can be formed by the crowding together of flying scattered locusts. On the other hand, winds can crowd scattered locusts by bringing them from afar into small areas where they are able to rest, feed or lay eggs (Roffey & Popov 1968).

Because heavy rains are associated with convergent winds near the ground, the two crowding mechanisms may well become mixed, and it may be unclear which is dominant in a given case. For example, a swarmlet of 0.5 by 0.5 km seen in Rajasthan on 17 June 1964 was at first attributed to crowding by convergent winds in a cyclone that crossed the area between the 12th and 14th (Varma & Sharma 1966, Mazumdar & Dharmaraj 1966), but calculated trajectories assuming downwind movement have shown that locusts most likely came from western Pakistan, having left there on the 11th and arrived in Rajasthan after the cyclone had dispersed (Venkatesh 1971, Wright 1975). Swarm formation in this case seems more likely to have been due to crowding into limited attractive sites.

Whatever the mechanisms may be that crowd locusts into swarms, a plague upsurge can happen only if there is a great growth in locust numbers due to breeding after several spells of widespread and heavy rains. Better monitoring of rain storms by satellite, and better understanding of their behaviour, together promise more precise and more comprehensive ways of finding locust breeding sites, thereby allowing more effective control, and possibly more economic control if a recognizable threshold in the distribution of rain needs to be crossed before a plague upsurge becomes possible.

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