11 Direction of Insect Migrations in Relation to the Wind

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1 Introduction

In recent decades, the views on the mechanics of long-range migrations of insects have diverged into two main lines: (1) French and White (1960), Shaw (1962), Hurst (1963, 1964), and Mikkola and Salmensuu (1965), working on Lepidoptera presumed downwind direction of migrations and analysed their data with the aid of wind trajectories which describe atmospheric tracks of air particles. Rainey (1963) showed that the displacement of locust swarms is predominantly downwind. A general theory was formulated on these lines by Kennedy (1961). (2) Baker (1978), however, has suggested that during migrations insects mainly use compass orientation. Thus, two controversial doctrines have been proposed. Nevertheless, it seems that even an individual species may use different migration and orientation mechanisms under different situations. In addition, regular and definite upwind migrations have been shown to occur in wasps and bumble bees (Mikkola 1978). The intention of this article is to document data on the role of wind as a factor affecting the direction of insect migrations. Examples come from the published and unpublished data gathered by the author in Finland and from the literature.

To discuss the problem at a more 'realistic' level, insect migrations may be compared with the movements of aeroplanes. Aeroplanes depart and land flying against the wind. From the classical studies of Kennedy (1940) we know that the takeoff of insects also regularly takes place against the wind (cf. e.g. Solbreck 1980). After the departure, an aeroplane may change its dependence on wind direction to compass or some other mechanical means of orientation. The track of migrating insects after takeoff is less well defined. This is the phase which is discussed in this article.

If an insect drifts in the wind, it is difficult to know if its direction is determined solely by the wind, or if the wind direction is the same as the compass or any other direction preferred by the insect. The former parallels the situation in which a balloon is carried by the wind, and the latter that in which a sailor uses midwind to reach his goal. Earlier authors such as Johnson (1969) have supported the downwind displacement thesis, but Baker (1978) claims that "to delegate displacement solely to prevailing wind (is) a strategy that has not yet been demonstrated for any animal". According to him, strong-flying migrants, even by night, choose such winds that are close to their preferred compass direction.

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2 Migrations with the Wind

In terms of the distance covered, downwind flights are the most spectacular migrations of insects. Single flights have been frequently cited in the literature (examples are given by Johnson 1969 and Pedgley 1982). There are extensive records on the occurrence of windborne insects in the United States (e.g., Pienkowski and Medler 1964; Rabb and Kennedy 1979; Raulston et al., Wolf et al., this volume), in Australia (Farrow 1975, this volume), China (Li et al. 1964), Japan (Oku 1983), Africa (Gunn and Rainey 1979), the United Kingdom (Johnson 1969; Johnson et al. 1962; Taylor 1974), and Northern Europe (Mikkola 1967). The windborne insect fauna has been analysed on fire ships or on weather ships (e.g. Asahina and Turuoka 1970; Haeseler 1974; Lempke 1962), on ships on transoceanic routes (e.g. Gressitt and Yoshimoto 1964), on oceanic islands (e.g. Fox 1978), and on mountainous ice fields (Burmann 1952; Edwards 1972).

2.1 Immigrations of Lepidoptera into Finland in 1946-1966 and 1972-1981

The Period 1946-1966. The 100 migrations observed during these 21 summers were compared to the daily weather patterns, the mean temperature of which exceeded the mean of 30 years by at least 2.5 centidegrees (Mikkola 1967). Warm days constituted 24.9% of all days, but 58 migrations of 100 occurred during warm days. Of these 58 migrations, 48 coincided also with movements of air currents. Statistical analysis of these data showed that the migrations and the occurrence of air currents were significantly correlated.

Air currents carrying migrants to Finland are regularly southern to southeastern (Fig. 1). Using wind trajectories it was shown that the South-Russian steppe area, south of 50°N is the probable source of most migrations which are observed in Finland north of 60°N. Baker (1978) referring to the above analysis wrote that "Large-scale backtracking ... can rarely distinguish between conditions in the study area suitable for flight and conditions that would lead to immigration from reasonable sources". This aspect has, in fact, been considered by Mikkola (1967). The significant correlation of the migrations both with the air currents originating to the south of 50°N and with warm days means that they are related to specific weather situations. Thus, neither warm stationary weather, air currents from the northern latitudes, nor colder ones from the south produce many migrants. It would seem that a warm air mass or a warm front arriving at the source area is a situation conducive to migrations and stimulates migrants to take off.

The above migrations, with the air currents moving towards the northern directions, probably end up all over in areas to the north of the steppe belt, the northern border of which is in eastern Europe roughly at 50°N. Within the steppe belt, the migrations cannot be clearly linked to weather patterns. A difficulty experienced in analysing data from Central or Western Europe is that the potential source areas are situated at roughly similar distances from the observation points in many directions, i.e. in North Africa, the Near East and the Russian steppes.

The Period 1972-1981. Yearly migration records have been published in the reports of the Finnish Lepidopterological Society meetings since 1972 and in the German