The Migration of Diamondback Moth

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Abstract

The adults of diamondback moth, *Plutella xylostella* L, are known to have been transoceanic migrants in Europe since ancient times. The insect, which has its origin in Asia Minor, spread to other parts of the world with the spread of the cultivation of its host, the crucifers, and by using its own migrational abilities over long distances. Several large scale transoceanic migrations have been reported in Europe. The moths are known to be able to migrate a distance of over 3000 km in continuous flight for several days. Finland and northwest Russia are the major sites of origin of the migratory moths. The insect also migrates from the United States to Canada. In the Orient, large scale migration has not been observed, but a few moths have been captured out over the East China Sea as far as 500 km away from any major landmass. In the Orient there is considerable variation in certain physiological characters of the moth between various geographical locations.

Introduction

Diamondback moth (DBM), *Plutella xylostella* L (Lepidoptera: Yponomeutidae), is a noted defoliator of numerous cruciferous plants in many areas of the world. In some cases, this insect is considered as the most important limiting factor of successful production of cruciferous vegetables. In Taiwan, DBM was first reported as a pest over 75 years ago (Hori and Shiraki 1910).

There are numerous insects which, like DBM, have the a world-wide distribution. These cosmopolitan insects have certain common characteristics which enable them to survive in the varying climatic conditions present over wider areas of their distribution. Besides the potential to colonize under varying conditions, their strong dispersal or migrating capacity is indispensable to the increase of their distribution range. Although the origin of DBM is not clear, judging from its close relationship with the cruciferous plants it is assumed that this insect originated in Asia Minor. From there the moth spread to other areas with the spread of cultivation of cruciferous vegetables. The strong flight ability of the moth helped its distribution to even wider areas. Miyata (1983) classified migratory moths into six categories. He assigned DBM to type F category—the super wide-distributing type—which has an omniphagous habit and strong dispersal capacity (Miyata 1983). While the DBM has a close relationship with cruciferous crops, it is considered as an oligophagous pest. Therefore, the present cosmopolitan distribution of the moth is attributed both to the extended cultivation of its host plant and to its own migration.

It is obvious that the migration of the insect is one of the important factors in the extension of its distribution. Both immigration and emigration result in big changes in the population size in the area concerned. For this reason, the migration of this pest insect requires the close attention of applied entomologists over an extended period. The concept of pest management entails the estimation of the economic threshold of each pest insect based on numbers. DBM's migration characteristics also underline the need

for the establishment of forecasting system which could have a definitive bearing on the integrated management of the pest.

The following brief review on the migration of DBM is compiled with the available information.

DBM Migration in Europe

The DBM has been known as a transoceanic migrating insect in Europe since ancient times. For example, in Britain the moth is recognized as an important insect, and damage is induced by migrated populations. Mass migration of DBM is relatively well studied in England. The earliest record of DBM mass migration was made by Curtis (1860). Ormerod (1891), Harper Gray (1915), and Miles (1924) reported large scale outbreaks due to migration of this insect in 1891, 1915, and 1924, respectively. Theobald (1929), reviewing the history of those attacks, cited 1837, 1851, 1885, 1888, 1891, 1914, 1923 and 1924 as years of heavy losses. Besides these, Mackenzie (1958) cited 1928, 1941, 1946, 1949 and 1958 as years of DBM outbreak. For the last 20 years, 1966 (Shaw and Hurst 1969), 1978 (Lokki et al 1978), 1979 (Lempke 1981), and 1980 (Lorimer 1981) are listed as years of severe DBM attack. Among those, 1891, 1914, 1958 outbreaks were of exceptional severity.

The migrating distance of the moth is generally considered to be over 3000 km (Thygesen 1968, Bretherton 1982). French (1967) reports a migration of 3680 km, with the moths in continuous flight for several days. Lokki et al (1978) also reported mass migration of the moth to Spitsbergen from South Finland and Finnish Lapland, carried by a strong south-southeastern storm. The estimated migration distance was at least 1000 km in one day.

The outbreak of the moth in the coastal area of northeastern England and eastern Scotland in 1958 is well documented by French and White (1960) and Shaw (1959, 1962). According to these reports, the sudden appearance of large numbers of moths occurred in the northern area of Scotland. The moths arrived at Aberdeen during the morning of 28 June (Hulme 1959). According to the survey carried out on 29 June, density was estimated 5 to 10 moths per square inch (approximately 70-140 million per ha), (Mackenzie 1958). Mackenzie described this spectacular phenomenon as follows 'On the evening of June 30, tremendous numbers were reported simultaneously in all the coastal towns from Berwick to Scarborough. Moth entered houses on such a scale as to cause alarm amongst householders; in the open, cyclists hesitated before riding through swarms; car drivers were obliged to stop and clean their windscreens. So great were the numbers, and so sudden in appearance, that the swarming was a major news item in the local press'. This mass immigration caused serious damage to many cruciferous vegetables such as turnip, cabbage, kale and so on. Later a large population of the moth was observed at 58°53'N, 19°10'W by the ocean weather watch ship on 4 July. As to the source of that population, Finland and Estonia are suggested as the areas of their origin. From the analysis of meteorological conditions, an area in northwest Russia, approximately between latitude 55 and 60°N which includs Estonia, Latvia, Lithuania, and the east coast of the Baltic Sea is assumed to be the origining area. In this season, the predominant wind direction is east to west in this area. That would stimulate the take-off of the moths towards the sea coast. While crossing the North Sea, and approaching the coast line, wind velocity is reduced towards the coast line on the far side of the North Sea thus tending to deposit the moths on the coast. This possibility explains the large numbers of moths which settled on the east coast of England and Scotland.

Although this seems to be a reasonable analysis from the meteorological point of view, it still cannot afford an adequate explanation from the DBM life history point

of view. At such a high latitude, the moth is considered to be unable to survive the low temperatures and maintain sufficient numbers to induce mass migration in early June. Therefore, the west coastal area of the Baltic Sea is considered as one of the transit areas for the mass migration and the true areas of its origin should be located further south.

In the Neararctic region, the recent mass migration of DBM in Ontario, Canada, is reported by Smith and Sears (1982). Harcourt (1982) also suggested that the occurrence of the moths in Ontario is due to emigration from southern areas where they can overwinter.

DBM Migration in the Orient

In the Orient, surveys of insect migration lagged far behind that of the European countries, especially before the 1960s. Insect migration studies began in the Orient in 1968. A weather ship collected numerous brown planthoppers (*Nilaparvata lugens*) and white backed rice planthoppers (*Sogatella furcifera*) at point 'Tango' located at 29°N, 135°E in the Pacific Ocean 500 km from the nearest landmass (Asahina and Turuoka 1970). This indicated the importance of the transoceanic migration of pest insects. For the purpose of establishing an improved forecasting system of important paddy insect pests, frequent and strenuous population monitoring especially over the East China Sea, is being carried out. Up to the present, 127 species of insects including 56 species of moth are listed as long distance migrants. (Asahina 1972, JMA 1983, Kiritani 1984). DBM is listed as one of these migrant insects. In Japan, some ecological studies point to the fact that DBM does not overwinter in areas north of Tokyo while it is a ubiquitous insect pest in the northern districts of Japan in summer months. Therefore, the migration of the moth from the southern area during spring and summer is suggested (Yamada and Umeya 1972).

DBM adults were also collected over the ocean far from the landmass; one specimen on 21 August and another on 27-28 August 1968 at 135°E, 29°N. (Asahina and Turuoka 1970). From 1976 to 1978, although 20 moth species were collected over the East China Sea, DBM was not listed in the collection (Hayashi et al 1978, 1979). It is obvious that the migration pattern of DBM in the Orient is quite different from that in Europe. This does not mean, however, that no mass migration of insects occurs in the Orient. Mass migrations of brown planthopper, oriental armyworm (*Pseudaletia separata*), and black cutworm (*Agrotis ypsilon*) are often recorded by entomologists. (Kishimoto 1975, Oku 1984, Oku et al 1975).

It is also worth noting that in the Orient considerable variation exists in DBM populations at various geographical locations. Umeya and Yamada (1973) found variation in the threshold temperature for growth and in the thermal constant for development between the Javanese and Japanese strains of DBM. In addition, Sun (1985) found geographical variation in insecticidal resistance and Maa (1985) reports considerable variation in pheromonal response in various DBM strains of Taiwan. The existence of such a geographical variation provides indirect evidence for the lack of mass migration occurring in this region.

It is worth pointing out that in Europe investigation of migration habits is carried out at latitudes beyond 50°N, while in the Orient monitoring is confined to the temperate zone between 30-40°N. This difference in the area of investigation may show dissimilar migration patterns between Europe and the Orient. For a better understanding of essential mechanisms of the migration of this moth international cooperative studies should be initiated.

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