# The Migrations of the Painted Lady Butterfly.

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THE migrations of birds have been known for centuries, and have, particularly in recent years, been moderately well studied and understood. The migrations of fishes are also generally known, and within the last few years the remarkable journeys of the eel have been definitely determined. Most people know that locusts make huge migratory flights, invading countries in countless numbers and doing incalculable damage; but it is surprising how few are aware that such frail insects as butterflies make extended migratory flights, often in enormous numbers and over hundreds and even thousands of miles.

Scattered throughout literature there are references to nearly two hundred species of butterflies which have been seen in migratory flights. In most of these there

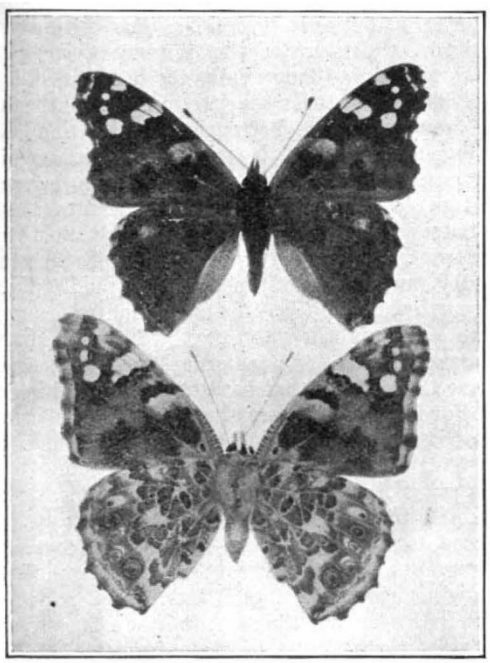

FIG. 1.—The Painted Lady or Thistle butterfly (*Pyrameis cardui*).

are unfortunately only one or two records for each species, and in only a very few cases do the records number more than a dozen. In two or three, however, we have sufficient evidence to get a general idea of the movement, and of these the most complete is that of the Painted Lady or Thistle butterfly, *Pyrameis cardui* (Fig. 1).

This butterfly, like many migrants, has a very wide range and is indeed known from every continent, and may be seen from the equatorial tropics to within a few degrees of the arctic circle. In Northern and Central Europe it is sometimes common, sometimes rare, and sometimes a summer will pass without a single specimen being seen. In England it is usually first seen at the end of May or beginning of June, and becomes again more common in August and September, but there is no evidence of an individual surviving the winter in any stage. The same seems to be true of all Europe north of a line through the middle of France and South Germany or Switzerland.

Observation has shown that north of this line the country is dependent for its Painted Lady butterflies entirely on migrations from the south. In the late spring, isolated individuals or huge swarms of this butterfly set their faces more or less to the north or north-west and, in Western Europe, cross France and England, and in some years may reach so far as Iceland. Farther east, similar migrating bands may fly from Italy or the Balkan peninsula, and cross Switzerland, Austria, Czecho-Slovakia, and Germany, and invade Scandinavia. Still farther east, in Russia, it is probable that the same movement occurs, but the records are few and far between.

Studying the movement in the south of Europe, we find that the majority of the migrating insects do not originate here, but cross the Mediterranean from North Africa, apparently finding but little difficulty in the long sea passage. Still more recently, evidence has been accumulating that even the north coast of Africa and Palestine do not represent the origin of the insect, and it appears that they reach the coastal regions of Africa from the south. They have been recorded entering Algeria from the south; they have been seen crossing the Nile Valley near Cairo in thousands, coming from the south-eastern desert; they have been recorded as entering Palestine from the east in countless numbers for days on end; and finally comes a record of the same butterfly flying towards the west in Mesopotamia. They have been seen massed in great numbers, apparently resting during migration, in the Egyptian Desert near the Sudan border; but south of the desert belt, there is no record except a doubtful hint from Nigeria.

The present state of our knowledge of their movements in Europe, North Africa, and Asia Minor can therefore be summarised as follows (see also Fig. 2):

From somewhere in, or south of, or south-east of the long line of desert stretching across North Africa and Asia Minor, the butterflies begin their north and north-westerly movement in the early spring and arrive at the southern shores of the Mediterranean usually about April. From Palestine they appear to fly through Syria and Turkey to the Balkan States, and from Egypt, Tripoli, and Algeria they cross the Mediterranean, arriving in southern Europe usually early in May. They pass on, probably leaving behind stragglers all the time, and arrive on the level of the southern shores of England at the end of May or beginning of June, reach the northern part of Scotland about the middle of June, and have been recorded in Iceland in July.

The dates given are those of the first main drift, but the movement appears to continue for many weeks or even months at irregular intervals. Thus the butterflies have been seen crossing the Mediterranean north of Egypt so late as July, and in some years they appear to reach England from the Continent so late as September. These presumably are the progeny of later broods than the first movement. Apparently there is a general tendency for all butterflies over the whole

area to drift to the north-west during a large part of the year.

In other parts of the world there are also migrations, but the records are at present too few to be capable of discussion. They fly into California from the south in the spring at irregular intervals and have also been seen migrating in Florida. It is, however, only in Europe, North Africa, and Asia Minor that we can bind together the evidence into the semblance of a whole. It is curious to note that in Ceylon, where migrations of many species of butterflies occur on a very large scale, one observer notes that *P. cardui*, although not uncommon, has not been noticed as entering into any of the flights.

As the migrations of birds are better understood than those of any other animal, it will be interesting to draw

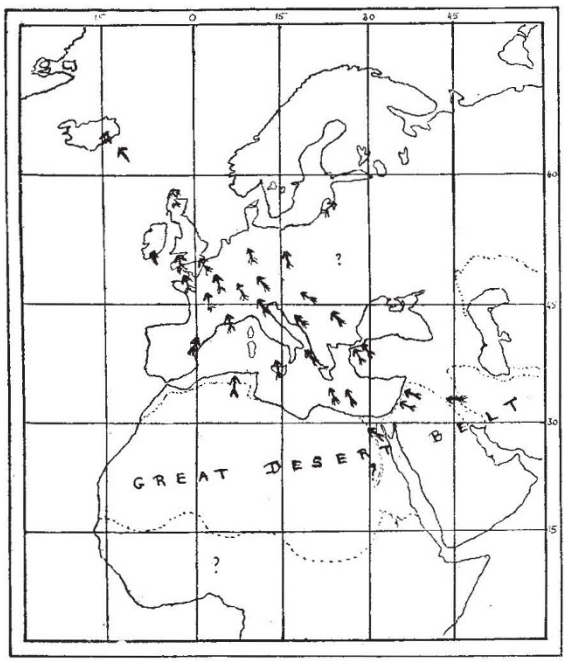


FIG. 2.—Sketch map indicating the known migrations of the Painted Lady butterfly.

a comparison and see to what extent the migrations of the Painted Lady butterfly resemble them.

In the first place, we have the remarkable fact that in the butterfly there is practically no evidence of any return from north to south in the autumn. So far as we can see, all those butterflies which fly to the north of the area in which they can breed throughout the year are lost completely to the species, as either they or their offspring perish during the winter. The butterfly does not seem to have developed the ability to hibernate in any stage; unless it can breed continuously it cannot survive. The statement seems so remarkable that some investigators believe that there is a return flight, but that it is performed individually and not in mass, and so escapes notice. While this may be so, it is at present unsupported by any direct evidence and must be classed as an hypothesis, as opposed to the known facts of the northward movement in the spring. One cannot help referring here to the remarkable contrast which is found in the case of the Monarch butterfly (*Anosia plexippus*) in North America. Here the southward autumn flight is known from dozens of observations, while the direct evidence for the northward flight in the spring is extremely scanty, although from the complete absence of any record of hibernation in the Northern United States and Canada, we presume that such a return flight must occur.

The possibility must also not be overlooked that considerable flights may take place at night. This may seem to be a rather unexpected statement to be applied to butterflies, but it is actually supported by direct observation and capture of Painted Lady butterflies at night at light-ships and on boats at sea. The same butterflies have also been seen flying to the north off the coast of Egypt between three and four in the afternoon, and to reach land in this direction they must fly all night or rest on the sea.

In the case of the Painted Lady, it follows that even if there is a return flight, it is in a later generation. No individual butterfly ever performs the same journey twice, even in opposite directions, thus differing from most birds, which make the journey twice a year for several years. This eliminates any possibility of memory being a factor in the determination of the route.

The next difference between the migration of the butterfly and most birds is that it is only a part of the butterfly population which migrates, while many stay behind to continue breeding in the countries where they hatched out. If it is really true that there is no return flight, this of course would be absolutely necessary, as otherwise the species would gradually move northwards and become exterminated.

Next we have the fact that while the migrants which reach England, for example, lay eggs and produce offspring there, those that have stayed behind in South Europe or North Africa are also breeding. In contrast to what is usually found in birds, breeding takes place throughout the whole range of the migration.

This raises the question as to whether it is the same individuals that perform the whole flight from Africa or Mesopotamia to Northern Europe, or whether the first migrants stop to lay eggs on the way and their offspring continue the flight later. The evidence at present indicates that the same individuals can, and in favourable years probably do, complete the whole flight, but that their progeny may also form a later migration, starting from where the eggs were laid by the original migrants, or may continue the migration alone if for any reason that of the previous generation has been brought to an end.

This in turn raises another question. How is it that the butterflies have time to perform their long journeys, and, having hatched from a pupa in Africa, can wait to lay their eggs in England? The answer to this is still obscure, except that we know that *P. cardui* usually hatches out from the chrysalis with the generative organs completely undeveloped, but with a very large reserve fat-body. Apparently the migration generally takes place before the genital organs are functional (thus resembling the locusts); but this is not an absolute rule, as butterflies have been known to lay eggs while apparently on migration. When we know what determines the original development of the fat-body at the expense of the ovaries, and what later circumstances cause the ovaries to develop at the

expense of the fat-body, we shall be nearer the solution of one of the problems of migration.

Finally, as the life of the butterfly is not dependent on migration, we get another important difference from birds in the great irregularity of the occurrence and extent of the movement. Sometimes, as in 1879, Western Europe is invaded by countless millions, while in other years the migration is at a minimum and scarcely a single individual reaches the British shores. This irregularity of flight is probably an indication of varying conditions in the countries of origin of the swarms, but as we are not yet certain where these are or if they are always the same, it is idle to speculate as to what are the conditions that determine the start of the flight. Once the migration is in progress, what little evidence we have indicates that the direction is influenced, but not entirely determined, by the wind. The butterflies have a tendency to fly into the wind rather than with it, and there are one or two records, from localities with a daily change in wind direction due to land and sea breeze, of a corresponding daily change in the direction of the flight.

This tendency to fly more or less into the wind would of itself partly account for the general trend of the migration to the north and north-west, as in the spring there are prevalent northerly winds over Southern Europe, the Mediterranean, and North Africa (see Fig. 3). However, one feels that this alone is not the explanation of the main trend of the flight, and further study and many more records are necessary before it will be possible even to guess at the real cause.

We are similarly in ignorance as to what are the conditions which cause the insects to cease migrating—if it is fatigue, low temperature, food, or the development of the sex organs and sex instinct, and if the latter, the problem is only put one stage further back to what is the cause of this change.

The final question, which is with so many the first to be asked, is: Why do the insects migrate?


FIG. 3.—Prevailing winds in Europe and North Africa. From Kendrew's "Climate of the Continents."

This is best perhaps at present left entirely alone. Whether, as some hold, a habit is explained when some advantage has been shown to accrue from it to the species, or whether, as I insist, there must be an immediate mechanistic cause for the migration of each individual, is a question the discussion of which would be out of place in the present article.

## Further Evidence regarding the Correlation between Solar Activity and Atmospheric Electricity.[1]

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THE geophysical element which has thus far shown the most marked correlation between manifestations of solar activity, as, for example, sunspottedness and prominences, is some measure of activity of the earth's magnetism. The range of the magnetic diurnal variation, as shown by observations extending over nearly a century, is known to pass through a definite fluctuation to the extent of 50 per cent., or more, during a sunspot cycle. The synchronism between the solar curve and the magnetic curve is not exact, however, the times of maxima of the two curves differing not infrequently by one year or more. Thus, at the Kew Observatory the absolute daily range of the magnetic declination during the period 1858–1900, or approximately 4 sunspot cycles, passed through a maximum value, three times out of the four cases, one year *in advance* of the sunspot maximum. During the recent sunspot cycle (1913–1923) the maximum magnetic activity showed a lag of two years with reference to the solar curve. In 1893, when sunspottedness was a maximum, the earth's magnetic activity, after having been increasing for several years previous, was quite markedly lessened, and then rose to a maximum value in 1894.

Attention may also be directed to the fact that no index of the sun's activity, as given thus far by solar observations, is apparently a complete measure of the radiations or emanations which are responsible for the magnetic phenomena just described. Nor do the solar measures in themselves, or for that matter the magnetic measures, give us a definite indication of the *sign* of the electrically charged particles which may be shot out by the sun during periods of intense activity.

The desirability is thus seen of finding some other geophysical element which may be affected in such a manner by solar changes as to supplement effectively the knowledge gained from magnetic effects and polar lights. That element may be atmospheric electricity; some results concerning the correlation of this element with solar activity were presented before these societies [2] a year ago. The present communication is based on atmospheric-electric data accumulated during the past 7 sunspot cycles. Manifestly, it will not be possible here to attempt more than a summary of the entire

[1] Presented before the joint meeting of the American Physical Society, the American Astronomical Society, and Sections B (Physics) and D (Astronomy) of the American Association for the Advancement of Science, Washington, D.C., December 30, 1924.

[2] See footnote 1.