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Movements of the dragonfly *Libellula quadrimaculata* LINNAEUS, 1758 in North-west Europe in 1963

(Odonata, Libellulidae)

by

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Abstract: During a period of anticyclonic weather at the end of May and in early June 1963, large movements of the dragonfly *Libellula quadrimaculata* L. were observed at several places on the North Sea and English Channel coasts of France, England and the Netherlands, and also on the coast of south-west Wales and on Lundy Island at the entrance to the Bristol Channel, south-west England. These are described here in detail.

A mass emergence of this species in late May in the wetland area of the Muritz See in north-east Germany was also reported. Although this might have been the origin of some of the *quadrimaculata* seen moving in the Netherlands, it is thought more likely that all or, at least, most of these migrations originated in the Landes and Gironde area of south-west France, in spite of the fact that it has not proved possible to obtain evidence of mass emergences or movements in that region in May 1963.

Introduction

In the latter part of May and in early June 1963 large movements of the dragonfly *Libellula quadrimaculata* L. occurred in the region of the North Sea and the English Channel during a prolonged period of anticyclonic weather over north-west Europe. They were reported from the coasts of southern England, south-west Wales, the Channel Islands, the Netherlands and north-west France.

The object of this paper is to list and describe the extent of these movements (Table 1; Fig. 1), and to discuss their origins as far as these could be ascertained. Originally, in co-operation with Dr. BOSTJAN KIAUTA, I prepared a draft in May 1965 and sent it to him to finalise as a joint paper. Unfortunately, he never returned it and we subsequently lost contact. In the meantime, in the absence of a response from Dr. KIAUTA to my reminders, I became involved with more pressing work and it was only after my retirement from my profession that I found the time to complete this account of which I believe to be an event well worth describing and publishing.

The extent of the movements

The Netherlands

Personal observations from Oostelijk Flevoland

From 28 May to 23 June 1963 I made a number of visits to the then relatively new Zuider Zee polder of Oostelijk Flevoland where I was at that time making sound recordings of wild birds and assisting with the making of a wildlife television film for the B.B.C. Natural History Unit.

On 4 June, a hot and sunny day, I suddenly realised that the great numbers present of the dragonfly *Libellula quadrimaculata* L., were participating in an easterly movement along the sea dyke (i. e., sea wall) at Kamperhoek, the most northerly point of the polder. They were flying singly and in small parties of from 4–12 individuals in an almost continuous procession along the dyke, mostly on its landward, sheltered side. At Kamperhoek the dyke wall runs W.S.W. at first, then turns S.E., so that by keeping inside this high dyke the dragonflies achieved considerable protection from the fresh north-easterly wind blowing across the IJsselmeer (formerly known as the Zuider Zee), but were deflected to the S.E. by the change in the direction of the dyke. In fact, the great majority of them kept low down in the shelter of the dyke, flying between a few centimetres and a metre or two above the ground. This behaviour, as described in the next section, was also observed elsewhere in the Netherlands.
Although I had noticed *quadrimaculata* flying around in large numbers during the morning whilst I was busy making sound recordings of the bird species *Charadrius alexandrinus* (L.), and other birds on the polder, it was not until I sat down on top of the dyke after lunch that I had the leisure to notice that there was a constant stream of these insects all fying in the same direction: to the east.
During the course of that afternoon I estimated that the dragonflies were passing me at an average rate of 220 every ten minutes (i. e., 1,320 per hour). My first observations began at approximately 14.00 hours C.E.T., and *quadrimaculata* was still moving eastwards at about 1,000 per hour when I left Kamperhoek at 1900 hours. Unfortunately, the pressure of my sound recording and filming work prevented me from making more than sample counts of ten minutes each over this period. Nevertheless, it seems that about 6,600 *quadrimaculata* flew eastwards whilst I was on site.
When I walked back over the polder to our Land Rover, I saw smaller numbers flying east on a broad front, but the main concentration was along the dyke. They all flew very low, fast and direct, without stopping. Only a few paused in flight over some object long enough for me to check their identity, which I was later able to confirm from film taken by one of the B.B.C. cameramen, and which is preserved in the film library of the B.B.C. Natural History Unit at Broadcasting House, Bristol. I am, in any case, very familiar with *quadrimaculata*. The flight behaviour of these dragonflies in Oostelijk Flevoland was identical with that of dragonflies I have seen migrating along the coast of south-west France (Burton & Owen, 1954).
Next day, 5 June, we had to travel to an inland part of the Netherlands and did not return to Oostelijk Flevoland until 10 June, by which time, although the weather was still hot and sunny with an easterly breeze, I did not notice any obvious directional movement of *quadrimaculata*, although good numbers were to be seen all over the polder on this and subsequent dates. Many of the males had taken up territories all along the drainage ditches criss-crossing the polder.

Observations by others in the Netherlands in 1963
Through Mr. J. H. Mook of the Instituut voor Oecologisch Onderzoek at Kampen, I heard that Dr. Cavé of that institute saw migrating *L. quadrimaculata* in other parts of Oostelijk Flevoland during the early days of June. The late Mr. B. J. Lempke (in litt.,) also informed me that easterly flights of this species were observed in the Netherlands on several dates during the first ten days of June 1963, especially on the islands of Overflakkee and Voorne between the estuaries of the rivers Scheldt (Schelde) and Maas. Huge concentrations were seen here, so much so that they were reported by the media.

I am indebted to Mr. MOOK for drawing my attention to an article by Mr. A DE JONG (1963) concerning the occurrence of four individuals of the rare, in western Europe, migrant falcon *Falco vespertinus* L., on Texel in early June 1963. In his article de Jong mentioned that enormous numbers of Libellulid dragonflies (precise species not stated but, in the circumstances, probably *quadrimaculata*) were observed coming in off the sea at several places along the west coast of this Friesian island throughout the day on 1 June. The next day they were still to be seen arriving from the sea, but in smaller numbers. They all flew low over the waves and once over the dunes spread out in all directions, most, however, flying to the south. The falcons *F. vespertinus* fed on the dragonflies, which were to be seen in abundance in the dunes. Both the dragonflies and the falcons had disappeared by 16 June, the day before a weather front reached the Netherlands from England, but the wings of many of the dragonflies eaten by the falcons were still to be seen scattered over the dunes.

According to KIAUTA (1964) a migratory movement of *L. quadrimaculata* was reported on 2 June at IJmuiden on the coast north-north-west of Haarlem and some 90 km. west-south-west of where I made my observations at Kamperhoek on 4 June. Later he received reports that large numbers of this dragonfly had been seen on the move on 31 May at St. Maartensdijk, St. Annaland, Oud Vossemeer and Stavenisse on Tholen, west-north-west of Bergen-op-Zoom. These movements ceased when the hitherto fine weather came to an end on 13 June and, as I noted myself in my diary, heavy rain ensued.
The movement at IJmuiden was seen by P. J. DERKSEN who reported that at about 11.00 hrs on 1 June 1963 he came upon a concentration of ca. 50 dragonflies in the Heeren Dunes resting near a small birchwood. When he went there the following morning he saw that the dragonflies were flying in a straight line to the north-east. They flew very quickly, two or three together, at intervals of three to five minutes.

On 3 June 1963 a migratory movement was also observed in the coastal province of Zuidholland on the island of Voorne at Nieuw-Helvoet by J. W. BIJL, and again on 11 June at Quackjeswater, a little to the north-west, by BOSTJAN KIAUTA and H. J. M. WERMENBOL. A map showing the precise position and flight directions of these movements, plus the direction of the wind is included in KIAUTA (1964). At Nieuw-Helvoet on 3 June the movement was observed taking place eastwards along the Zuiddijk (South Dyke) on the south coast from 11.30 hrs. to 15.30 hrs. in hot, sunny weather against a fairly strong east wind. At 11.30 hrs. 224 individual dragonflies were recorded passing the observation point within five mimutes, thus giving, at that time, a rate of 2,688 per hour; at 12.45 hrs. 166 individuals passed in five minutes (i. e., at a rate of 1,992 per hour); and at 15.30 hrs. 154 passed in five minutes (i. e., at a rate of 1,848 per hour). Thus the density of the movement declined from 2,688 per hour at 11.30 hrs. to 1848 per hour at 15.30 hrs. These figures can be compared with my estimate of 1,320 per hour flying eastwards at Kamperhoek, Oost. Flevoland, which was also made around 15.30 hrs. in the afternoon on 4 June. At 16.00 hrs. on 3 June BIJL noted a thin movement still continuing at Nieuw-Helvoet, whereas on 4 June I recorded *quadrimaculata* continuing to move at an estimated 1,000 per hour as late as 19.00 hrs. at Kamperhoek. BIJL mentioned that at Nieuw-Helvoet the dragonflies collected at two concentration points: one at a farm and the other, a little to the east, at a small marsh. They flew out of these collection points on a front of one to two metres between 10 to 50 cm above the surface of the sea (lee) side of the dyke (sea wall), which gave them some protection from the easterly wind. At a

point where the sea dyke turned to the north-east and then, a little farther on, to the east again the dragonflies also changed direction to follow the lee side of the dyke along the coast. The migratory flight observed along the canal dyke at Quackjeswater on 11 June was observed from 11.00 hrs to 13.30 hrs in hot, sunny weather with a slight mist. The dragonflies flew in dense numbers over the vegetation at a height of between one and two metres above the ground in a south-easterly direction, and almost at right angles to the strong north-easterly wind blowing at the time. A count revealed that about 700 individuals passed the observation point in ten minutes, thus producing a rate of ca. 4,200 per hour. Next day, this directional movement ceased, but the Quackjeswater and its environs still held a high density of *quadrimaculata*. In the dunes between the lake and the sea the density was found to be 15 individuals per 100 square metres. They behaved normally; hunting and resting from time to time on plants or on the bare soil. No sexual activity amongst them was seen to take place. Of 84 examples collected, 44 were males. Most had only just emerged (there were no old ones), yet had suffered a fair amount of damage to their wings, presumably as a result of their migratory flight.

Belgium

These movements may also have occurred on the Belgian coast as they were observed both on the French coast to the south (see next section) as well as the Dutch coast to the north, but, apart from a report (DUMONT, 1964) that no migrating dragonflies were seen between Calais and Ostend on 31 May 1963 although specifically looked for, no accounts of movements in Belgium were forthcoming. However, DUMONT (op. cit.) found that at four sites, near Antwerp and in Brabant and eastern Flanders, where he counted *quadrimaculata* in June 1962, these dragonflies were four or five times more numerous in June 1963, suggesting that an unusual immigration had occurred.

France

DUMONT (1964) described a large southwards migration of *L. quadrimaculata* between Cap Griz-Nez and Boulogne which he observed while staying at the Marine Biological Station at Wimereux, about 6 km north of Boulogne, from 15 to 31 May 1963. No dragonflies were seen until 26 May when two *quadrimaculata* passed the station; next day ten were counted and the same number on 28 May. The following day, 29 May, a big invasion of this species began and he saw them swarming all over the coastal dunes and the adjacent meadows around the biological station. They flew remarkably slowly and hesitatingly low above the ground, and frequently rested. When one individual took wing it usually provoked flight in most of the others within a radius of one or two metres. As with those in the Netherlands, captured individuals all proved to be adult and one female laid eggs in captivity.
On 30 May the dragonflies were more active and DUMONT observed swarms migrating along the coast directly to the south from 07.00 hours to 20.30 hours in sunny conditions with a maximum temperature of 22° Celsius. Their numbers reached a peak between 14.00 hours and 16.00 hours. He followed the column of migrants all the way to Boulogne, where they were to be seen even in the centre of the town. Here he made counts from a fixed point during

five-minute periods between 15.25 hours and 15.40 hours. From these he calculated that they were passing him at the rate of 4,000 per hour, similar to the rates recorded in the Netherlands around midday, particularly the 4,200 per hour recorded at Quackjeswater on 11 June. Except in the town, where they were forced to fly higher, DUMONT did not see the dragonflies flying higher than five metres.
The next day, 31 May, DUMONT found that the movement was even greater along the coast than before, a colleague of his observing it as far north as Cap Griz-Nez where the dragonflies seemed to be arriving from over the sea. As already mentioned, he saw none north of Calais. He was unable to continue his observations after 31 May.

The Channel Islands

The late RODERICK DOBSON (in litt.) informed me that there was definite evidence of an immigration of *L. quadrimaculata* on the island of Jersey in early June 1963, where, according to him, the species had not been seen since 1958. He saw the first one at midday on 1 June flying over his garden pond at St. Brelade and managed, with difficulty, to capture it. By the early afternoon there were four of five, all very active; the males (he only saw males at first) taking up positions on prominent twigs. The following day there were at least twelve in his garden and many more were to be seen scattered elsewhere all over the island. On 4 June he noticed female *quadrimaculata* ovipositing in his pond.
On 3 June DOBSON visited the Ecrehous reef, midway between Jersey and Granville in France; here he found many *quadrimaculata* resting. He did not detect a definite directional movement, but noted that at all times these insects were flying very strongly and did not appear to be suffering from exhaustion. There is no fresh water on the reef and, therefore, no suitable breeding habitat for this species.

The British Isles

In 1963 and 1964 I wrote to several British entomologists living in likely coastal localities for observing dragonfly movements and asked them if they had noticed any during May and June; likewise I also wrote to the wardens of all the major British coastal bird migration observatories. In most cases negative replies were received, but some interesting and useful observations did come to light from others. These are detailed below:
At Gibraltar Point Bird Observatory, Lincolnshire, on the east coast of England and opposite the Dutch northern coasts, unusually large numbers of dragonflies were noticed in the late spring of 1963, probably early June (B. WILKINSON, in litt.). Several at a time were seen flying around the Observatory's Heligoland-type bird traps. Unfortunately, no special attention was paid to the movement by the ornithologists present and the flight direction, actual numbers involved and the identity of the dragonfly species concerned were not recorded. It seems highly probable, in the circumstances, that the species was *L. quadrimaculata*. This was the northernmost report I obtained in Britain: all the bird migration observatories farther north reported that they had not seen any unusual numbers of dragonflies. I received a similar negative report from the bird observatory at Bradwell-on-Sea on the Essex coast, farther

south than Gibraltar Point. However, farther south still big movements were witnessed at the bird migration observatories at Sandwich and Dungeness on the Kent coast.
At Sandwich the first evidence of dragonfly movements was obtained on 23 May, a day of south-east winds, when numbers were above normal, but these decreased and nothing more was observed until 30 May when large numbers of dragonflies were seen on the dunes and dune slacks (D. M. BATCHELOR, in litt.). On this day the wind blew from the north-east, following a period of more or less westerly or south-westerly winds. The direction of flight was not recorded and no counts were made, unfortunately, but it was thought that the species concerned were *quadrimaculata* and a species of *Sympetrum*. The dragonflies remained fairly numerous throughout the following week, then on 3 June reached "invasion" proportions when thousands were seen around the coast at Sandwich Bay. Some of these were captured and their identity confirmed as *L. quadrimaculata*. Subsequently, their numbers declined and there was no more suggestion of an immigration until later in June when, with south-east winds on the 20th, a smaller movement of dragonflies occurred together with an immigration of the butterfly *Cynthia cardui* L.
Nearly ten kilometres farther south, at Deal, Kent, the late BRIAN HAWKES (in litt.) estimated that 5,000 passed him in a single hour on 4 June (a date when large movements were seen in the Netherlands), flying south-eastwards along the coast. At this time a light northerly wind was blowing here. He believed that his estimate did not adequately reflect the scale of this movement, stating that many thousands were present around Deal.
Farther south still, at Dungeness, R. E. SCOTT (in litt.) reported that the movement was noticed in early June and that the species involved was considered to be *quadrimaculata* by the ornithologists present. It seems virtually certain that their opinion was correct. The dragonflies were extremely numerous, coming in off the sea from the south and east. They were seen everywhere, including in the Heligoland bird trap; on one morning it contained at least 50 examples. Sadly, again no counts were made or precise dates noted.
No dragonfly movements were reported in May or June 1963 from the south coast of England between Dungeness in the east and the Isles of Scilly in the west. The bird migration observatories at Portland Bill, Dorset, and St. Agnes, Isles of Scilly, both reported that they had seen nothing unusual. However, at Lundy Island, just off the North Devon coast of south-west England, a huge number of *L. quadrimaculata*, said by the then warden of the bird observatory (MICHAEL JONES, in litt.) to number thousands, was observed on the west coast of the island from 14.00 hours G.M.T. on 1 June 1963 (French, 1964). The wind was east-north-east, force 4, at the time. They were still present on the island on the 2nd, 3rd and 4th June; on the last-mentioned date a pair was seen in copula. When they first arrived they were noticeably sluggish and reluctant to fly, and could easily be caught by hand!; but later they became more active and difficult to catch.
Farther north-west (ca. 72 km) B. L. SAGE (1964) kindly informed me that D. R. SAUNDERS discovered small numbers of *quadrimaculata* present on Skomer Island, close to the south-west tip of Pembrokeshire, Wales, on 2 June 1963, a day of light north-east to east winds in this area. Varying numbers of *Libellula* dragonfly species were also noted on the island until 10 June. On 9 June the same observer saw about 15 dragonflies on Grassholm Island, 11 km due west of Skomer, all of which appeared to be *quadrimaculata*. Sage also informed me that the late T. A. W. DAVIS witnessed a small immigration of *Libellula* species from 1 to 4 June inclusive on the Pembrokeshire coast, precise localities being Dinas Head, Dinas Island, St. Brides and St. Ishmaels, all to the north of Skomer Island, except for St. Ishmaels which lies

about 15 km.to the east-south-east. Also in Pembrokeshire, many *quadrimaculata* were seen near the coast at Dowrog Pool, St. David's, on the northern side of St. Bride's Bay from Skomer on 15 June and at Buckspool, Bosherston, on 22 June, nearly 30 km. east-south-east of Skomer. It seems probable that all these arrivals on Lundy Island and the Pembrokeshire coast arrived from somewhere to the south or south-west.
The bird migration observatories at Bardsey Island off the north-west coast of Wales and at Great Saltee off the south-east coast of Ireland informed me that no dragonfly movements were noticed there in 1963; moreover, the late Miss C. E. LONGFIELD, a renowned authority on dragonflies who lived in Ireland, told me (in litt.) that she knew of no movements of *quadrimaculata* in this country that year.
I also wrote to several leading odonatists in the undermentioned countries, but the replies received, with the exception of Germany, provided little evidence of dragonfly movements in 1963.

Germany

In answer to enquiries, Dr. R. SCHLEGEL of the Vogelschutzwarte at Neschwitz, east-north-east of Dresden, and Dr. H. SCHIEMENZ of the Institut für Landesforschung und Naturschutz Halle both stated that they had not heard of any movements of dragonflies in the territory of the then German Democratic Republic in 1963. However, Dr. HELMUT SCHWARZBERG of Magdeburg provided some interesting observations that suggested that at least a local movement had occurred in that district in June. In an area of pasture with small ditches and pools about 10 km west of Magdeburg he noted the first imagine of *L. quadrimaculata* on 1 June. On 4 June he discovered between 30 and 50 at a small pool (10 x 15 metres) where he had rarely seen this species in the past, and even then only in ones and twos, because the water is very brackish. By 14 June only a few remained.
Dr. SCHWARZBERG also wrote that he had visited the Müritz See wetland area of Mecklenburg from 14 to 20 May and had found large numbers of *L. quadrimaculata*, a mass emergence obviously having occurred in these lakes as he found exuviae everywhere. In some places he counted 70 or more dragonflies perched in a single square metre and six or seven could be caught with a single stroke of his net. By the beginning of June only a few remained. SCHWARZBERG suggested that a migratory movement could well have started in this area.

Latvia

In response to a letter, Dr. Z. D. SPURIS of the Biological Institute of the Latvian Academy of Sciences in Riga stated that he had not heard of any movements of *L. quadrimaculata* in Latvia in 1963, apart from one vague, unconfirmed report.

Scandinavia

Dr. BOSTJAN KIAUTA and I corresponded with several entomologists in Denmark, Norway, Sweden and Finland, but none of them had heard of any large movements of *L. quadrimaculata* in Scandinavia in 1963.

Weather conditions

In 1964 J. M. Scott of the London Weather Centre kindly supplied me with a summary of the weather situation during the period under consideration and on which the following notes are based. From 28 May to 5 June 1963 pressure was low over France and the Mediterranean, and a high pressure belt extended from Ireland to Finland. This gradually moved westwards, then northwards to the vicinity of Iceland by 5 June, maintaining light east to north-east winds over England and the Low Countries. The wind became light and variable on 6 and 7 June; then easterlies became re-established on 8 June and persisted up to 10 June. Between 11 and 14 June, winds over north-west Europe became variable again with high pressure to the south-west of Britain and with low pressure over southern Scandinavia.
The anticyclone which thus affected north-west Europe during the last few days of May and the first twelve days of June produced hot, sunny and settled weather over Belgium, the Netherlands, England and Wales until a series of shallow troughs crossed England from the Atlantic Ocean on 13 June and brought very wet weather to Belgium and the Netherlands that same evening. Then, while an Atlantic depression moved towards Iceland, a frontal system associated with it moved across England on 16 June and reached the Netherlands on 17 June.

Table 1: Movements of *Libellula quadrimaculata* L. in the North Sea region in 1963

date	location	max. rate per hour	flight direction	wind direction
23 May	Sandwich, Kent, GB	—	S.E?	S.E.
30 May	Sandwich, Kent, GB	—	S.E?	N.E.
3 June	Sandwich, Kent, GB	—	S.E?	N.E.
20 June	Sandwich, Kent, GB	—	S.E?	S.E.
Early June	Dungeness, Kent, GB	—	S & E	N.E.
4 June	Deal, Kent, GB	5,000	S.E.	N.E.
Early June	Gibraltar Point, GB	—	?	N.E.
29 May	Boulogne area, F	—	?	?
30 May	Boulogne area, F	4,000	S.	N.E?
31 May	Boulogne area, F	—	S.	N.E?
1–4 June	Jersey, C.I.	—	?	E/N.E.
3 June	Ecrehous, C.I./F	—	?	N.E.
1 & 2 June	Texel, NI	—	E.	N.E.
1 & 2 June	IJmuiden, NL	—	N.E.	N.E.
1–10 June	Maas-Scheldt, NL	—	E.	N.E.
3 June	Voorne, NL	2,688	E.	E
4 June	Oost. Flevoland, NL	1,320	E.	N.E.
11 June	Voorne, NL	4,200	S.E.	N.E.
1 June	Lundy Island, GB	—	W?	E.N.E.
1–15 June	S.W. Wales, GB	—	W.	E.N.E.
2 June	Skomer Island, GB	—	?	E./N.E.

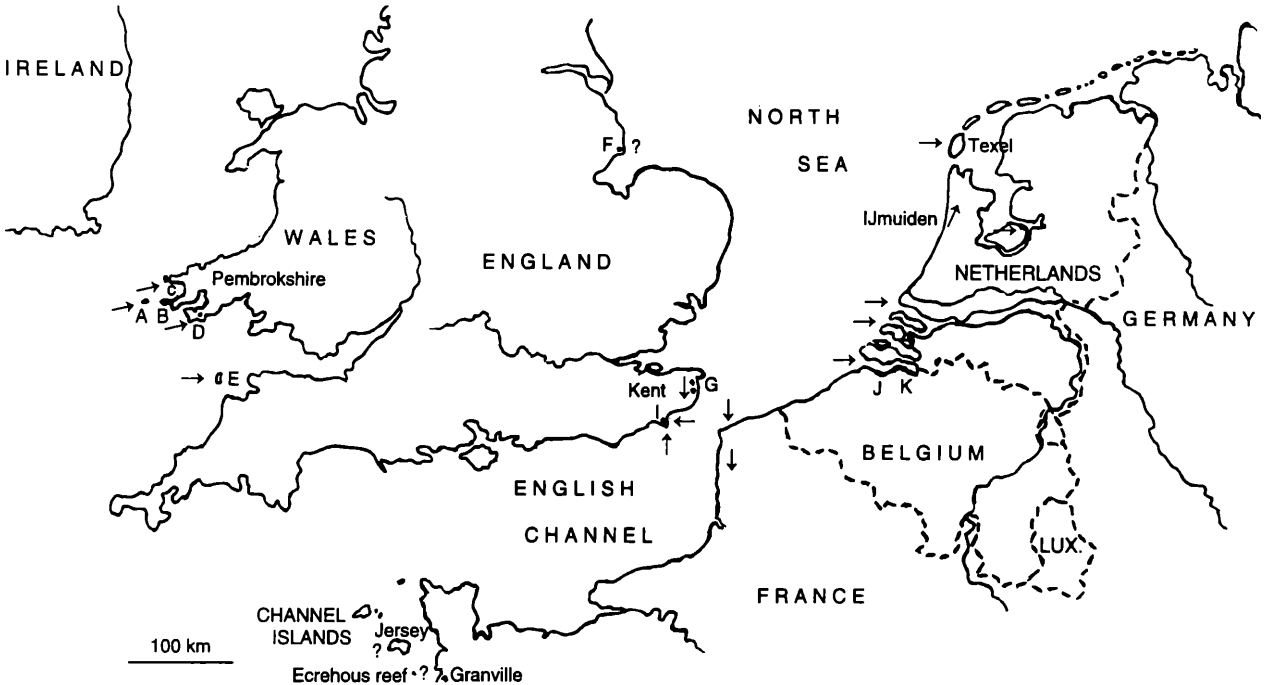

Fig. 1: Directions taken by *Libellula quadrimaculata* L. movements in May–June 1963.
? = direction of flight not recorded.
A = Grassholm, B = Skomer Island, C = St. Bride's Bay, D = Bosherston, E = Lundy Island, F = Gibraltar Point, G = Sandwich, H = Deal, I = Dungeness, J + K = area where much increased numbers of *quadrimaculata* were seen in 1963.

Libellula quadrimaculata has a circumboreal distribution and normally breeds, with the exception of Iceland, throughout Europe, including Ireland, Britain, the Low Countries, France and Spain (D'AGUILAR et al., 1986). It is well known to undertake the most spectacular migratory movements of all the European dragonflies. It breeds in enormous numbers in the lakes of Fenno-Scandia and eastern Europe, from whence it sometimes emigrates in huge quantity to the west (CORBET et al., 1960). WILLIAMS (1958) mentioned that mass flights of this species have been reported in the past from the British Isles, France, Denmark, Finland, Germany, the Netherlands, Poland, Russia and Sweden.

The place of origin of the dragonflies participating in the movements described in this paper is difficult to ascertain, owing to the lack of observations from some key areas of Europe, and is thus largely a matter for speculation. At first, I thought that they may have started from the bogs and marshes of Ireland where *quadrimaculata* is locally very common (LONGFIELD, 1949). This idea was prompted by the mainly easterly course taken by the arrivals on the Dutch coast, and the arrival of others on the west coast of Lundy Island in the Bristol Channel and on the Pembrokeshire coast of west Wales.
With reference to the Pembrokeshire immigrants, B. L. SAGE, an authority on the Welsh Odonata, wrote to me in 1964 to say that he thought "it very probable that the Welsh *L. quadrimaculata* originated from Ireland", as two males of *Brachytron pratense* (MÜLLER) were seen with them on Caldey Island and at Bosherston Lily Ponds, Pembrokeshire, and he was quite certain that this species does not breed in Pembrokeshire (this is confirmed by HAMMOND, 1983), although it does so in the nearby south-east corner of Ireland. He therefore thought that the two species flew together across the St. George's Channel from Ireland, and that it was "improbable that the *pratense* came from elsewhere in Wales to this part of coastal Pembrokeshire." However, as already mentioned, the late Miss C. E. LONGFIELD told me (in litt.) in 1964 that she saw no *quadrimaculata* in Ireland in May or June 1963, nor had anyone else reported any to her knowledge; but, of course, as the species does breed widely there it is quite possible that a local emigration occurred undetected, especially as such movements are less easily seen when leaving a coast than when arriving. It is quite possible, therefore, that SAGE was correct in suggesting that this particular movement began in southern Ireland; in which case it was probably unconnected with the large movements in the English Channel and North Sea areas. Furthermore, it is also quite possible that the Lundy Island *quadrimaculata* originated from this source too, forming part of the same local movement. The fact that they were first seen on 1 June, the same date as the first of the Dutch arrivals, could simply have been coincidental, although stimulated by the same weather situation.
On the other hand, it is also conceivably possible that the Welsh and Lundy Island *quadrimaculata* did form part of the North Sea and English Channel movements, the *pratense* having accompanied them from a starting point or points on the European mainland. It is well known that individual dragonflies are often attracted to migrants and join them (GRASSÉ, 1932). Moreover, if they did come from the European mainland, they might have originated in south-west France, as will be discussed in greater detail later in this paper, and could then have formed a part of an emigration which brought the large influx to the English Channel coast of Kent and the neighbouring parts of France. If this was the case, it seems rather surprising that none were reported for the south coast of England between Kent and Cornwall, unless

the migration split into two arms over the Bay of Biscay, the western arm proceeding into the St. George's Channel to reach south-west Wales and the eastern arm turning north-east into the English Channel and proceeding close to the French coast, then fanning out on reaching the narrow Straits of Dover to appear on the coast of Kent and on the French coast opposite between Boulogne and Cap Gris-Nez. On crossing these coasts some of the dragonflies may then have coasted southwards, as at Deal, Kent, and Cap Gris-Nez, contrary to the original direction of flight, in response to a combination of local physiographical conditions and the strong north-easterly winds. The majority of those that continued on through the Straits of Dover and into the southern part of the North Sea might then have fanned out eastwards to make land-fall on the Dutch coast between the estuaries of the Scheldt in the south and Texel in the north, having missed out the intervening Belgian coast.

On the whole, the dates fit this latter scenario best; the earliest recorded *quadrimaculata*, at the end of May, having appeared on both sides of the Straits of Dover. Such discrepancies as there are, as, for example, at Deal, Kent, may have been due to the absence there of human observers during the last few days of May. Those dragonflies that appeared at Sandwich, Kent, were presumably the vanguard of the main movement.

Yet another alternative explanation, supported by Dr. HELMUT SCHWARBERG's report of a mass emergence of *Libellula quadrimaculata* in the Müritz See wetland area of Mecklenburg, in north-east Germany, during the latter half of May, could be that the *quadrimaculata* moved *en masse* from here west-north-westwards across northern Germany and out into the North Sea where, by the first few days of June, they flew with the then prevailing north-easterly wind, most of them eventually making land-fall on the Dutch coast and some on the east coast of England, as at Gibraltar Point, Lincolnshire. An obvious objection to this hypothesis is that it does not fit in well with the arrivals on the Kent and French coasts at the end of May, days earlier than the arrivals on the Dutch North Sea coast. Of course, these two immigrations could have been unconnected, having originated in different areas, as also could the immigrations seen on the south-west coast of Wales and on Lundy Island, which might perhaps have come from southern Ireland, as already suggested.

The late Miss C. E. LONGFIELD (in litt.) suggested a fourth explanation: that the dragonflies could have migrated into the North Sea from Scandinavia with the north-east winds then prevailing. This, at first sight, seemed very possible, especially as many of the mass migrations of the past have come from there and north-east Europe, and at this time of year and under similar, anticyclonic weather conditions. Dr. BOSTJAN KIAUTA and I investigated this possibility, but, as already stated, all enquiries directed to Scandinavian entomologists revealed no evidence of mass emergences or large movements there.

On balance, having consulted the appropriate weather maps kindly supplied by the British Meteorological Office, I favour the explanation that the origin of the movements was somewhere in the vicinity of the Bay of Biscay. The weather maps do not suggest any particular weather situation which would clearly give rise to a mass movement (or movements) or suggest a precise source. However, I did notice that light north-east winds (8 to 12 knots) were blowing consistently over the Landes coast of south-west France from 25 to 29 May, 1963. There is a chain of large, shallow lakes with some marshy edges along the Gironde and Landes coasts from the mouth of the Gironde at Arcachon in the north to Mimizan in the south. It seems possible that there was a mass emergence of *L. quadrimaculata* in these lakes in the latter half of May. When I visited them in late September and October 1953 (BURTON, 1953) and again in late September and October 1966 I found them to have a rich

dragonfly fauna. They are situated well within the normal breeding range of *L. quadrimaculata*, although it was too late in the season to see this species on the wing.
Assuming that such a mass emergence of *quadrimaculata* did occur in this region in May 1963, it is possible that a mass exodus took place in the last few days of that month. By flying in a northerly direction against the north-easterly winds they might well have been deflected out into the Bay of Biscay to the north-west. Subsequently, those on the western flank of the migration, as already suggested, could have split off from the main body and reached Lundy Island and the south-west coast of Wales (Pembrokeshire) by 1 June, whilst the rest changed direction and flew north-east against the wind and into into the English Channel to reach the French coast near Boulogne on 29 May and the Kent coast of England about the same time. It will be remembered that they were reported as flying in off the sea from the south and east at Dungeness, Kent, and also as coming in from the sea at Cap Griz-Nez, France. The majority could then have continued on through the Straits of Dover towards the Dutch North Sea coast, the vanguard arriving there a day later. The rest of the flight would have followed over successive days in early June.
I am unaware of any positive evidence in 1963 from south-west France in support of this latter hypothesis, but it does seem to be the most plausible explanation for at least the main source of the large *quadrimaculata* movements that year. Dragonflies are usually abundant around the lakes of the Gironde and the Landes, and a big movement of them leaving the coast could conceivably pass unnoticed by local people used to seeing them in large numbers. Moreover, few entomologists and even fewer odonatists lived in that region in the early 1960s. So it does seem possible that the mass migrations described in this paper could have originated in south-west France, but in the absence of positive evidence from that area it is impossible to prove this.
Yet another possibility, of course, is that more than one source of these migrations was involved and that they resulted from local mass emergences quite close to the localities where the movements were observed taking place. In this connection it is worth mentioning that, following the very severe winter of 1962–63, the spring of 1963 was late and generally cold, and the sudden development of very warm and sunny anticyclonic weather in late May would have been particularly conducive to sudden mass emergences of such insects as *Libellula quadrimaculata*.

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