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Migration in Auchenorrhyncha

W. DELLA GIUSTINA

Abstract

Migration is a behaviour widely distributed among animals. Among insects, a part of Auchenorrhyncha species present a such behaviour and are able to move over more or less long distance. This possibility concerns only macropterous forms with wings completly developed. This phenomenon is under the influence of numerous parameters, internal and external factors such as: absence of food plants, ephemeral habitats, bad weather conditions, population density (intra or extra specific competition), etc. Two exemples of migration on a long range distance are given, the first in France with *Zyginidia scutellaris*, the 2nd one concerns *Nilaparvata lugens* an important pest for rice cultures in the Far East.

Resumé: La migration est un comportement que l'on rencontre souvent chez les animaux. Parmi les insectes, de nombreuses espèces d'Auchenorrhyncha sont capables de se déplacer sur des distances plus ou moins grandes et concerne seulement les macroptères aux ailes complètement développées. Ce phénomène est dirigé par de nombreux paramètres, des facteurs internes et externes tels que: l'absence de plantes-hôtes, les habitats éphémères, les mauvaises conditions climatiques, la densité de population (compétition intra et extra spécifique), etc. Deux exemples de migration sur une longues distance sont présentés: *Zyginidia scutellaris* en France, le second concerne *Nilaparvata lugens* un important ravageur de la riziculture en Extrême-Orient.

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Introduction

Migration means to pass from one place to another, removing or shifting, coming and going. For the public, this definition concerns vertebrates like birds (swallows, white storks, snow gooses, etc.) and mammalians (seals, whales, elephants, buffalos, etc.) An entertainment seen frequently on cinema screens and TV sets.

Fig. 1:
Water trap, insects attracted by yellow coloration, fall into water and die.

Fig. 2:
Malaise trap, walking insects fall in a plastic bottle with water inside.

Human history offers many examples of migration as well, hunting people following the seasons in order to meet water and food, immigrations and emigrations caused by political and economical reasons. Migration known as transhumance concerns active seasonal movements leading farm animals to the best pastures in different altitudes or localities according to climatic conditions. Since the XIXth century tourism became a transhumance migration activity, mainly directed from north to south, looking for ideal weather conditions during summer and winter. This is probably the most pleasant kind of migration if traffic jams are excluded.

Migration concerns a large number of animals. Insects, too, are able to migrate or move over more or less long distances, a phenomenon well documented in different orders like butterflies and flies. A very spectacular displacement is exhibited by adult ladybirds (Coleoptera) moving between the Mediterranean coast and the interior for hibernation during the cold season.

« Migration is characterized by the interaction of specialized behavioral responses which serve a specific ecological function, namely, the choice of where the next generation will breed, options described by Southwood. Migration encompasses a range of spatial and temporal scales of distances, from the short-distances (less than 1 km and 1 hour, in that case), to mean-distances (up to 100 km and 2 days) and long-distances » (KISIMOTO & ROSENBERG 1994). Short-distance migration can be realised by hopping and walking, not necessarily by flying. The 2 other options mainly refer to the intrinsic flight capabilities (flight duration etc.) of insects and several physical parameters such as: wind force and its direction, absence of rain, air speed, air temperature and its degree of humidity, day lenght etc. and also depends on several environmental factors like host plant quality and population density. However, migration differs from simple movement by its genetically controlled heredity.

The ability of flight concerns macropterous insects with wings completely developed.

The degree of migrational movements (percent macroptery) decreases significantly as the supply of permanent habitats increases. Species inhabiting temporary habitats (agricultural crops) are primarily macropterous, whereas those occurring in permanent habitats are mostly brachypterous. Among species with two wing forms, macropterous populations are associated with ephemeral habitats.

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Such species relationships are very interesting because they allow genetic crossings between different populations.

Methods

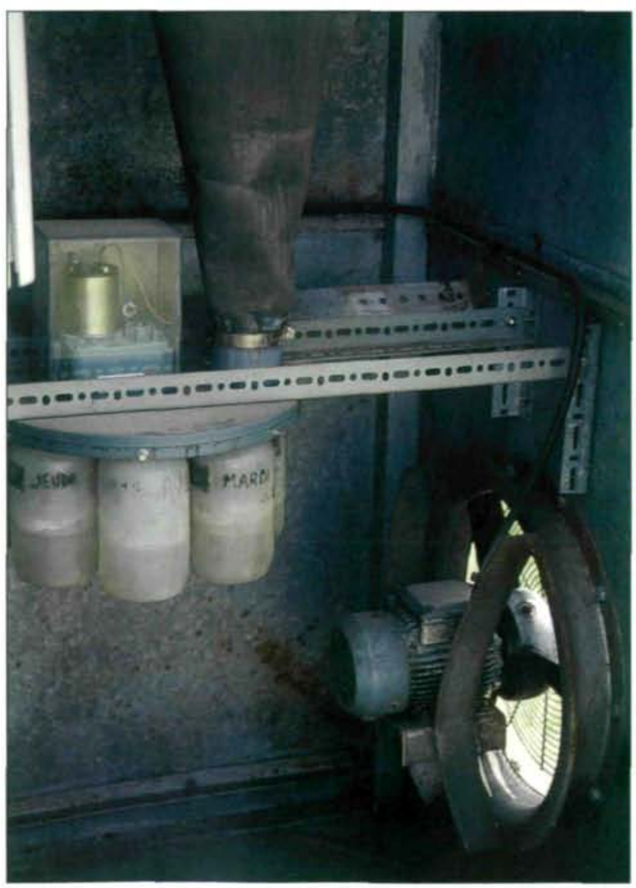
Among the many methods used for studying migration, insects are mainly collected by different traps: water color plates (fig. 1), yellow being the most attractive color for Homoptera and many other insects, malaise traps (fig. 2), sticky traps, suction traps (figs 3 & 4), the later can be used at different heights. Radar and aircraft traps are now used for mass migrations at high altitude. For measuring migration activity mark and recapture experiments are favoured.

Migration in Homoptera taxa

Wing dimorphism (macroptery and brachyptery), in the same population is a characteristic of a great number of Homoptera including Auchenorrhyncha, like the delphacid *Conomelus anceps* (figs 5 & 6). Well studied are migrations of aphids, being important pests for plant cultivations by primary damages (sap removal) and secondary damages (modifications of the plant growth and their high efficiency as vectors of virus diseases). For instance, the green peach aphid *Myzus persicae* is able to inoculate more than 130 diseases to its different host plants. This was the main reason why the suction trap was designed in Great Britain during the 1950's to study aphids dispersal. Traps in a mean height of 12,3 m allow the best representation of the aphid population pressure gradient between ground and more than 1000 m altitude. Eliminating catches from the surroundings of the traps gives a better appreciation of migratory activities. Throughout the year aerial plankton can be collected using powerful vacuum traps. Specimens are trapped in a bottle containing water and detergent. The rythm of bottle displacement can be carried out automatically, usually each 24 hours. Now the Euraphid Network includes 15 countries, with a total of 60 suction traps. Extending such programmes will hopefully obtain similar results with other insect groups collected, particularly with Auchenorrhyncha, their relatives.

Migration in Auchenorrhyncha

Different causes to explain the dimorphism have been cited previously, for instance, the number of macropters increases with intra- or/and interspecific competition at the larval instars. In the latter, one species is more active than the other one. Brachypters and macropters have different functions. The smaller female brachypters are generally more



Figs 3 and 4: Suction trap : insects are sucked at the top of the tower and fall into a plastic bottle.

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fecund than the others (DENNO et al. 1989), and can reproduce more quickly in permanent habitats. Other authors found fecundity to be equivalent in both morphs. Macropters, with larger body size, are capable of colonizing new areas and reproduce later in life. Their larger body evolved of needing more energy such as carbohydrate and lipid reserves for flying. Because brachypters and submacropters mainly move by walking or hopping, they are collected near the ground level and their active range is very limited (less than 10s m). Macropters are capable of mean and long-distance migration by flight, but there is considerable interspecific variation.

Fig. 5:
A couple of brachypterous *Conomelus anceps*.

Fig. 6:
***Conomelus anceps* : a macropterous female.**

Auchenorrhyncha mostly belong to the group for which emigrates without returning, usually realised by relatively short-lived individuals. More common in the Delphacidae, but known in the Cicadellidae too, many species exhibit two wing forms. Their relative proportion in a given population depends on environmental and genetic interaction and varies in time.

Among numerous studies conducted to study migration in Auchenorrhyncha, we cite the three following surveys for Europe:

- WALOFF (1973) - England (Silwood): flight dispersal investigated by suction traps suspended at different heights and colour plates.
- GÜNTHART (1987) - Switzerland (near Basel): Sticky mesh traps fixed on a meteorological tower at eight levels between 5 and 155 m above the ground. From 294 Auchenorrhyncha specimens caught 20 species were identified from 14 collectings between May 11th and September 3rd 1984.
- DELLA GIUSTINA & BALASSE (1999) - France: By the French Agraphid network, 13 suction traps were used in 1994 for studying the most dangerous aphid pests for agriculture. Out of 10,790 specimens comprising 137 of the 850 French known Auchenorrhyncha species were identified.

Two examples of migration

Two species will be presented as examples: *Zyginidia scutellaris* (H.-S.) a Typhlocybinae (Cicadellidae) characterized by populations with only one wingform, all specimens being macropterous, and the brown planthopper (BPH) *Nilaparvata lugens* STÅL, a Far East Delphacidae.

Zyginidia scutellaris (fig. 7), the maize leafhopper

Widely distributed in France, it is one of the most common French species and widespread in Europe except Scandinavia and eastern Europe. As a mesophyll feeder, the damage on maize appears as pale stripes, most frequent on the first leaves, at the beginning of plant growth (fig. 8). So far, it is not a pest in France but in several localities of the south west some damage is caused to maize cultiva-

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ted for seed production. *Z. scutellaris* is pluri-voltine, hibernating at the egg stage, but some adults can survive during the winter (predominantly females). The maize culture in France (3,500,000 ha) is probably an important parameter for its develoment because maize grows actively during summer when many indigenous grasses are already dry. It is important to note that maize which is only present in Europe since 400 years is the most attractive plant for this leafhopper. But during summer, *Z. scutellaris* can also survive for some periods on several dicotyledons.

After studies where yellow plates and suction traps were used for collecting the following migration pattern turns up in France. In spring the first generation deriving from eggs deposited in autumn give rise to a second generation on cultivated cereals and weeds. Migration activity starts in June with short population shifts from graminaceous plants, such as wheat, barley and wild grasses to the young neighbouring maize plants having been sown some weeks earlier. Adults are only collected by traps near the ground level. With suction traps, the peak catch occurs at the end of July until the beginning of August and corresponds to adults of the first generation developed on maize. Populations then decrease progressively until mid October. After mid-August interspecific competition occurs with several aphids living on the same host plant, especially *Rhopalosyphum padi*. At the end of September they fly back to small grain grasses

Fig. 7: ***Zyginia scutellaris*** **female.**

Fig. 8: **Damages on a maize leaf.**

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when the maize is drying. The young plants of wheat and barley are quickly colonized in October, as soon as they appear after sowing. But adult populations decrease quickly with the cold and wet atmospheric conditions of the second part of October and November, even though some can survive during the cold period of the year. Females deposit eggs on young leaves before disappearing during the second part of autumn. These spring and autumn dispersals, well indicated by trapping on yellow plates, only refer to short distance movements between fields and are not recorded by suction traps. During summer, captures at 12.3 m by the suction traps indicate that a part of the population is able to fly on mean-distances (fig. 1), to colonize habitats far away from their native area.

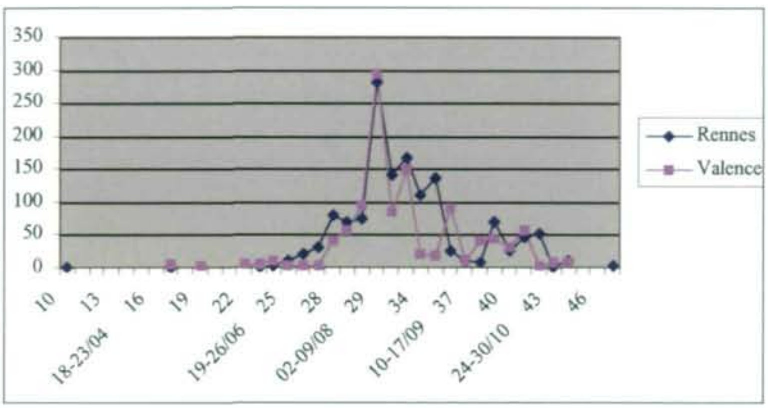

Fig. 1:
Two exemples of fluctuation populations of *Z. scutellaris* collected by suction traps, in Rennes and Valence (France) in 1984.

Fig. 9:
A meteotower near Basel, Switzerland with sticky mesh traps situated between 5 and 155 m above ground.
(from GÜNTHART 1987)

Nilaparvata lugens STÅL, the brown planthopper (BPH; fig. 13).

This species is studied as a major pest on rice, causing massive losses in crop production throughout Asia.

The conditions for migration needed by long-distance flyers have been summarized by KISIMOTO & ROSENBERG (1994). Planthoppers like *Nilaparvata lugens* fly slowly and must take use of winds for traversing any significant distances, thus migrating above the flight boundary layer (above ground air-layer within which insects have control over their ground related movements). Above this boundary layer, insect displacements are determined by the windfields in which they are flying, the direction of movement being determined by wind direction and the extent of movement by the wind speed, and the insect's own flight duration. The effects of air temperature and humidity determine whether take-off is possible and influence the height of flight.

During the dry season in the tropical region, BPH can fly on mean-distance (up to 30 km), a sufficient distance to ensure the insects' survival because of the presence of asynchronous rice cultivation in the same area. Much more spectacular are long-distance movements from the tropics to about 42 to 44°N, to colonize the newly transplanted rice crop in Korea and Japan each spring and early summer, a trans-oceanic migration from China (600-1000 km) (fig. 2). From Philippines to Taiwan and southern China, BPH (K1, L 1-2) are less documented than for northern areas but they must influence the seasonal redistribution of specimens. Five waves of migration have been identified in China (C1-C5), between mid-April and early August, associated with the southerly and southwesterly winds of the summer monsoon.

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The movements to Korea and Japan are linked with « strong south westerly low-level jets occuring up to 1000 m above the surface in the warm sectors of eastward-moving frontal depressions (MF1-3, TYP) ». Driven by these winds this phenomenon occurs annually and the rice cultures around the Chinese sea are colonised and submitted to important injuries each year.

interesting that one *Arthaldeus pascuellus* specimen (Cicadellidae), was the only Auchenorrhyncha collected at an altitude between 1000 and 1200 m. Ribaut, the French Auchenorrhyncha specialist, was surprised to identify this species. He expected to meet better fliers like members of the Typhlocybinae (Cicadellidae), living on trees, all species of this subfamily being only macropterous.

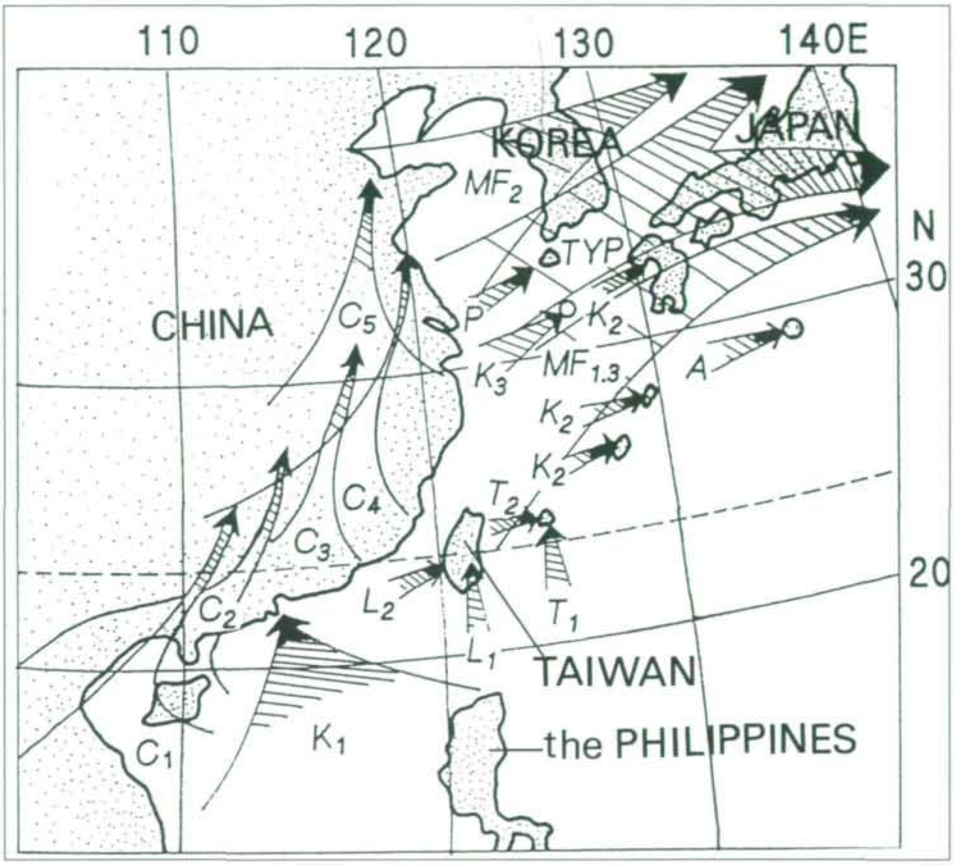

Fig. 2:
Schematic diagram of the northward migration of *Nilaparvata lugens* and *Sogatella furcifera*, in eastern Asia (after KISIMOTO & ROSENBERG 1994). C1-C5: China; K1: Hong Kong; K2: Okinawa; L1-L2: Taiwan; MF2: mass immigration to Korea and partly for Japan; MF1.3: minor immigrations to Japan; MYP: mass immigrations to Japan.

Conclusion

For being able to leave non-permanent habitats Auchenorrhyncha are mainly short-distance migrants. They are therefore mainly collected in traps placed near ground level. To move over such short distances it is not necessary to fly, but to walk and/or hop. Nevertheless, some species can fly over longer distances and are therefore collected on higher placed traps, thus showing a correlation between flying height and migration distance (*Zyginidia scutellaris*, *Javesella pellucida*, *Laodelphax striatellus*, etc.). The first European studies of aerial plankton seem to refer to BERLAND (1935), in the Parisian area, following a short study directed by COAD (1931), in USA. It is

Fig. 10:
***Laodelphax striatellus*, female.**

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During her study using sticky mesh traps ($1m^2$) fixed on a meteotower (fig. 8), GUNTHART (1987), observed very few insects at high altitude, only one specimen was collected at 155 m (*Laodelphax striatellus*, fig. 10), and 5 specimens belonging to 5 different species were collected at 100 m: *Cixius nervosus* (Cixiidae), *L. striatellus*, *Idiocerus poecilus*, *Idiocerus* sp., the 5th being a damaged specimen.

Auchenorrhyncha migrations sometimes cover long distances, as we have seen with the delphacid *Nilaparvata lugens*. A huge invasion of *Balclutha pauxilla* LINDBERG, (Cicadellidae), was observed in the Ascension Island in the Atlantic Ocean which lies at a point roughly equidistant between Recife (South America) and Luanda (Africa); the specimens were probably coming from Africa and flew more than 2,000 km above the Ocean (GHAURI 1983). Behavioural processes of how insects are landing on ground are not completely known. Therefore it is difficult to imagine that these specimens were still flying above the flight boundary layer when they arrived over the island. Differences of colour between land and sea surface might have been of importance to trigger their landing.

Human induced migration occurs worldwide including Auchenorrhyncha are included in a such way of easily migration! Thanks to poplar trading several European Idiocerinae (Cicadellidae) have now colonised many countries far away. Probably because of apple tree trading, *Metcalfa pruinosa* SAY (figs 11 & 12), a Flatidae widely distributed in America, from Quebec up to Brazil, was first discovered in Northen Italy in 1983, then in France in 1985. Now it is present at least in Switzerland, Slovenia, Austria and Spain. The invasion progressed quickly due to a wide polyphagy and the fact that they have no natural enemies in Europe. Because warm summers are the major physical parameter for its development the expansion in Europe seems to be going on and several other countries will be colonised in a more or less close future.

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Fig. 11: ***Metcalfa pruinosa*, adult.**

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Fig. 12: **A colony of *M. pruinosa* on a young branch of Peach tree.**

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Fig. 13: ***Nilaparvata lugens*** **(Photo: M. Claridge)**

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Zusammenfassung

Wanderungsbewegungen sind von sehr vielen Tierarten bekannt. Innerhalb der Insekten zeigen unter anderem Zikaden derartige Verhaltensweisen. Ausschließlich langflügelige Morphen sind hierbei imstande, mehr oder minder große Wanderbewegungen durchzuführen. Dieses Phänomen wird von verschiedenen inneren und äußeren Rahmenbedingungen, z. B. Nährpflanzen-Mangel, kurzlebige Habitate, schlechte Witterung, (hohe) Populationsdichte (intra- oder interspezifische Konkurrenz) beeinflusst. Zwei Beispiele für Wanderungen über große Entfernungen werden vorgestellt: Jene von *Zyginidia scutellaris* in Frankreich, und jene von *Nilaparvata lugens*, einem wichtigen Reisschädling, in Südostasien.

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Address of the author

Dr. William DELLA GIUSTINA
1 rue Charles-Michels
F 78210 St-Cyr-l'Ecole
France
Email: dellagiustina@wanadoo.fr

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