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Meeting report

Organisms on the move: ecology and evolution of dispersal

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The symposium and workshop ‘Organisms on the move: ecology and evolution of dispersal’, held in Ghent (Belgium), 14–18 September 2009, brought together a wide range of researchers using empirical and modelling approaches to examine the dispersal process. This meeting provided an opportunity to assess how much cross-fertilization there has been between empiricists and theoreticians, to present novel insights on dispersal patterns in plants, animals and micro-organisms and to measure the progress made in examining the causes and consequences of dispersal.

Keywords: dispersal; condition dependent; costs; information; movement ecology

1. INTRODUCTION

Dispersal is the process that ultimately causes gene flow through space or time. In the context of landscape fragmentation and global climate change, understanding how, where and why organisms move among local populations and to new areas is of utmost importance. To function over ecological and evolutionary time scales, populations facing such environmental changes need to be provided with functionally connected networks of habitats, and the success of these networks is reliant on the species having sufficient dispersal ability to track suitable habitats. Besides this crucial role in population dynamics, dispersal also plays a central role in the evolution of populations and species. Indeed, dispersal drives the spatial and temporal redistribution of genotypes, a process that is inseparable from the evolution of life-history traits (Roncz 2007).

The biology of dispersal is thus a fundament for many areas of ecology and evolutionary biology (Clobert et al. 2001; Bullock et al. 2002; Bowler & Benton 2005; Kokko & Lopez-Sepulcre 2006). As a consequence, dispersal has attracted the attention of a growing number of researchers, resulting in a large amount of papers and meetings devoted solely to the ecology and evolution of dispersal. After having first regarded the phenomenology of dispersal, researchers gradually considered a more mechanistic approach to dispersal. This approach stimulated the dissection of dispersal into its three constitutive steps: emigration, transfer and settlement, as previously proposed by Lidicker & Stenseth (1992). This mechanistic approach encouraged major advances in our understanding of dispersal (e.g. Van Dyck & Baguette 2005; Baguette & Van Dyck 2007).

The symposium ‘Organisms on the move: ecology and evolution of dispersal’ was co-organized by Dries Bonte and Hans Van Dyck and sponsored by the Flemish Fund for Scientific Research. This was the fourth meeting of an informal and open group of researchers, which first met in 2005 at the joint initiative of Silke Hein, Thomas Hovestadt, Hans-Joachim Poethke and Hans Van Dyck, and aimed to invite and encourage theoreticians and empiricists to work together more closely. It was this emphasis on using a more integrated approach that ensured the success of this workshop. After this seminal impulse, the group regularly met at workshops and conferences. This fourth meeting provided an opportunity to assess how much integration has been achieved between empiricists and theoreticians, to present novel insights on dispersal patterns in plants, animals and micro-organisms, and to measure the progress made in examining the causes and consequences of dispersal. Here we summarize the most recent advances in dispersal research presented and discussed at this meeting.

2. DISPERSAL FRAMEWORK: THE ROLE OF INFORMATION

In his introductory talk, Thomas Hovestadt presented a ‘movement framework’ originating from discussions in the dispersal workshop in Paris, 2007. According to this framework, decisions about direction and speed of movement are based on the information available to an individual. Information is used to update more or less complex ‘prior’ internal representations of the location of fitness-relevant environmental attributes to ‘posterior’ expectations. Posterials may be built from multiple levels of information, such as resource distribution, mating opportunities, predation risk or competition. They can be based on personal experience, cultural experience, or experience accumulated by natural selection into the genome. These layers are continuously updated according to the current internal state of the individual, and then assimilated into the individual’s actual needs. Thus, at any moment, the weighted integration of the different layers results in an overall posterior reflecting the current fitness expectations across space. Movements should always be directed towards peaks of this current spatial fitness map. The statistical attributes of movement paths like distribution of step lengths and turning angles thus reflect the series of those external and internal events that made individuals change their movement.

This new framework highlights the potential importance of information during dispersal processes, which was confirmed by several empirical studies at this meeting. Jean Clobert experimentally demonstrated that dispersing common lizards ‘carry’ information about their dispersal status (philopatric or disperser),
the density at their natal site, conditions during disper-
sal and even the distance they have moved. Using
microcosms, Nicolas Schtickzelle showed that even
simple organisms such as protists use direct (own
population, surrounding population) and indirect
information sources (immigrants) during dispersal.

3. DISPERAL AT THE LEVEL OF INDIVIDUALS

After being long ignored, it is now recognized that
interindividual differences in dispersal are important.
In her meta-analysis, Virginie Stevens showed that dis-
persal ability of butterflies varied as much within
species as among species. Another example also
showed that within-species variation in butterfly flight
morphology can vary greatly along a latitudinal cline
and across landscape types (Sofie Vandewoestijne).
This emphasizes the importance of considering the
causes and consequences of such interindividual
variation.

Erik Matthesen highlighted the importance of person-
ality types and showed that in great tits, fast
explorers moved further away than slow explorers in
response to the removal of a food source; however,
the tits’ personality was not correlated with spatial
behaviour before food was removed, suggesting that
this trait is a way to ‘cope’ when challenged by a
decrease in food availability, rather than just a baseline
behaviour. This suggests that dispersal behaviour
could differ according to the personality of the tits.

Another important factor is interindividual variation
in the costs associated with dispersal, as dispersing
individuals face increased energy expenditure, poten-
tially higher predation risks and the risk of not
finding a suitable area to settle. These costs can
obviously have important repercussions for the evolu-
tion of dispersal, and this was intensively discussed
during the workshop that followed the symposium.
Dispersal costs have been very little investigated so
far (as demonstrated by a review of the literature,
Aurélie Coulon). However, one noticeable characteristic
of this symposium was the relatively high number of
talks covering this topic. Debora Arlt investigated
search costs in the northern wheatear. Marjo Saasta-
moinen and Melanie Gibbs examined the costs of
flight on reproductive output in butterflies. Gibbs
showed the potential for flight-induced changes in egg
provisioning to have cross-generational consequences
for offspring. Saastamoinen showed that the cost of
flight is condition dependent: alterations in phenotype
induced by stressful conditions during the larval stage
helped females to buffer against stressful forced flight.

4. DISPERAL AND POPULATION DYNAMICS

A number of presentations examined how environ-
mental factors may influence individual dispersal
decisions, and how these individual decisions can
affect population dynamics. Tim Benton demonstrated
that by experimentally manipulating mites in micro-
cosms, it was possible to investigate the factors
determining individual movement decisions and to
assess population consequences. Benton showed that
movement decisions are often condition dependent,
and that condition may reduce mortality costs during
dispersal. Benton also showed how the effects of dis-
persal on population dynamics are sometimes
counterintuitive, e.g. reducing synchrony and
population size.

In animals, both empirical and theoretical studies
have successfully demonstrated how dispersal influ-
ences the long-term persistence of a metapopulation,
as local extinctions need to be compensated via recolo-
nizations. James Bullock illustrated how the metapopulation theory may not always be applicable
to plant populations, as even in populations with a
high turnover, the seedbank may have a greater role
in recolonizations than dispersal. Bullock highlighted
the need for comparative research at multiple taxo-
nomic levels to improve our general understanding
of the processes and implications of dispersal on
population dynamics and survival.

Studies involving biological interactions such as
bird-mediated seed dispersal showed the potential
impact of these complex and often context-dependent
processes on ecosystems (Valerie Lehouck). Future
research investigating species interactions during
dispersal may have important implications for
conservation and habitat management.

5. DISPERAL EVOLUTION

Theoretical models provide a powerful tool to study
the evolution of dispersal. However, as Justin Travis
pointed out, although the three-step framework of dis-
persal was already proposed in 1992 (Lidicker &
Stenseth 1992), most work exploring dispersal evolu-
tion still focuses only on the first step (emigration).
In general, theoretical work exploring the actual pro-
cess by which individuals move between patches is
lacking. Using a continuous space population model,
Travis explored how the evolution of a random walk
depends on the cost of dispersal, patch density and
emigration rate, and emphasized that models like this
are required to make long-term predictions of popu-
lation dynamics in fragmented landscapes. The
inclusion of patch quality and condition-dependent
costs of dispersal in event-based models can greatly
affect global population size and the evolution of dis-
persal distance (Calvin Dytham). The importance of
addressing condition-dependent dispersal and interin-
dividual variation in dispersal costs was a common
conclusion throughout the meeting. Selection on indi-
vidual variation in dispersal does not necessarily
promote dispersal rules that make populations use
space in an optimal way. This may lead to tension
between individual and population-level benefits and
greatly affect the evolution of dispersal (Hanna
Kokko).

6. PERSPECTIVES

The general consensus at this meeting was that a more
integrative approach to studying dispersal is impera-
tive: (i) for a detailed examination of the costs and
benefits associated with each of the three steps of dis-
persal, and (ii) to gain a better understanding of how
interactions between dispersal and other life-history
traits may contribute to variation in dispersal across individuals, populations and species. The new framework presented by Hovestadt proposed to incorporate the concept of information-driven decision rules (Dall et al. 2005) to examine how individuals use information from their environment to assess the costs and benefits associated with dispersal, and to mitigate such costs. This would improve our ability to predict how dispersal patterns will alter in response to changing ecological conditions.

Another common conclusion of the meeting was the need to address condition-dependent movement decisions and interindividual variation in dispersal costs. Further discussions at the workshop concluded that we need to specifically design experimental studies integrated with modelling approaches to better understand the way in which various costs of dispersal—incurred at the three steps of dispersal—interact with each other to shape the evolution of dispersal-related traits.

In his recent review on dispersal modelling, Hawkes (2009) highlighted the fact that models addressing how heritable changes in dispersal propensity can impact population dynamics were currently missing from the literature. Modelling work presented at this meeting will go some way towards filling this gap. Furthermore, these theoretical models continue to move the field forward by incorporating interindividual variation and each of the three steps of dispersal. Another review revealed a general lack of integration across research fields studying dispersal (Holyoak et al. 2008). This dispersal meeting clearly highlighted how interchange between empiricists and theoreticians can be mutually productive and beneficial and as such, we strongly encourage further cross-fertilization in the future.

Although this meeting successfully addressed various recent advances in the study of dispersal, we feel that some important topics were still under-represented. In her review, Coulon showed that the influence of landscape configuration on dispersal has been under-investigated, but rather encouragingly, the development of new technologies has stimulated more research into this area (also see Nathan et al. 2008). In addition, few of the studies presented investigated the relationship between landscape structure, dispersal and population genetics. We are confident, however, that recent advances in landscape genetics should help disentangle how landscape configuration can influence the evolution of dispersal. Another research angle that was under-represented at this meeting is the role that developmental/phenotypic plasticity and, in particular, transgenerational plasticity (i.e. maternal effects) may play in generating variability in dispersal propensity both within and across populations (e.g. Duckworth 2009).

This meeting brought together researchers studying a wide range of taxa, from viruses through micro-organisms and plants to animals, presenting work on a wide range of topics including conservation biology, epidemiology, climate change biology, landscape ecology and evolutionary ecology. In general, these researchers shared a common goal: to understand how dispersal patterns are, and will continue to be, affected by rapidly changing ecological conditions. The framework proposed by Hovestadt should provide a much needed step towards achieving this goal. Through increased collaboration and integration across fields, it should be possible to provide timely and accurate data to improve our understanding of this linchpin process in the functioning and evolution of natural populations.

We are grateful to Dries Bonte and Hans Van Dyck who organized this fruitful meeting and to the sponsor, FWO.


