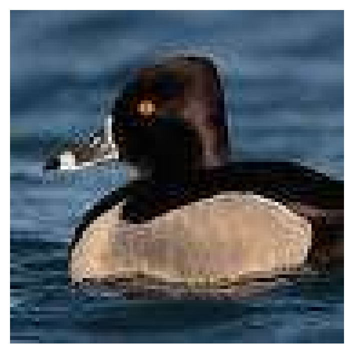
Climate change and applied Zoology: understanding human-induced effects on wildlife

Fundamentals of digital and ecological transitions

Lesson 7

To truly understand how humans impact our planet, we must first learn to read the natural movements of species.

Knowing where and how animals and plants move allows us to recognise the traces of human influence and to protect the life around us, from forests to the most hidden environments, such as caves.



Overcoming the Barriers – when travelers become permanent established -

- Collared dove (*Streptopelia decaocto*) represents perhaps the most dramatic natural change in distribution recorded for any vertebrate in recent times.
- Since its introduction to the Bahamas in 1974, the collared dove has also spread rapidly through North America
- It is unlikely that the collared dove would have been able to take advantage of these changes without a change in its own genetic make-up, perhaps a physiological one permitting the species to tolerate a wider range of climatic conditions or to utilize a wider range of food substances

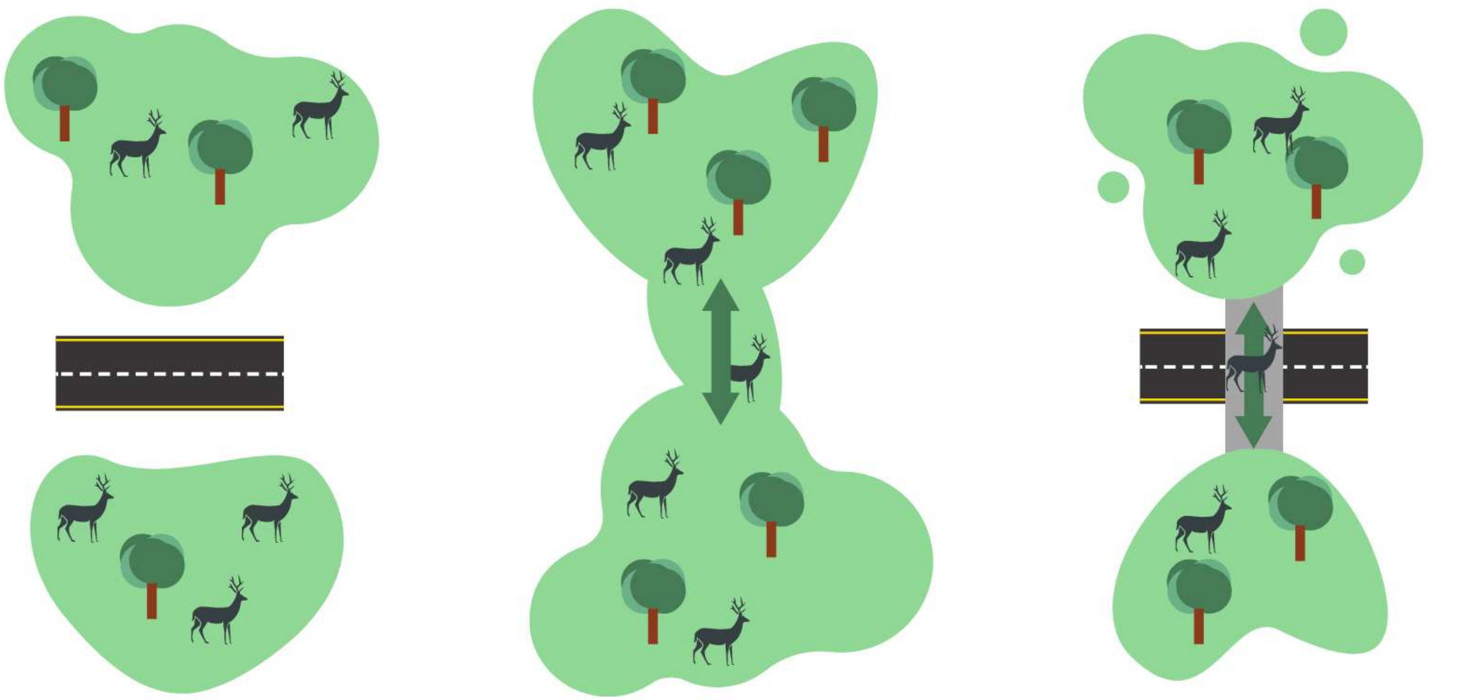
Spreading pathway

- **Corridor**: a wide variety of interconnecting habitats, so that the majority of organisms found at either end of the corridor would find little difficulty in traversing it.

- The two ends would therefore come to be almost identical in their biota (the fauna + the flora); for example, the great continent of Eurasia that links western Europe to China has acted as a corridor for the dispersal of animals and plants.

Spreading pathway

- **Filter**: a region may contain a more limited variety of habitats, so that only those organisms that can exist in these habitats will be able to disperse through it.
- i.e. Peculiar tropical lowlands of Central America provide a good example. Not all types of animal and plant are able to traverse this type of terrain.



No connectivity | **Connectivity via corridor** | **Connectivity via crossing**

Spreading pathway

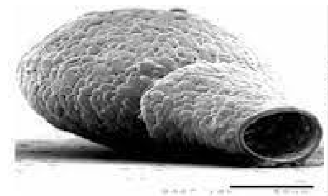
- **Sweepstakes route:** is a pathway for accidental, infrequent, and random dispersal of a species across a major barrier, such as an ocean

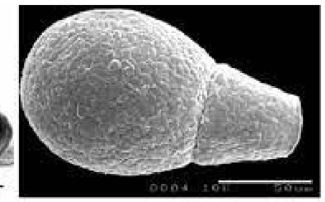
i.e. Islands, the specially adapted biota of a high mountain peak, of a cave or of a large

- The chances of such a dispersal are therefore extremely low, and largely due to chance combinations of favourable circumstances, such as high winds or floating rafts of vegetation.

The example of the Iguana sp.

The case of the Testate Amoeba





- Small organisms tend to be cosmopolitan
- Due to their small size, the problems of finding them and the difficulties involved in identifying testate amoebae.
- This is not a species that has highly specific requirements for its habitat.

one feature that links all the regions occupied by *N. vas* is the fact that they were once part of a huge supercontinent called Gondwana

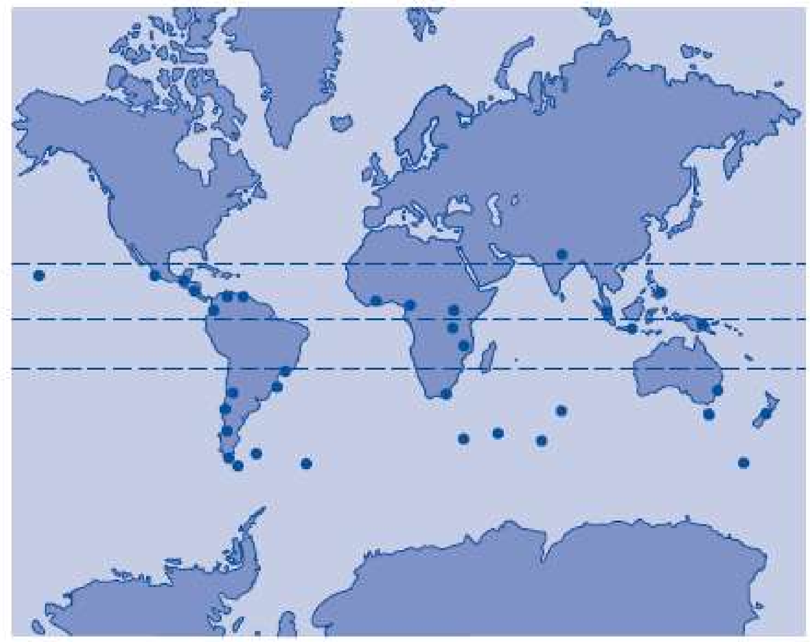


Figure 2.19 Locations around the world where the testate amoeba *Nebela vas* has been recorded. Note its predominantly Southern Hemisphere and tropical distribution. This may be explained by former linkage of the land masses in the supercontinent of Gondwana. From Smith and Wilkinson [23]. (Reproduced with permission of John Wiley & Sons.)

Climatic Relicts

- Animals widely distributed in the past and today restricted in smaller areas called **climatic relicts**.
- The Northern Hemisphere has an interesting group of **glacial relict** species
- Many species that were adapted to cold conditions at that time had distributions to the south of the ice sheets almost as far as the Mediterranean in Europe.
- Now that these areas are much warmer, such species survive there only in the coldest places (high altitudes in mountain ranges) and the greater part of their distribution lies far to the north in Scandinavia, Scotland or Iceland
- In some cases, species even appear to have become extinct in northern regions and are represented now only by **relict populations** at high altitude in the south, such as in the Alpine ranges.
- The places where relicts have managed to survive through a time of stress are called **refugia**

Springtail *Tetracanthella arctica* (Collembola).

- common in the soils of Iceland and Svalbard, and it has also been found further west in Greenland and a few places in Arctic Canada.
- Outside these truly Arctic regions it is known to occur in only two locations – in the Pyrenean Mountains between France and Spain, and in the Tatra Mountains on the borders of Poland and Slovakia.
- *T. arctica* has not been found at high altitudes in the Alps (perhaps it has simply not yet been noticed, or perhaps it used to occur there but has since died out).

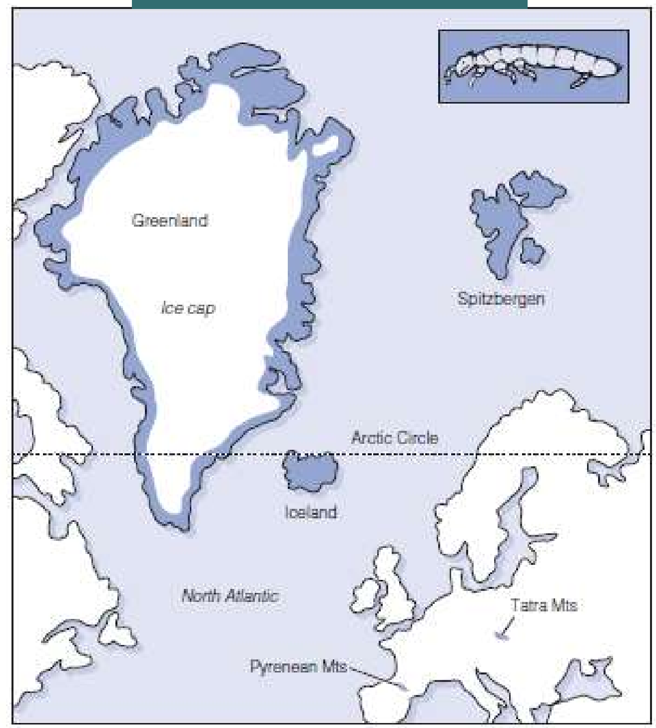


Figure 2.20 The springtail *Tetracanthella arctica*, and a map of its distribution. It is found mostly in northern regions, but populations exist in the Pyrenees and in mountains in central Europe. These populations were isolated at these cold, high altitudes when the ice sheet retreated northward at the end of the Ice Age.

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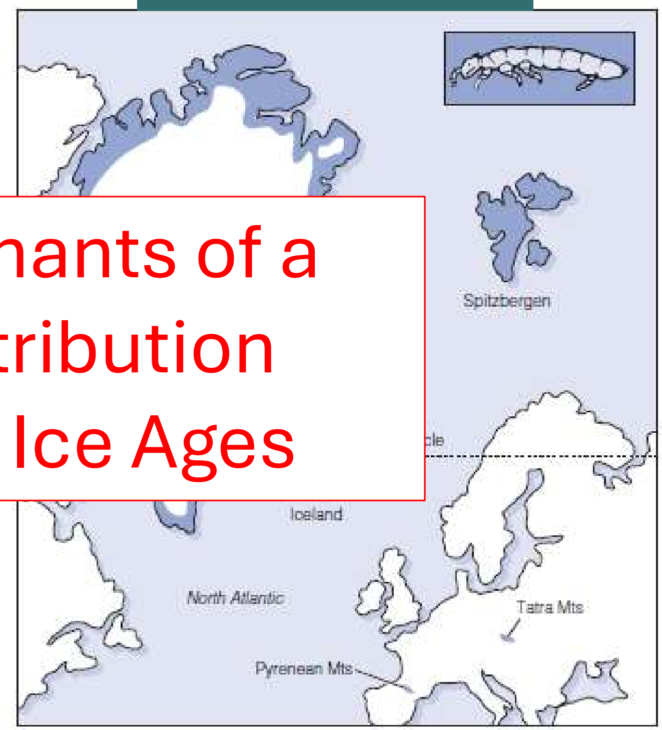
It is likely a remnants of a much wider distribution in Europe in the Ice Ages



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Displaced dung beetle

Concept Box 2.1

One very remarkable example of a glacial relict is the dung beetle species *Aphodius holdereri* (Figure 2.22). This beetle is now restricted to the high Tibetan plateau (3000–5000 m), and its southern limit is the northern slopes of the Himalayas. In 1973, G. Russell Coope, of London University, found the fossil remains of at least 150 individuals of this species in a peaty deposit from a gravel pit in southern England [28]. The deposit dated from the middle of the last glaciation. Subsequently 14 sites have yielded remains of this species in Britain, all dated between 25 000 and 40 000 years ago. Evidently, *A. holdereri* was then a geographically widespread species, possibly ranging right through Europe and Asia, but climatic changes, especially the warmer conditions of the last 10 000 years, have severely restricted the availability of suitable habitats for its survival. Only the remote Tibetan mountains now provide *A. holdereri* with the extreme climatic conditions within which it is able to survive, free from the competition of more temperate species of dung beetle.

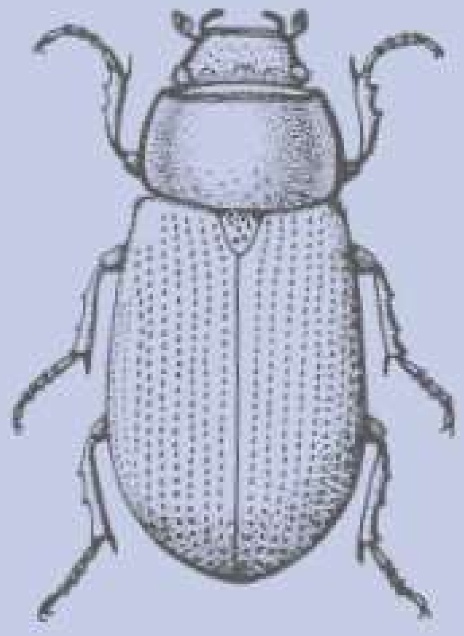


Figure 2.22 *Aphodius holdereri*, a dung beetle now found only in the high plateau of Tibet but which has been found fossilized as far west as Great Britain.

Lusitanian species (example of disjunct distribution)

- Plants and animals native to the Iberian Peninsula, but also found in other isolated areas, particularly in southwestern of Ireland

Kerry slug (*Geomalacus maculosus*)

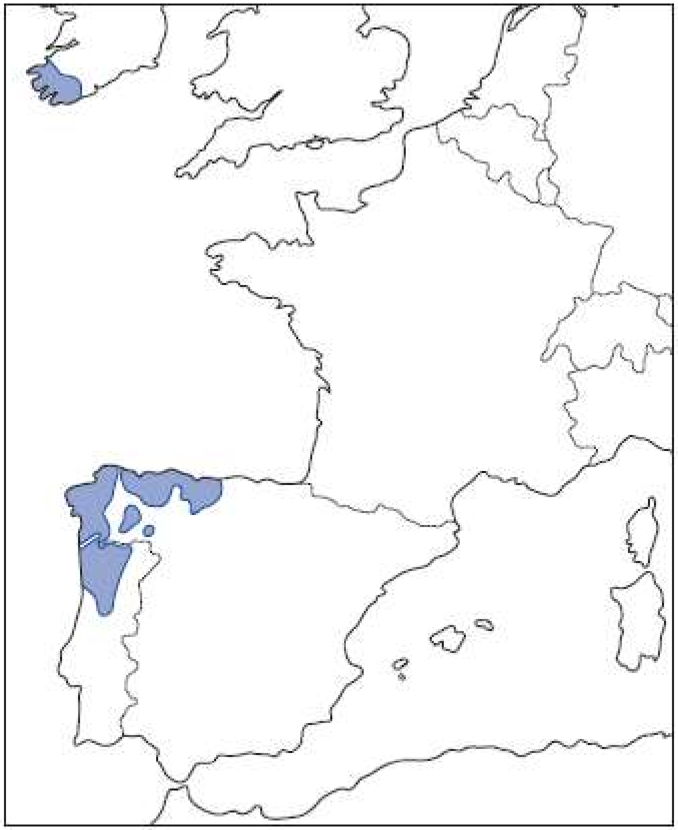


Figure 2.24 Distribution of the Kerry slug in western Europe. Like the strawberry tree, it is a Lusitanian species that is likely to have spread north following the retreat of the glaciers some 10 000 years ago, assisted by much lower sea levels at that time. Rising sea levels have now obliterated any intervening populations. Adapted from Beebee [31].

- The western gorilla (*Gorilla gorilla*) is found in an area of lowland tropical rainforest in the extreme west of tropical Africa. 2 subspecies: *Gorilla gorilla gorilla* (west of its range), and *Gorilla gorilla diehli* (eastern side of the range).
- The eastern gorilla (*Gorilla beringei*), 2 subspecies: *Gorilla beringei beringei* in the mountains, and *Gorilla beringei graueri* in the eastern lowland forest

Figure 2.25 Distribution map of the gorilla (*Gorilla* species), a mammalian genus with a disjunct distribution. The two populations are now regarded as distinct species: *Gorilla gorilla*, the western lowland gorilla, and *Gorilla beringei*, the eastern gorilla, which consists of two subspecies, the mountain gorilla (*G. b. beringei*) and the eastern lowland gorilla (*G. b. graueri*).

Topographical Limits and Endemisms

- The longer an area has been isolated, the higher the taxonomic rank of its endemic organisms is likely to be, and vice versa

  - after 2 million years the biota of an isolated area might contain only a few endemic species.

  - after 10 million years, the descendants of these species might be so unlike their nearest relatives in other areas that they might be placed in one or more endemic genera.

  - After 35 million years, these genera might appear to be sufficiently different from their nearest relatives as to be placed in a different family, and so on.

Physical factors

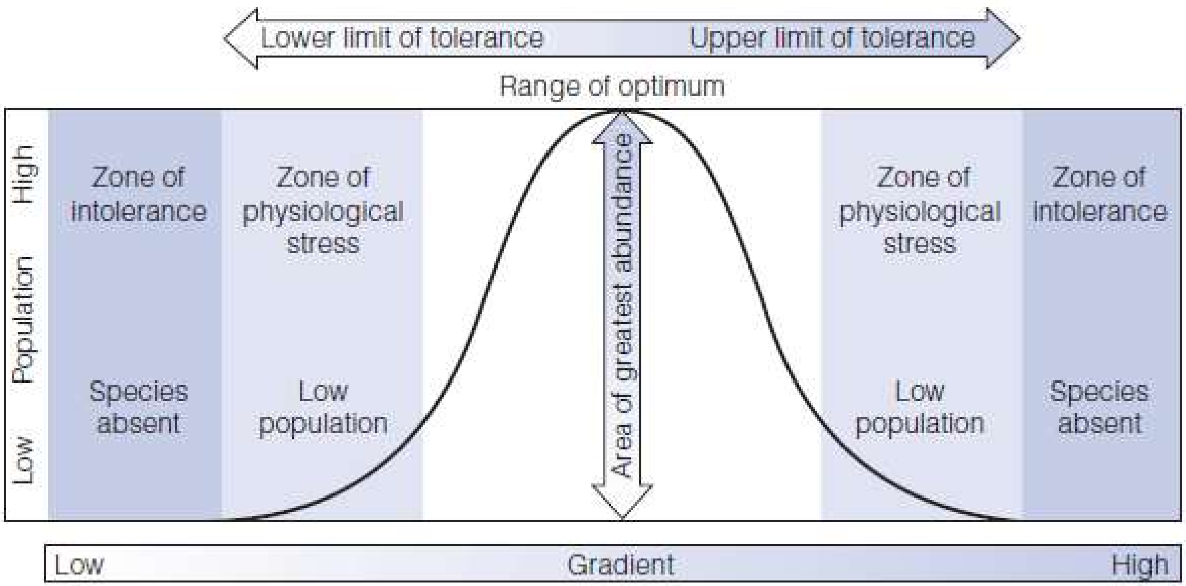


Figure 2.27 Graphic model of the population abundance maintained by a species of animal or plant along a gradient of a physical factor in its environment.

Limiting Factors

Birds have their limits

Concept Box 2.2

Even mobile animals, like birds, may have their distributions closely linked to temperature, as in the case of the eastern phoebe (*Sayornis phoebe*), a migratory bird of eastern and central North America. Analysing data collected by ornithologists of the National Audubon Society, ecologist Terry Root has been able to check the winter distribution of this bird against climatic conditions [37]. She found that the wintering population of the eastern phoebe was confined to that part of the United States in which the mean minimum January temperature exceeded –4°C. The very close correspondence of the bird's winter range to this isotherm, shown in Figure 2.29, probably relates to the energy balance of the birds. Warm-blooded animals, such as birds, use up large quantities of energy to maintain their high blood temperature, and in cold conditions they can lose a great deal of energy in this way, which means they therefore have to eat more. Terry Root found that birds in general do not occupy regions where low temperature forces them to raise their resting metabolic rate (i.e. their energy consumption) by a factor of more than 2.5. In the case of the eastern phoebe, this critical point is reached when the temperature falls below –4°C, so the bird fails to occupy colder regions. Other birds have different temperature limits because they have different efficiencies in their heat generation and conservation, but they still seem to draw the line at raising their resting metabolism by a factor of more than 2.5.

Figure 2.29 Northern boundary (solid line) of the distribution of the eastern phoebe (*Sayornis phoebe*) in North America in December and January, compared with the –4 °C January minimum isotherm (dashed line). From Root [37].

Zonation

True freshwater species

Moderate tolerance of saltwater

Estuarine species

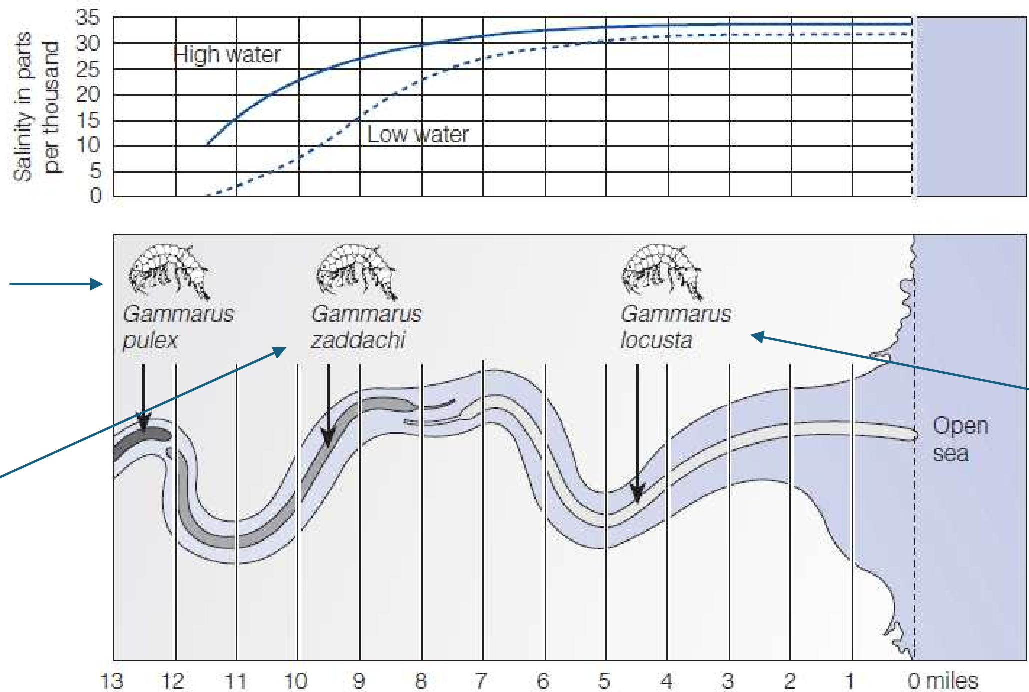
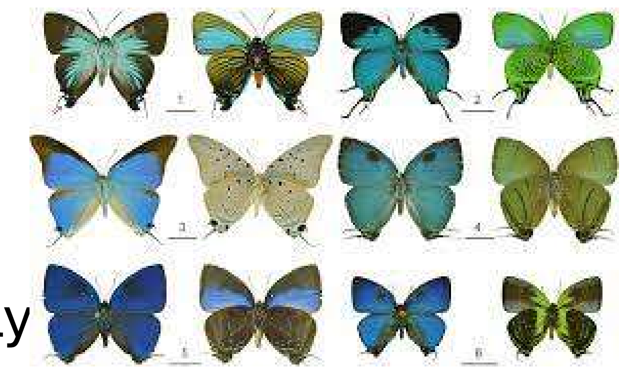


Figure 2.32 Distribution along a river of three closely related species of amphipod (Crustacea), relative to the concentration of salt in the water. *Gammarus locusta* is an estuarine species and is found in regions where the salt concentration does not fall below about 25 parts per thousand (ppt). *Gammarus zaddachi* is a species with a moderate tolerance of saltwater and is found along a stretch of water between 11 and 19 km (8–12 miles) from the river mouth, where salt concentrations average 10–20 ppt. *Gammarus pulex* is a true freshwater species and does not occur at all in parts of the river showing any influence of the tide or saltwater. From Spooner [41].

Species Interaction: a Case of the Blues

- One species may depend strictly on another for food

  i.e. blue butterflies (Lycaenidae)



- 5000 species They are found in both the Old and New Worlds. Several of the species of blue butterfly have complex relationships with other organisms

Example 1

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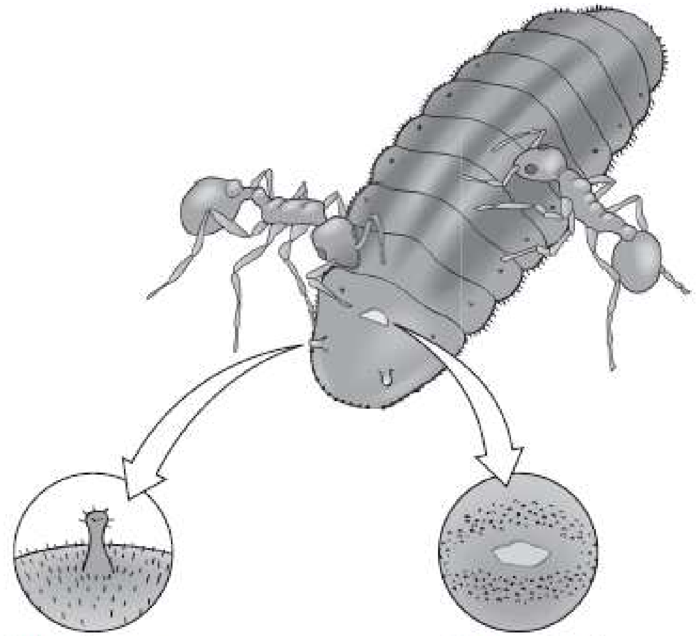

Figure 2.33 Ants attending the caterpillar of an Adonis blue butterfly. Also shown are the two types of gland, the tentacle organ that secretes volatile attractants, and the honey gland that secretes honeydew. After Thomas and Lewington [43]. (Reproduced with permission of Bloomsbury Publishing plc.)

Example 2

the large blue (*Maculinea arion)*

- It is found from Scandinavia, to Spain, and Italy

and Greece, and Russia and Siberia, Mongolia, China and Japan.

- The larvae feed on various species of wild thyme (*Thymus spp*.), which between them cover a very wide range of geology and habitat, from acid to alkaline.
- its caterpillars have a honey gland that secretes honeydew and this is attractive to ants, but in this case it is just one genus of red ant, Myrmica, that takes charge of them

Competition

Chthamalus stellatus

- It is found in the upper zone of the shore
- larvae settle over the upper part of the shore above mean tide level.

Balanus balanoides

-It occupies a wider zone, down to the low-water mark
-larvae settled between high and low water,
including the area occupied by the adults of *C. stellatus*

Reducing competition

- Considerable advantage in avoiding competition, whether with other species or other member of its own species.

→species with similar food or space requirements exploit the same resources at different seasons of the year, or even at different times of day.

To avoid direct competition!

Temporal separation

vs

i.e. Many species of owl hunt at night, judging the location of their prey mostly by ear, whereas the hawks and falcons are daytime hunters with extremely keen eyesight, especially adapted for judging distances accurately

Temporal separation

i.e. [2] bats are night-active insectivores, avoiding competition for prey with insectivorous birds during the day, and also avoiding the predatory attention of day-active hawks and falcons.

Spatial separation

- the resources of a habitat are divided up by the restriction of each species to only part of the available area, to specialized microhabitats.
- It means that each species must be adapted to live within the fixed set of physical conditions of its particular microhabitat.
- It also means that such a species is not as well adapted to live in other microhabitats, and may find it difficult to invade them even if they were for some reason vacant and their food resources untapped.

- the oystercatcher (*Haematopus ostralegus*) has a strong predilection for the bivalve mollusc *Cerastoderma edulis*, the common cockle, and this is found mainly on sandy and muddy shores just below the mean high-water mark of neap tides. →Therefore, this is the favourite feeding zone of the oystercatcher

- the mud-dwelling crustacean *Corophium volutator* is a favoured food species for the redshank (*Tringa totanus*), and, because it thrives best in the upper regions of mudflats, usually above the mean high-water mark of neap tides, this is often where large numbers of feeding redshanks can be found.

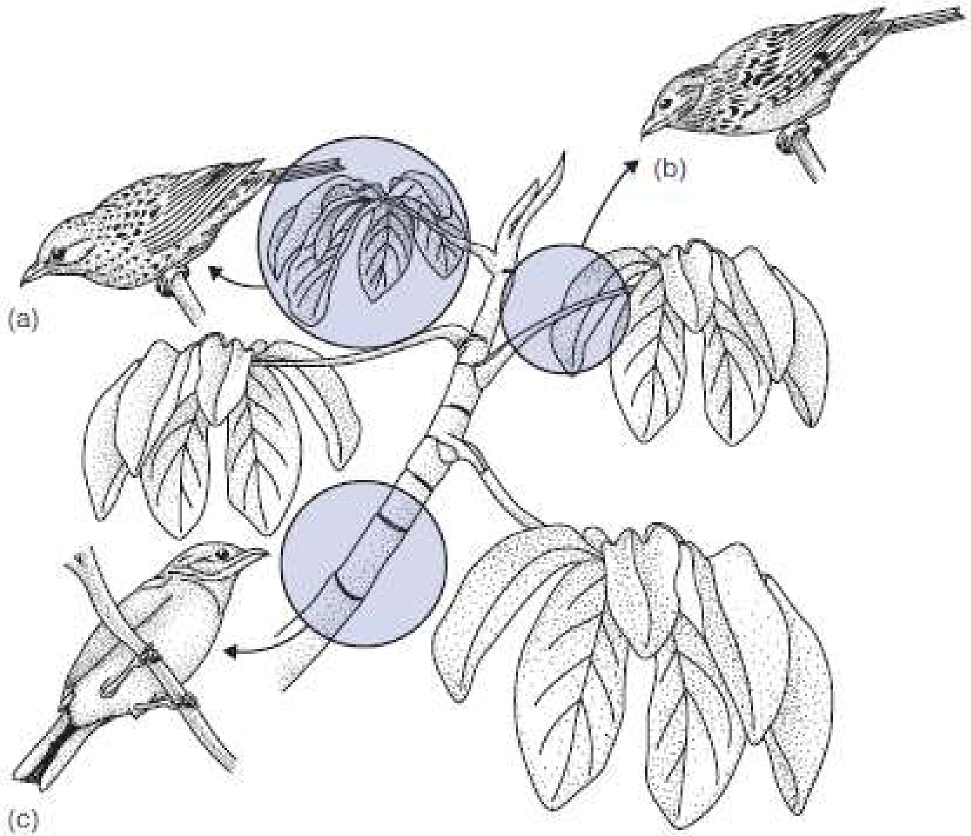

Figure 2.37 Three species of tanager that coexist in the same forest on the island of Trinidad in the West Indies. All feed on insects, but they exploit different microhabitats within the canopy and thus avoid direct competition. (a) The speckled tanager takes insects from the underside of leaves; (b) the turquoise tanager obtains its insects from fine twigs and leaf petioles; and (c) the bay-headed tanager preys upon insects on the main branches.

(a) the speckled tanager (*Tangara guttata*)

(b) the bay-headed tanager (*Tangara gyrola*)

(c) the turquoise tanager (*Tangara mexicana*)

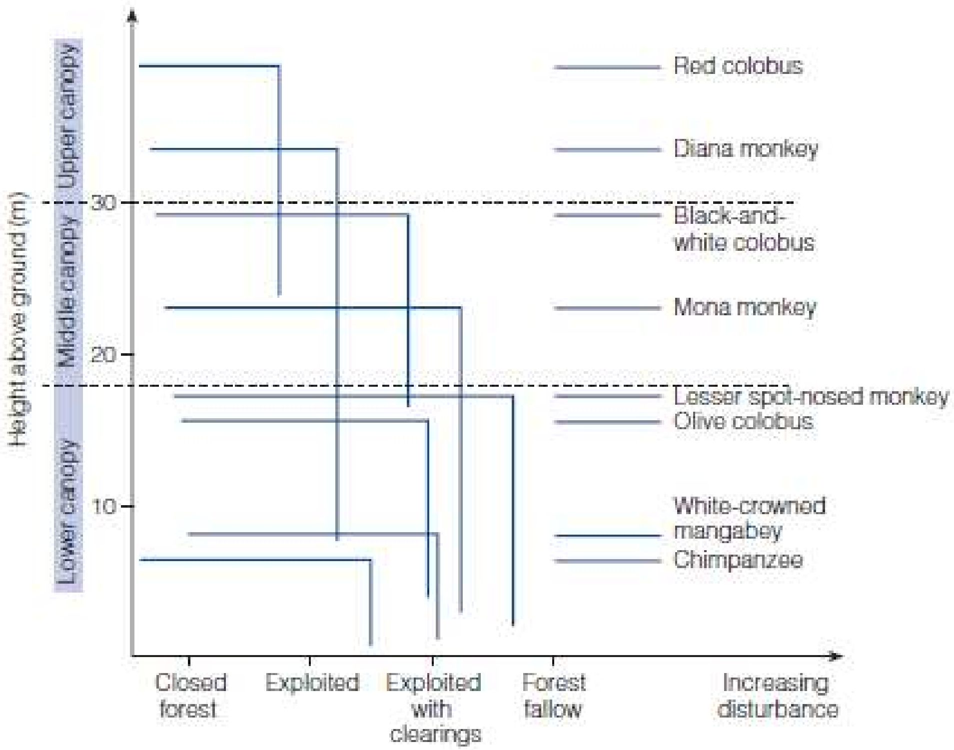

Figure 2.38 Diagram to illustrate the limits to different niche requirements of a range of primate species in the tropical forest of West Africa in relation to canopy height and degree of human disturbance. Each species indicated occupies the space below and to the left of the lines. Although the demands of the various species overlap, each has a particular height in the canopy or a type of site where it is most efficient as a competitor, and therefore more successful. From Martin [49].

Predators and Prey

- Experimentally: predators sometimes eat all the representatives of a species in their environment, particularly when the species is already rare.
- In reality: it is not in the interests of predatory species to eliminate a prey species, because if they do this they destroy a potential source of food.
- No species is preyed upon too heavily, and the predators can always turn to alternative food species if the numbers of their usual prey should be reduced by climatic or other influences (**prey switching**)

Prey switching of this type has been described on the island of Newfoundland, where the grey wolf (*Canis lupus*) and the lynx (*Lynx lynx*) were major predators in the 19th century, but where the wolf is now extinct as a result of human persecution.

The lynx was a rare animal until a new potential prey animal was introduced to the island in 1864, namely, the snowshoe hare (*Lepus americanus*).

The hares multiplied rapidly, and so did the lynxes in response to the newly available food source.

- The snowshoe hare population crashed to low levels in 1915 and the lynx, faced with starvation, switched its attentions to caribou calves, which had once been a major food source for the wolf.
- The snowshoe hare has now developed a 10-year cycle of high and low population levels, and the lynx has continued to switch between hare and caribou depending upon whether the former is in a peak or a trough

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Parasites and Hosts

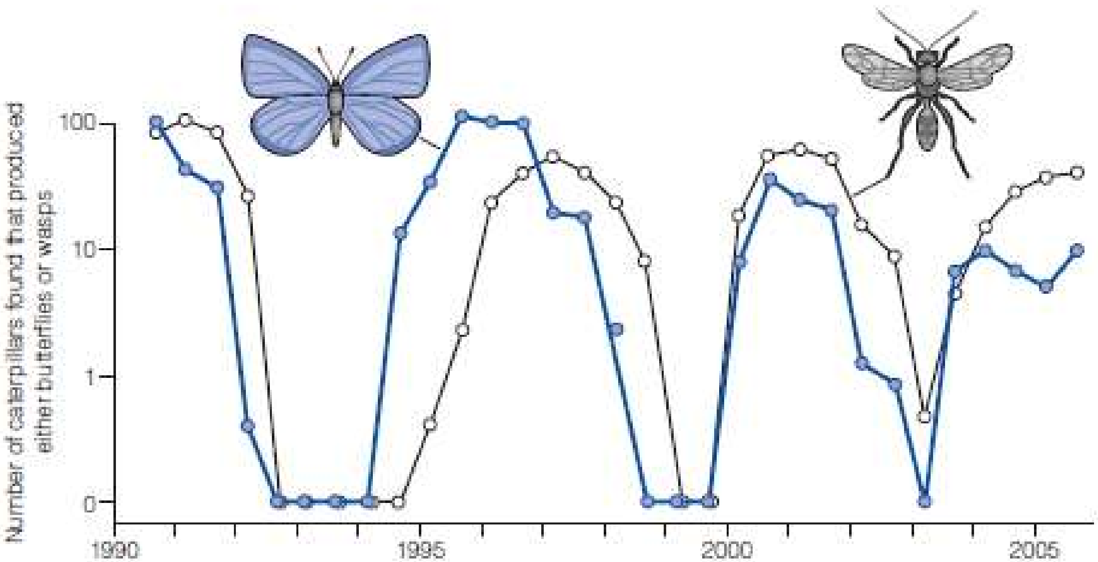


Figure 2.35 Cyclic population fluctuations in the holly blue butterfly and the parasitoid wasp *Listrodomus nycthemerus*. The butterfly population tends to peak every 2–3 years while the wasp population is low. From Thomas and Lewington [43]. (Reproduced with permission of Bloomsbury Publishing plc.)

Although parasitism causes a collapse in the butterfly population, this is only temporary and recovery takes place after the collapse of the parasite population, creating a cycle.

Predatory starfish

Many studies of natural communities have confirmed the hypothesis that predators may increase the number of different species that can live in a habitat. The American ecologist Robert T. Paine made an especially fine study on the animal community of a rocky shore on the Pacific coast of North America [55]. The community included 15 species, comprising acorn barnacles, limpets, chitons, mussels, dog whelks and one major predator, the starfish *Pisaster ochraceus*, a generalist which fed on all the other species. Paine carried out an experiment on a small area of the shore in which he removed all the starfish and prevented any others from entering. Within a few months, 60–80% of the available space in the experimental area was occupied by newly settled barnacles, which began to grow over other species and eliminate them. After a year or so, however, the barnacles themselves began to be crowded out by large numbers of small but rapidly growing mussels, and when the study ended these completely dominated the community, which now consisted of only eight species. The removal of predators thus resulted in the halving of the number of species, and there was additional evidence that the number of plant species of the community (mainly rock-encrusting algae) was also reduced, because of competition from the barnacles and mussels for the available space.

Long distance migration

- Some species travel vast distances to access seasonal food supplies. e.g. terrestrial birds in the Northern Hemisphere migrate northward in spring to take advantage of abundant summer food resources.

- In autumn, they move south to savannahs, where food becomes plentiful following the rainy season.

- Thus, long-distance migration often enables species, such as swallows, to alternate between regions that provide abundant resources, but only for limited periods.

Migration


Latitudinal movements of animals in order to take advantage of long summer days and high productivity in the high latitudes, and then to retreat to lower latitudes to avoid the stresses of the winter season.

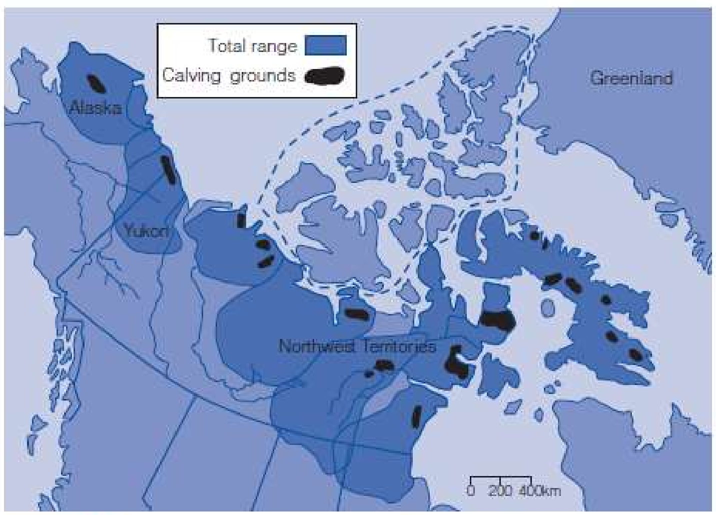


Figure 2.39 Ranges of caribou herds in North America, also showing their calving grounds to which they migrate each spring. Caribou are also located on the islands enclosed within the dashed line. From Sage [59].

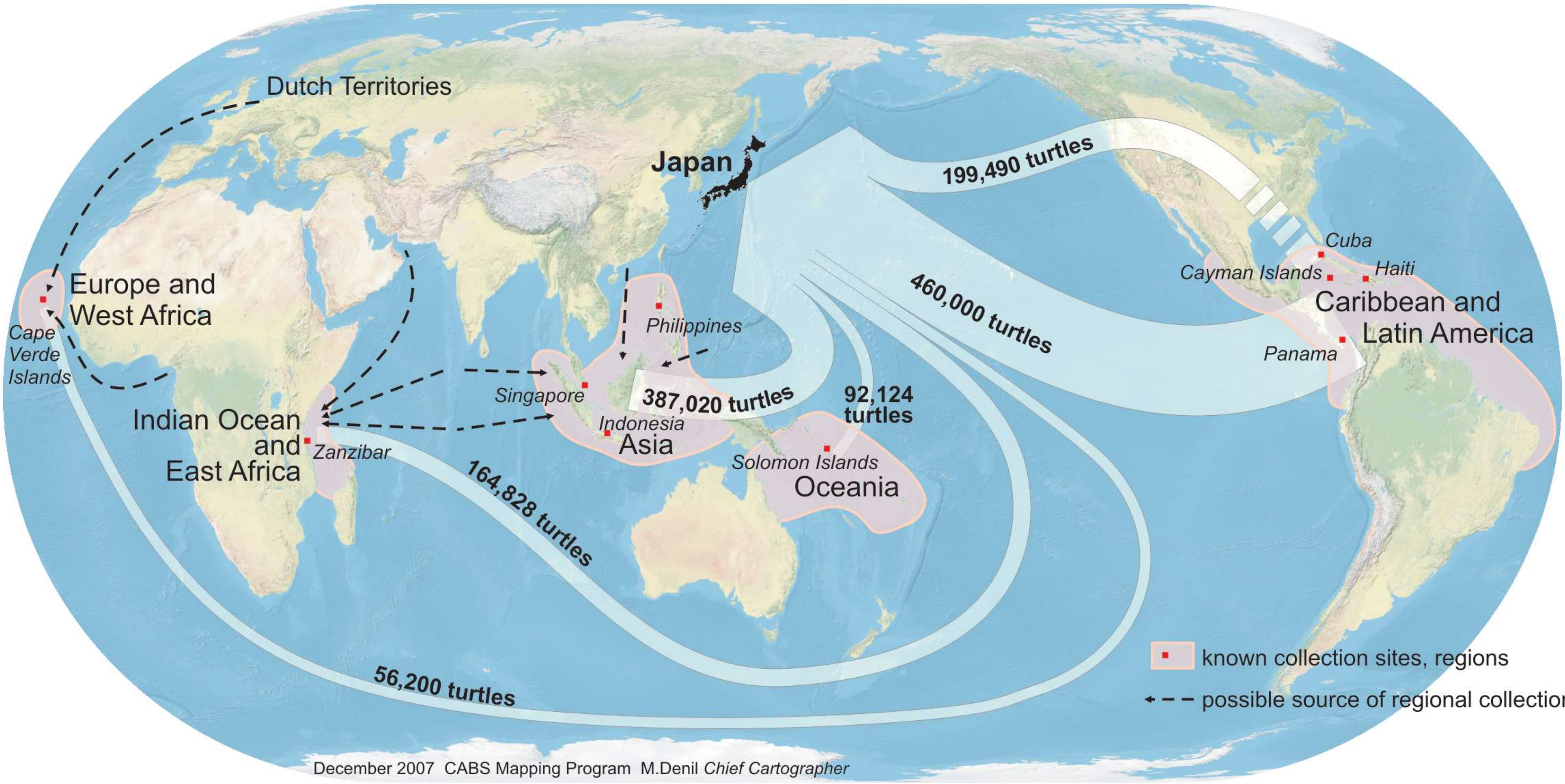
Knowing when to Migrate

❖ How do animals know when it is time to migrate?

- Internal signals, such as hormonal changes, trigger a powerful urge to eat, mate, and reproduce.

- External signal, such as Temperature change, Daylight hours, Scarce food supply

https://www.seaturtlestatus.org/printed-maps



Japanese Bekko Imports by Region, 1950–1992 | From "Trade Routes for Tortoiseshell" in *SWOT Report*, vol. III (2008).

Butterfly migration

- East of the Rocky Mountains, monarchs travel up to an astonishing 3,000 miles to central Mexico, whereas the shorter migration west of the Rockies is to the California coast