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Communication II
Case study: the evolution of the honeybee dance language

Photo Scott Camazine

The honeybee waggle dance

Photo Scott Camazine

Successful forager bee returns to the nest and advertises the location of a profitable flower patch to nest mates

The waggle dance is figure of eight shaped sequence of movements which encodes **distance** and **direction** to food

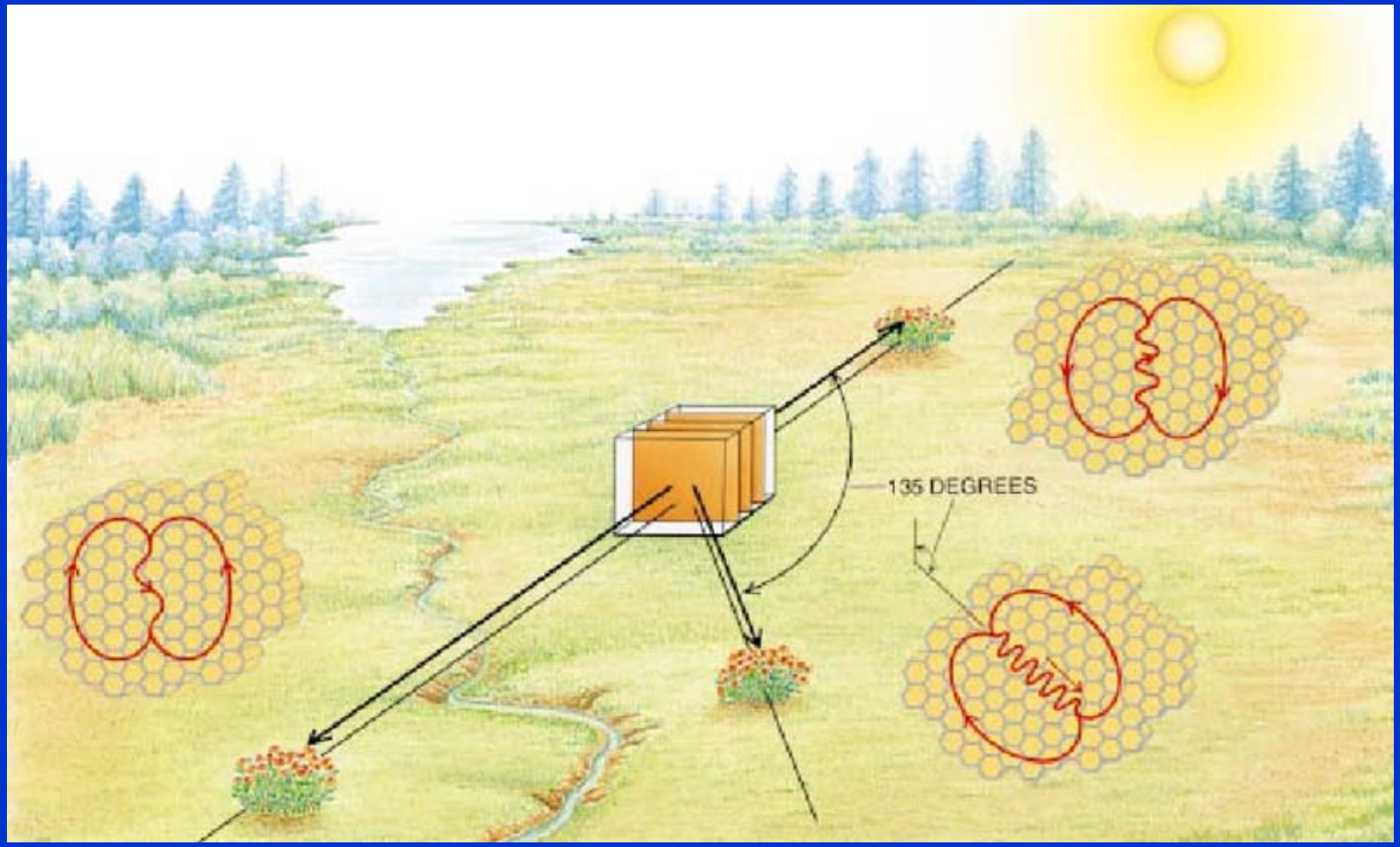
Dance followers soon appear at the location advertised

Decoding the waggle dance

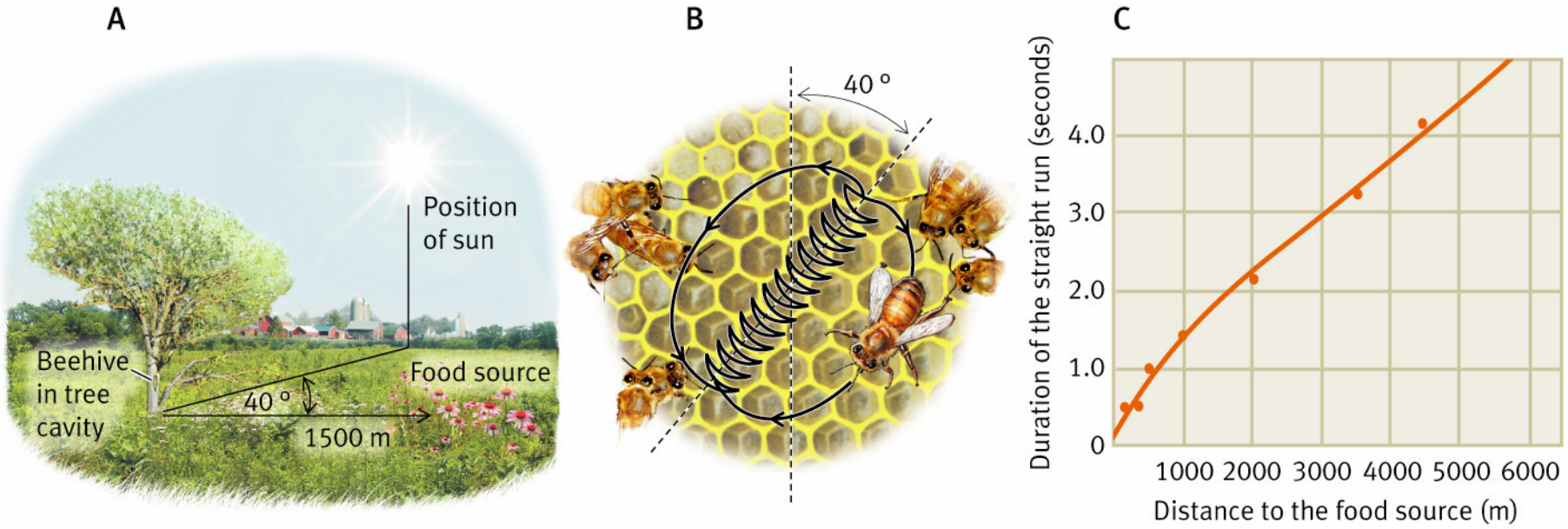
Karl von Frisch
Austrian Ethologist (1886-1982)

von Frisch was a joint winner of 1973 Nobel prize for Physiology for his work (with Tinbergen and Lorenz).

How does the dance encode direction?



How does the dance encode distance?



The duration of the 'waggle run' phase of the dance tells dance followers how far to fly to reach the flower patch

Apis cerana – the Asian hive bee

Sister species to *A. mellifera*

Similar appearance and ecology

Suitable for (hive) domestication

Photos Zachary Huang

Apis dorsata – the giant honeybee (or rock bee)

Workers up to 1 inch long

Nests under rock overhangs, buildings or strong branches

Photos Zachary Huang

Apis florea – the dwarf honeybee

A. dorsata and *A. florea* in comparison

Photos Zachary Huang

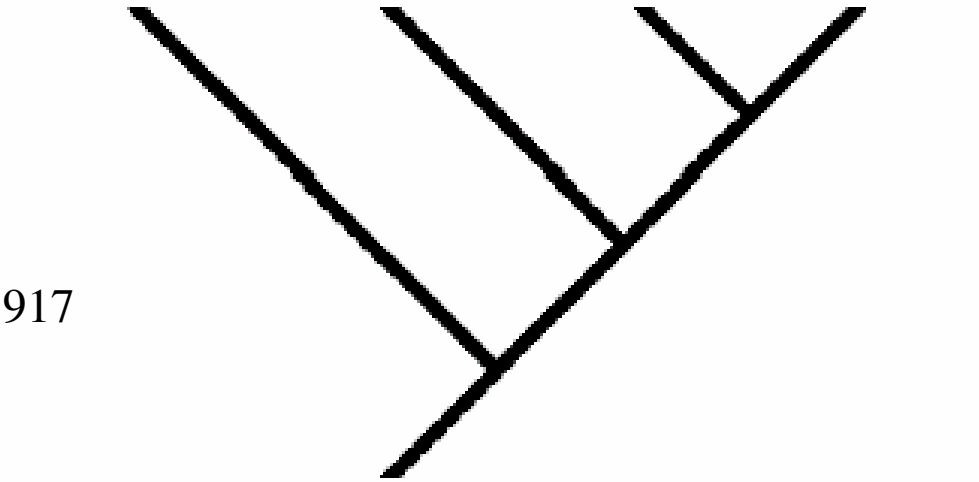
Apis florea (dwarf honeybee) nest

Dances are performed on the horizontal surface, so waggle runs are directly oriented to the food source

Photos Zachary Huang

The evolution of the dance language

	dwarf bees	rock bees	Eastern hive bees	Western hive bee
Typical dance plane	0°-80°	90°	90°	90°
Gravity used	N	Y	Y	Y
Sky cues used	Y	Y	Y	Y
Nest exposure	open	open	cavity	cavity



ANCESTRAL *APIS*

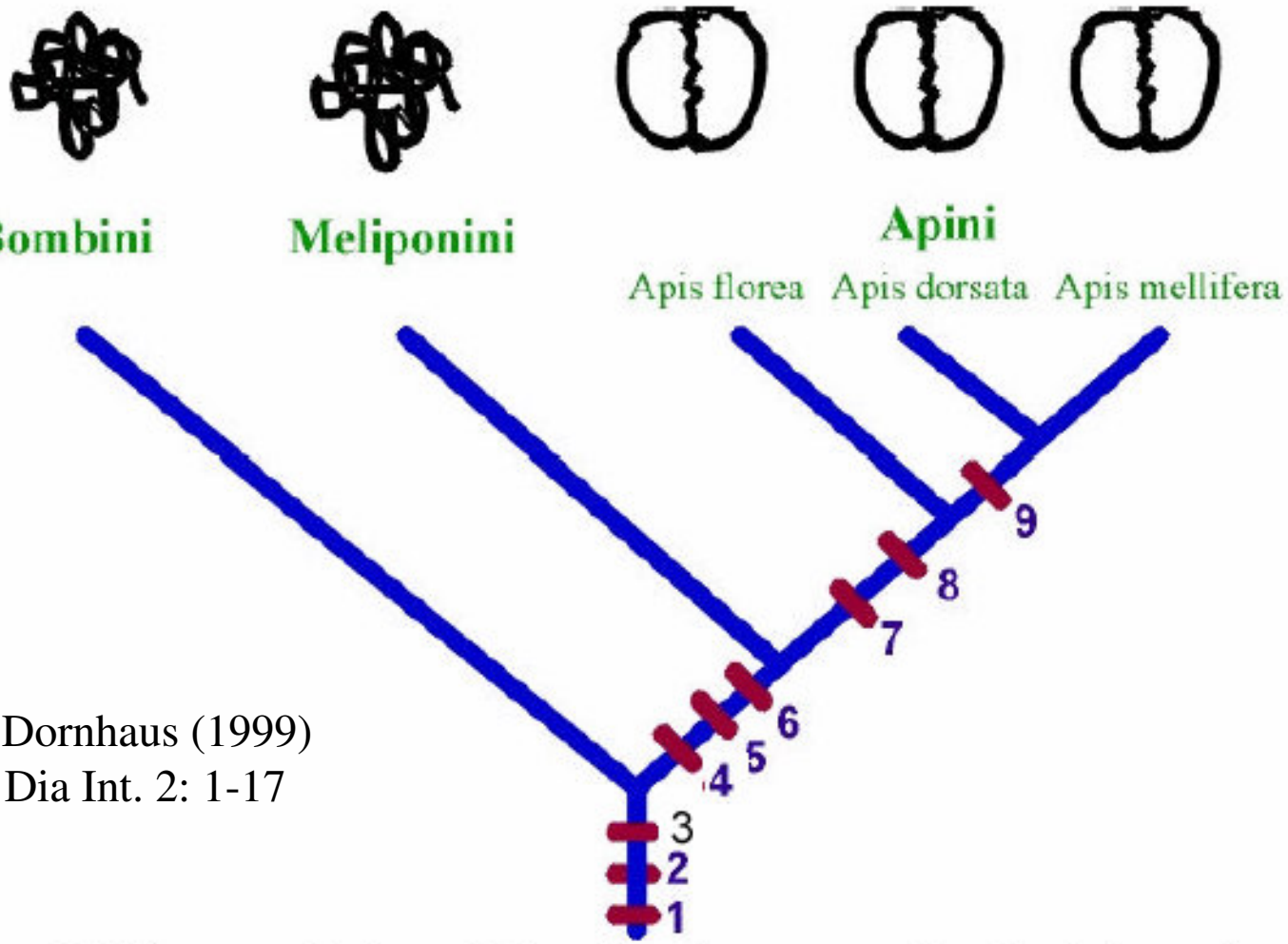
Dyer (2002) Ann Rev Entomol 47: 917

Bumblebee recruitment (*Bombus terrestris*)

Successful forager returns to the nest advertising food

Excited running from 13s to 10min (average 2.6 min)

Dornhaus & Chittka (1999) Nature 401: 38.



Chittka & Dornhaus (1999)
Ciencia al Dia Int. 2: 1-17

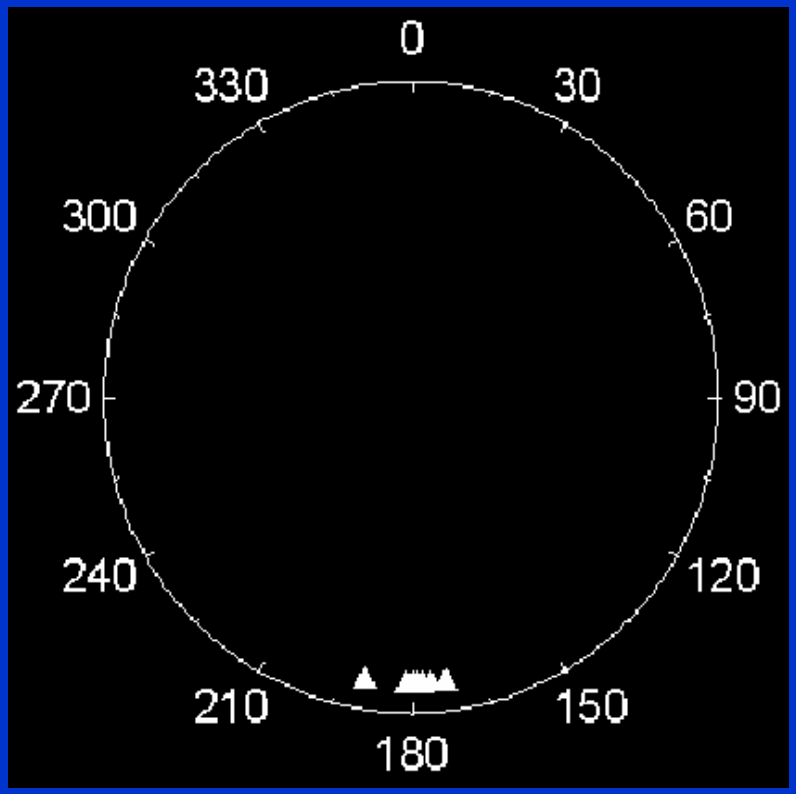
Figure 3: Major events in the evolution of bee dances, mapped on the phylogenetic tree of the eusocial bees. Basic structures of "dances" in various taxa are shown on top. 1. excited runs on the nest by succesful foragers; 2. workers probe nectar that has been brought into the nest; 3. sound/vibration pulses produced by returning foragers; 4. trophallaxis; 5. length of buzzes correlates with distance to food; 6. "dance"-following, or at least "turning responses" towards the successful forager; 7. figure-eight waggle dance pattern; 8. dance performed on horizontal surface; 9. waggle dance performed on vertical combs.

How can we measure the adaptive benefits of communication?

‘Jamming’ the information content of the waggle dance

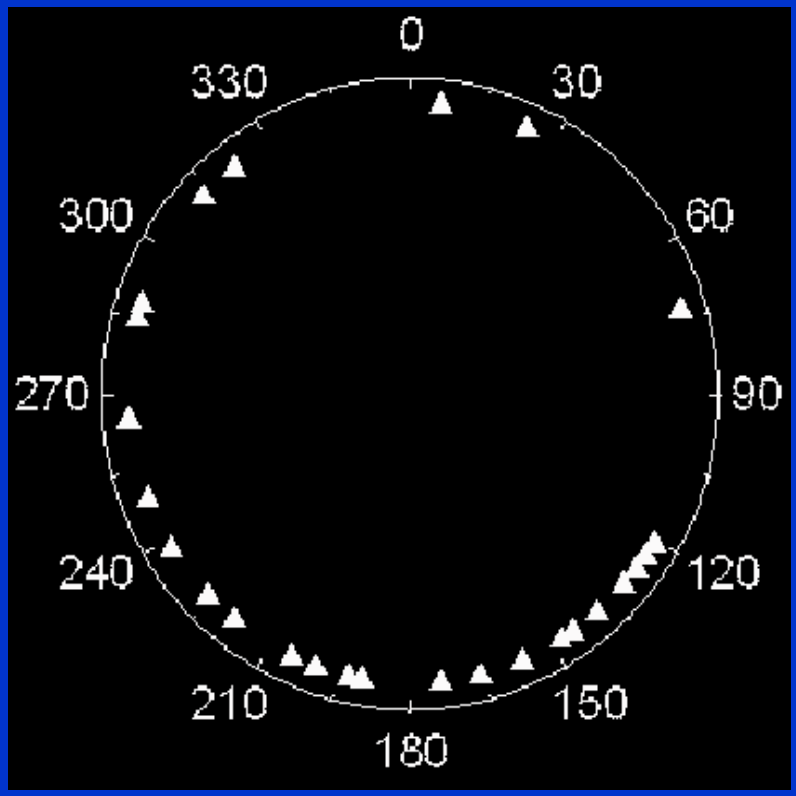
Oriented dances require light on horizontal comb

Light cue available



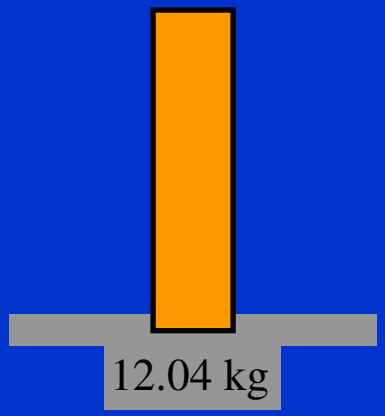
Oriented dance

No light



Disoriented dance

Measuring foraging success

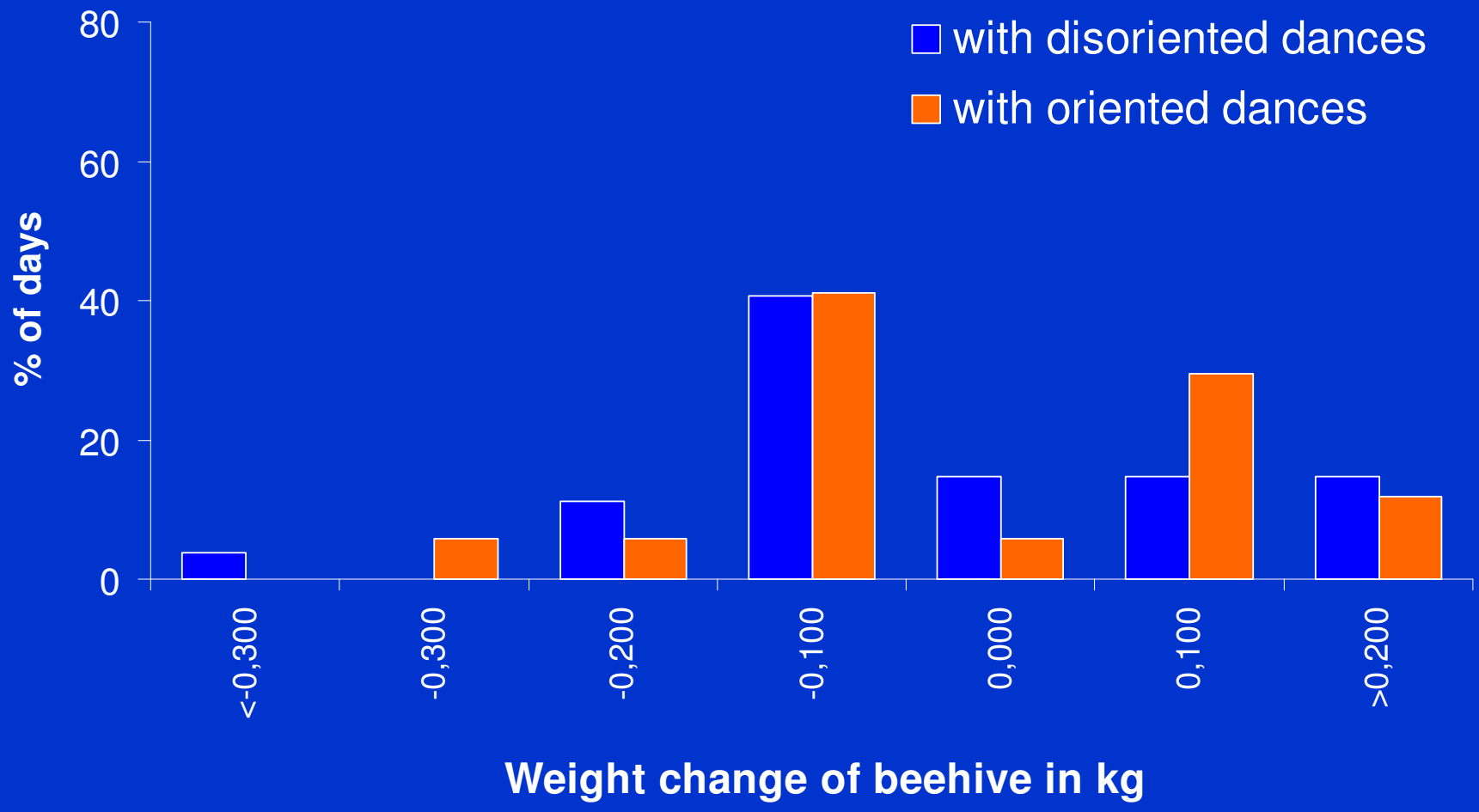


Daily weight changes of a beehive can be measured on a scale - this reflects mostly nectar intake (i.e. foraging success)

Colonies given light or no light on alternating days: hence on some days bees follow disoriented dances.

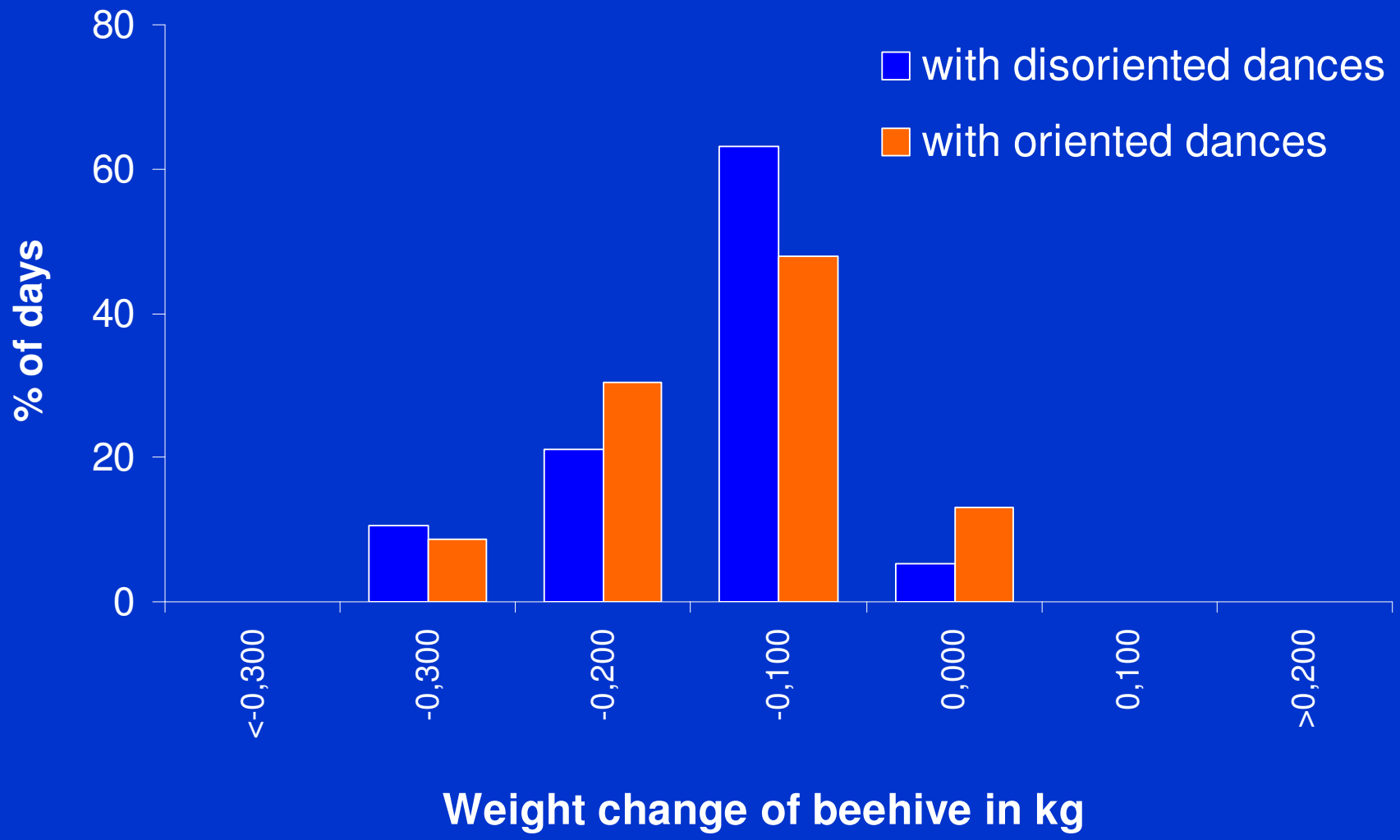
Prediction: foraging success should be lower on days in which bees following disoriented dances

Temperate habitat (Central Europe)



Dornhaus & Chittka (2004) Behav Ecol Sociobiol 55: 395

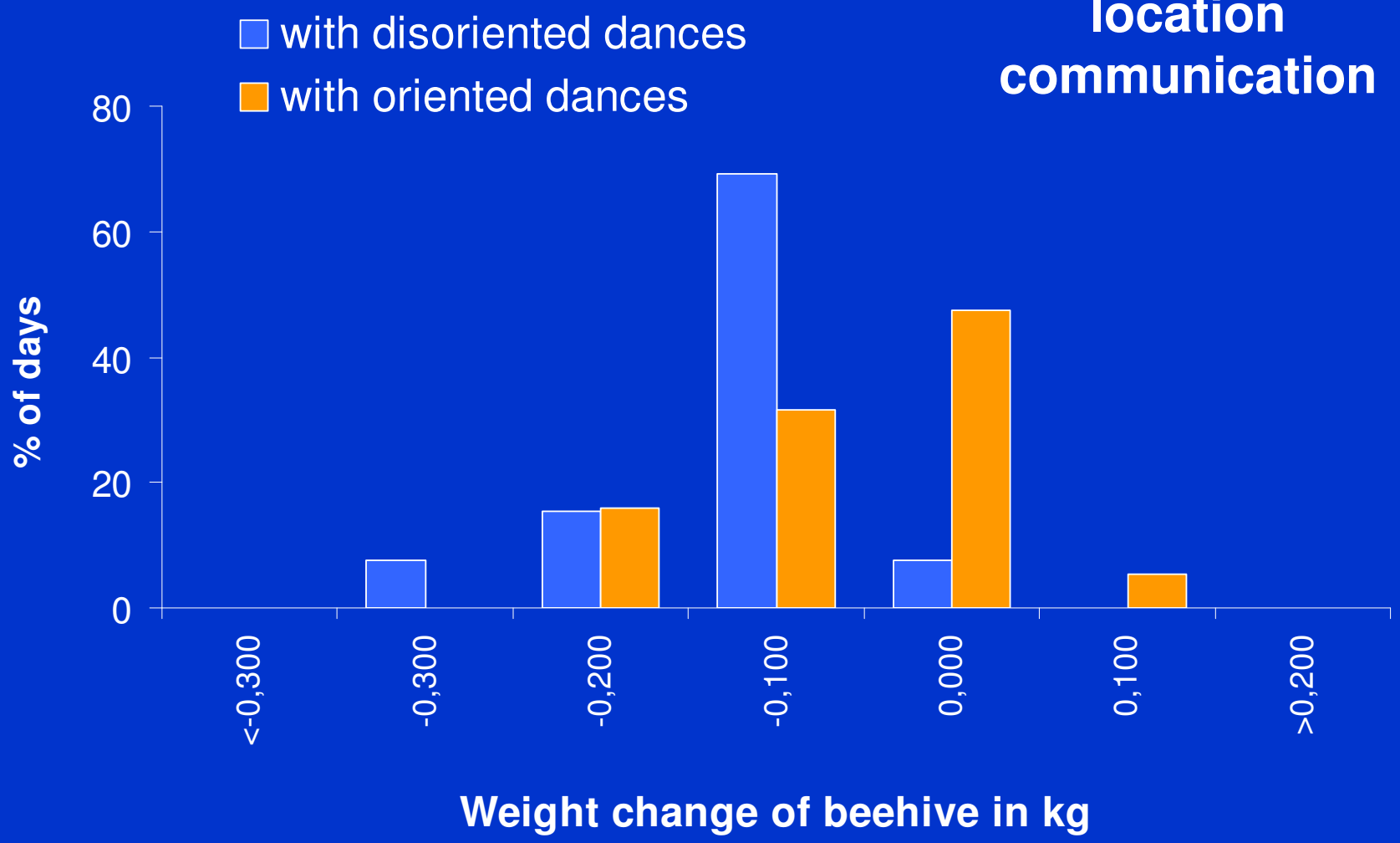
Temperate habitat (Mediterranean)



Dornhaus & Chittka (2004) Behav Ecol Sociobiol 55: 395

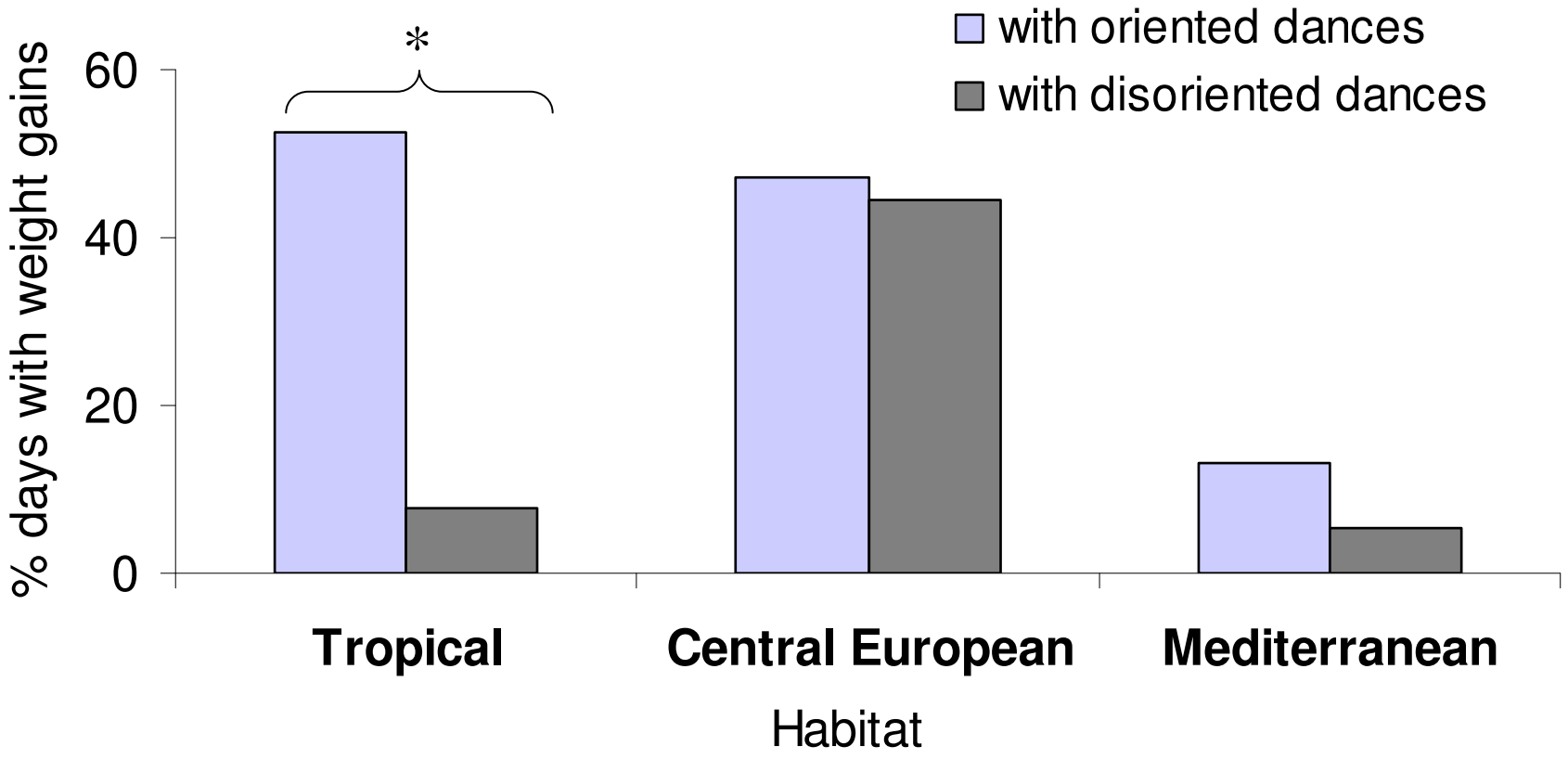
Tropical habitat (India)

- days of high nectar intake are missing without location communication



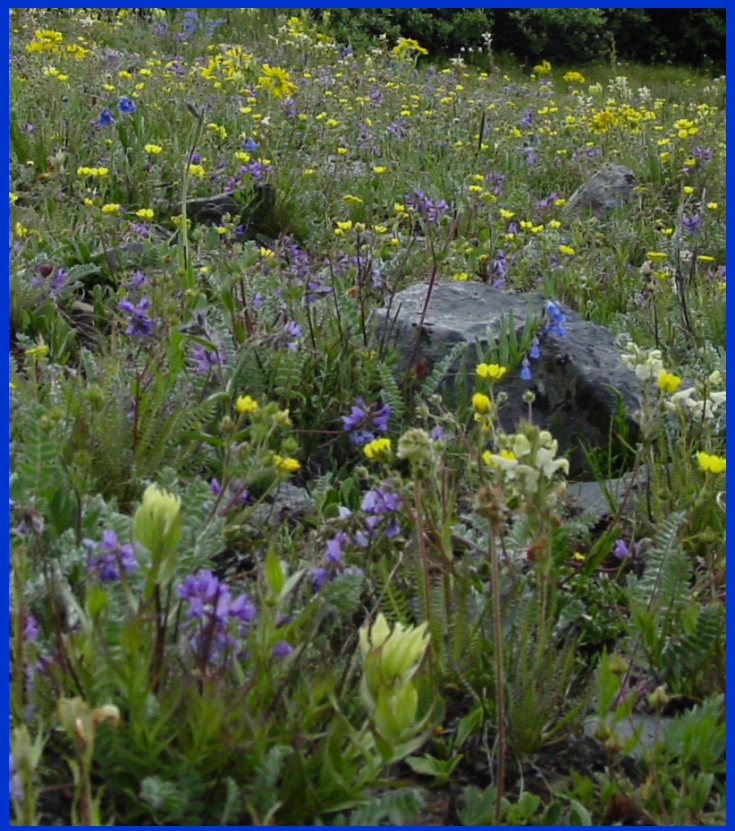
Dornhaus & Chittka (2004) Behav Ecol Sociobiol 55: 395

Benefits of dance communication are limited to the tropical habitat



Dornhaus & Chittka (2004) Apidologie 35: 183

Flower distribution

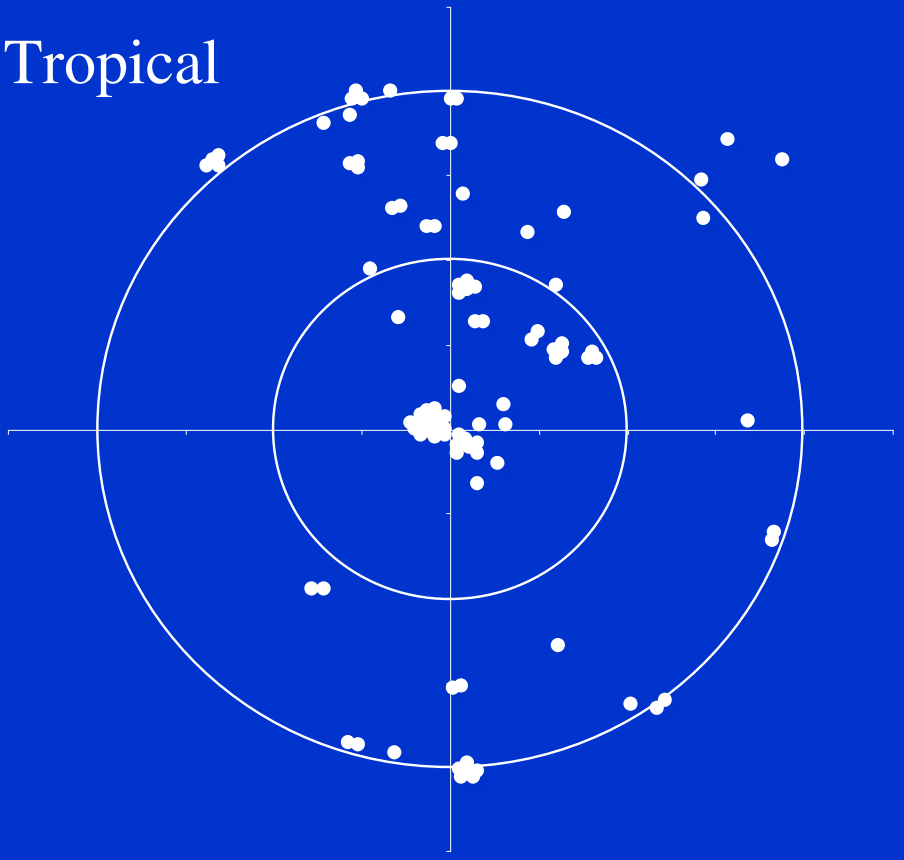


temperate habitats

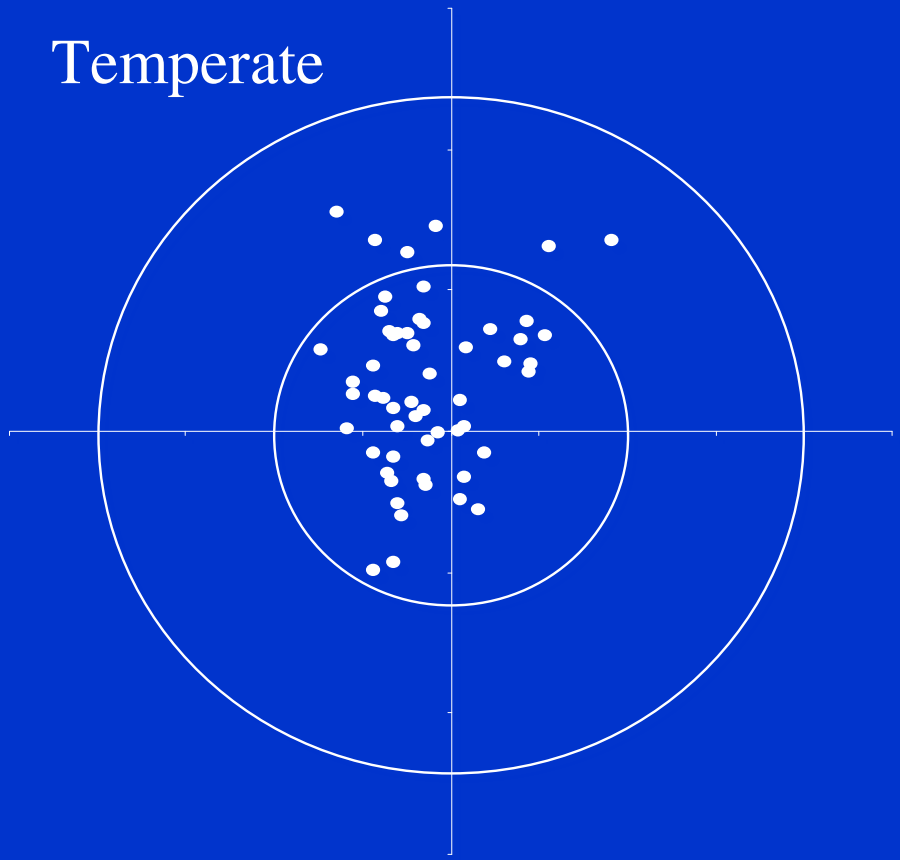
tropical habitats

Dance maps showing aggregation of flower patches

Tropical



Temperate

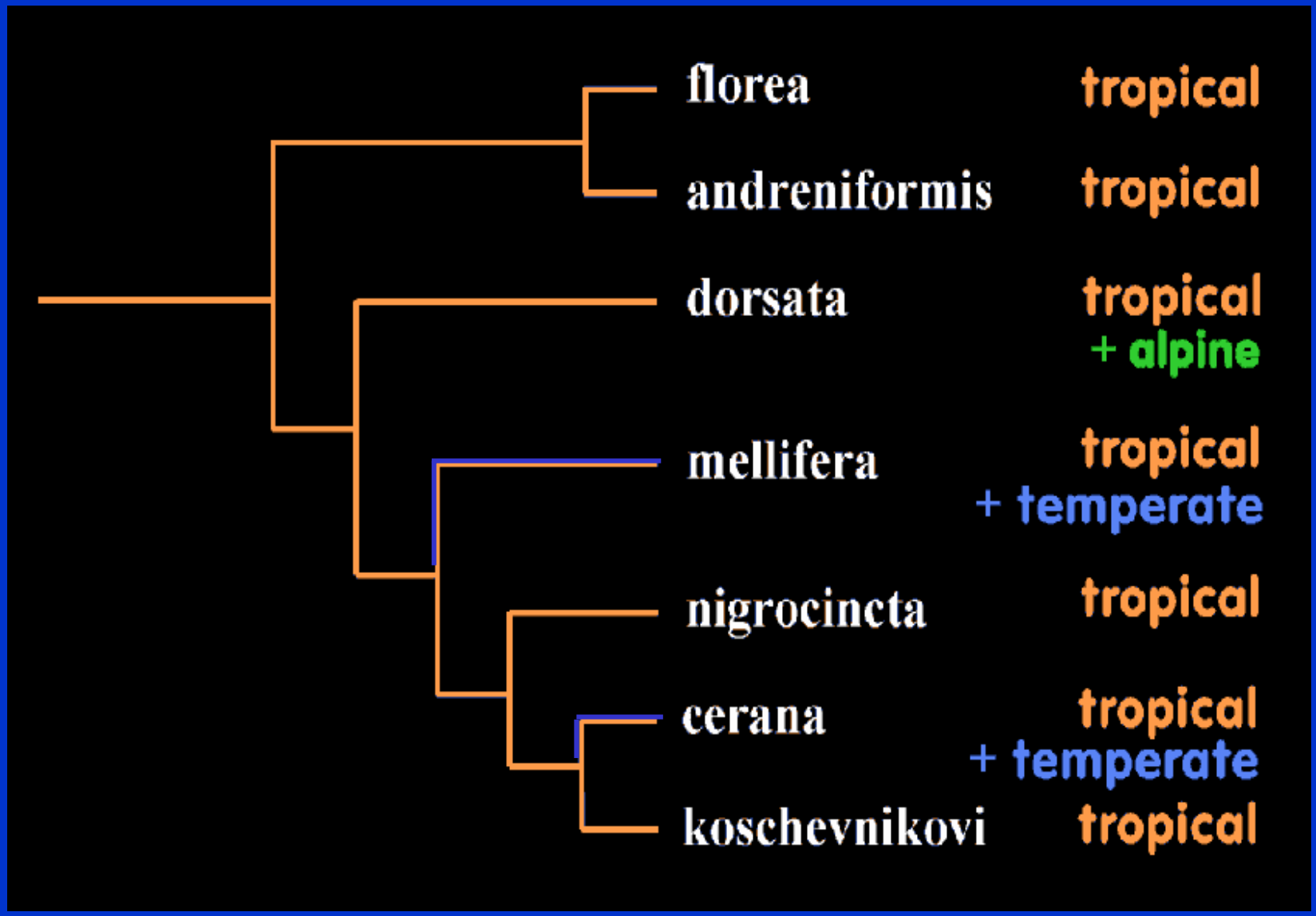


Foraging sites much more clumped in tropical forest

More even spread of foraging locations in temperate habitat

Dornhaus & Chittka (2004) Behav Ecol Sociobiol 55: 395

The honeybees originated in tropical Asia



Some species have since adapted to more temperate habitats