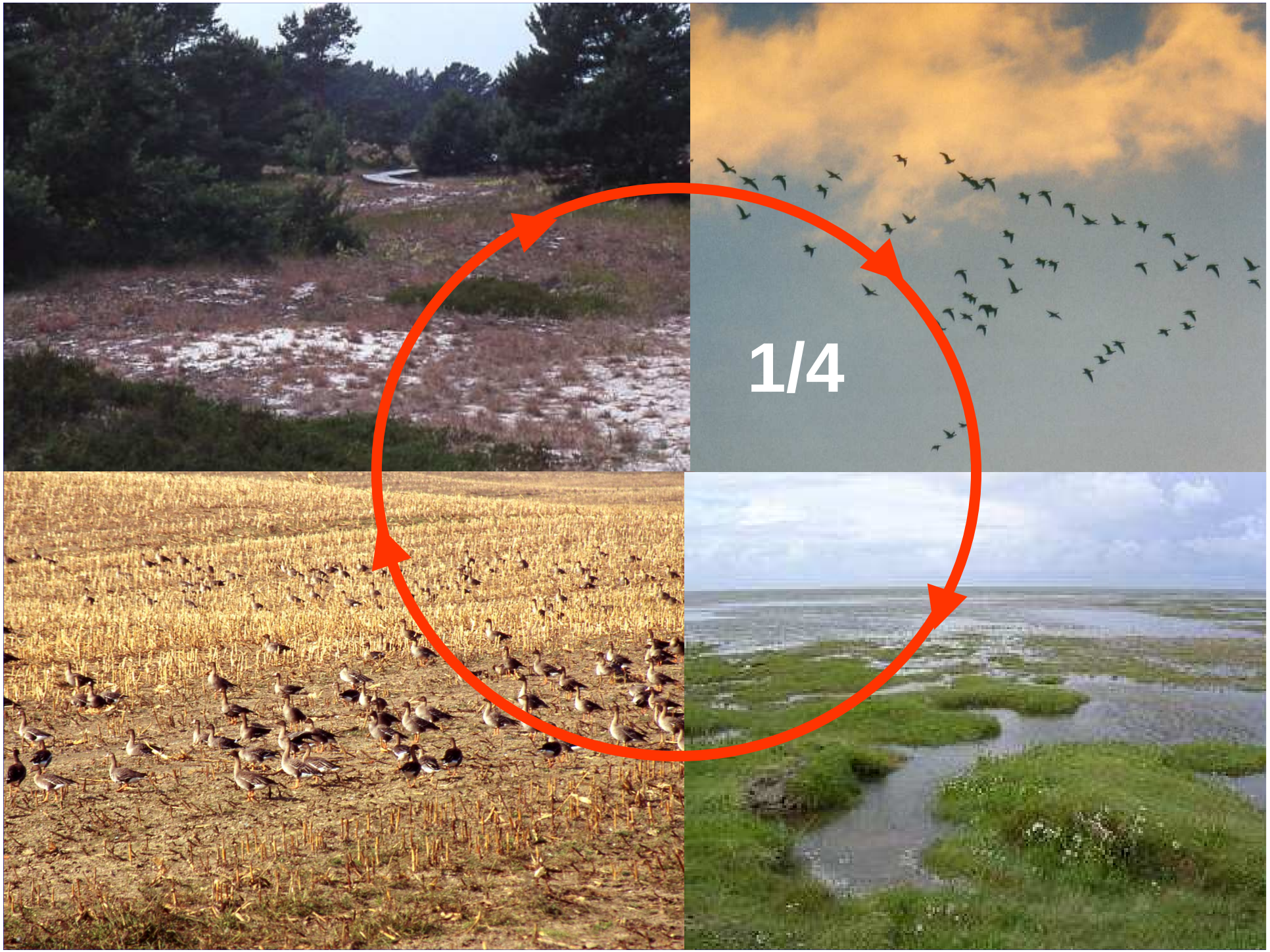
The study of stopover

- behavior, ecology, physiology -

Franz Bairlein
Institute of Avian Research
„Vogelwarte Helgoland“
Wilhelmshaven, Germany

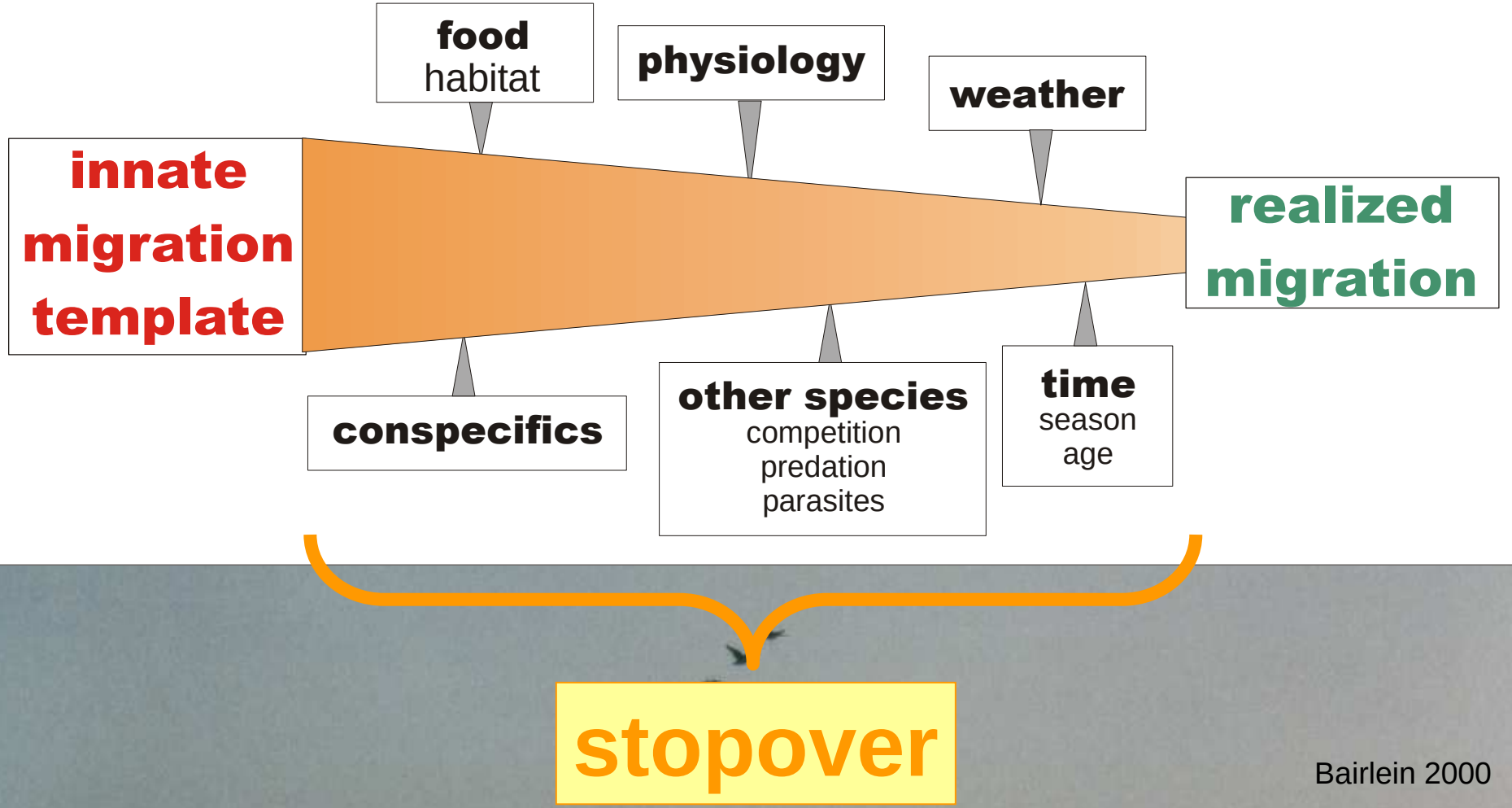
www.vogelwarte-helgoland.de


1/4

The study of stopover
Where to land – when to leave

- Scope
- Methods/tools
- Case studies

How birds migrate –
The shaping of migration



Bairlein 2000

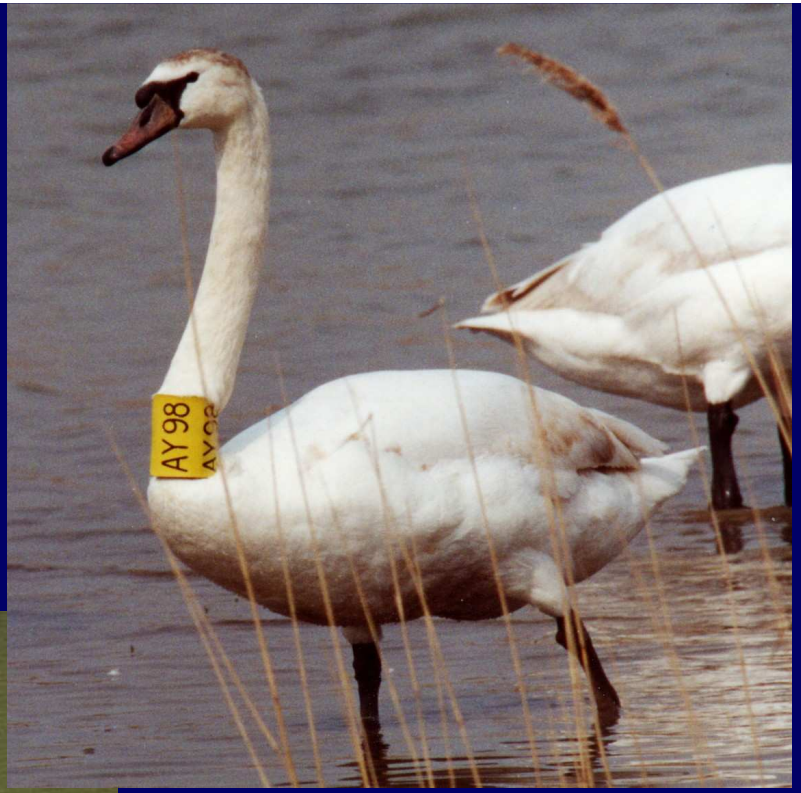
scan-sampling

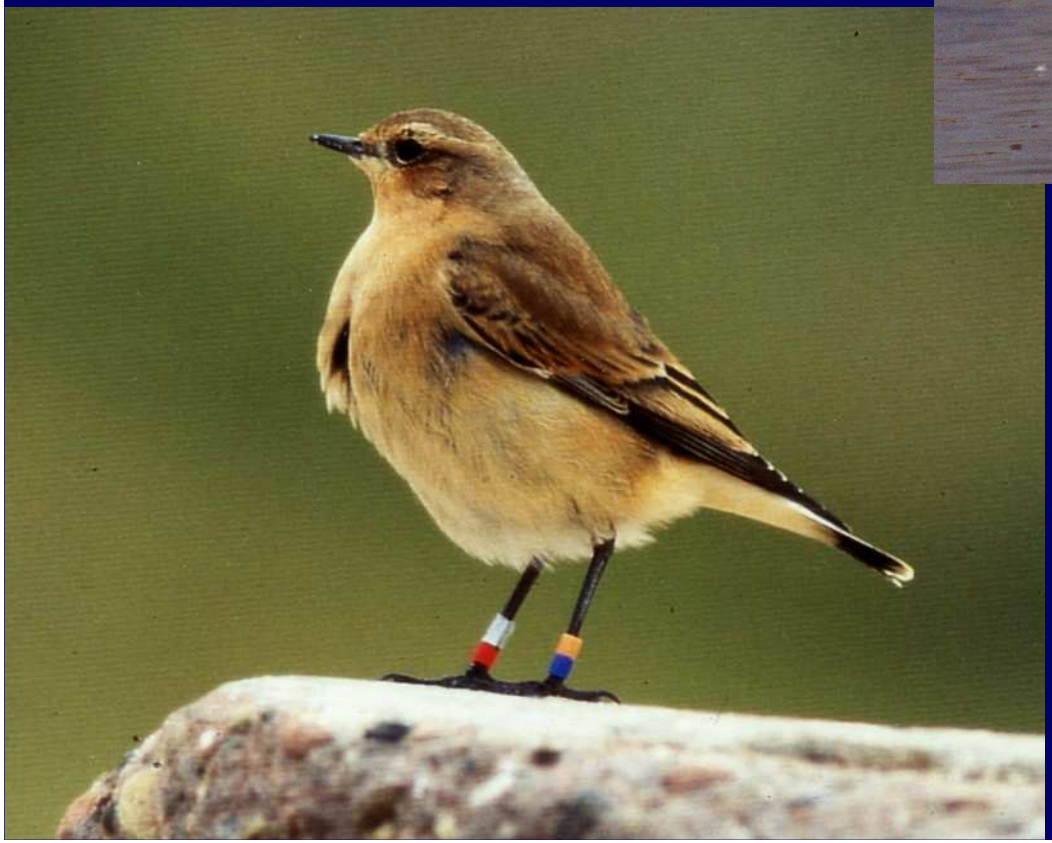
% of birds with particular behavior

focal sampling

% of behaviors per unit time


C9


AY98




A799
please inform:Vogelwarte
78315 Radolfzell;Germania
ring@vowa.ornithol.mpg.de
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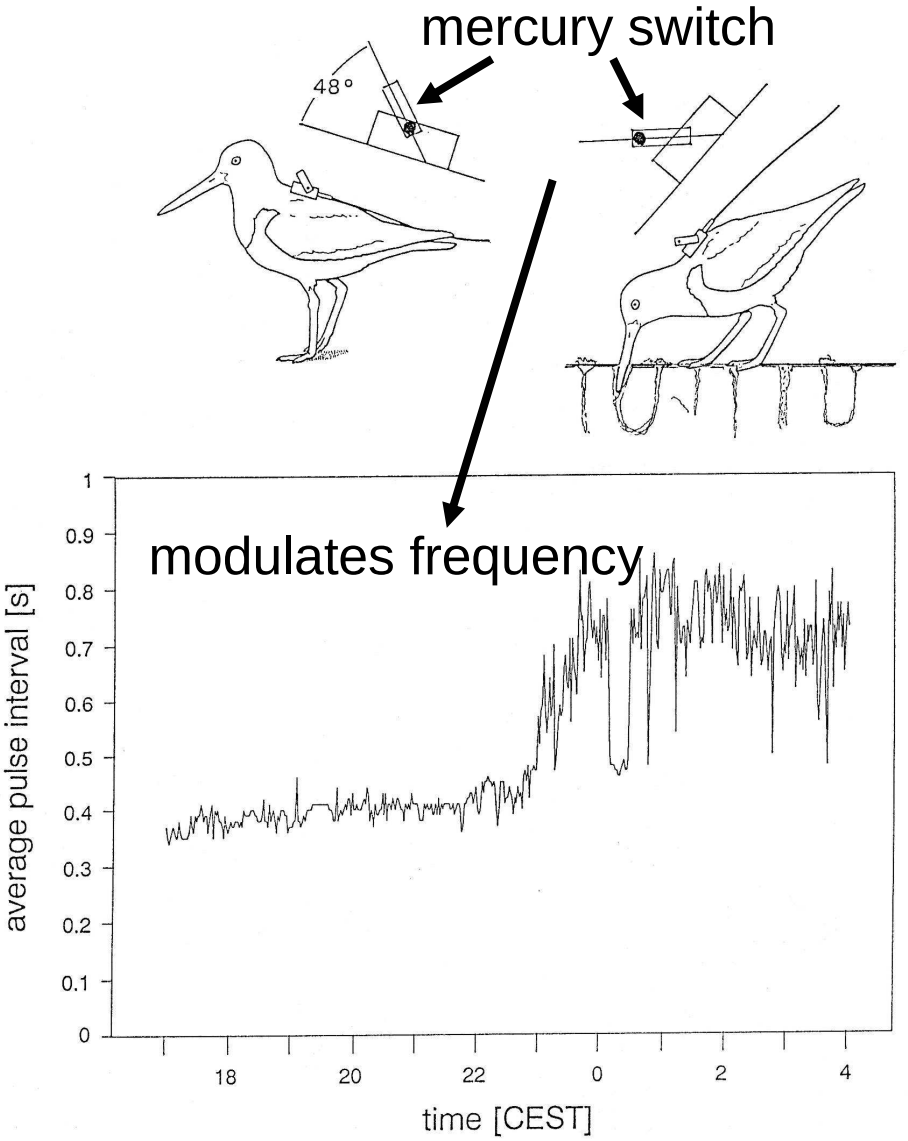
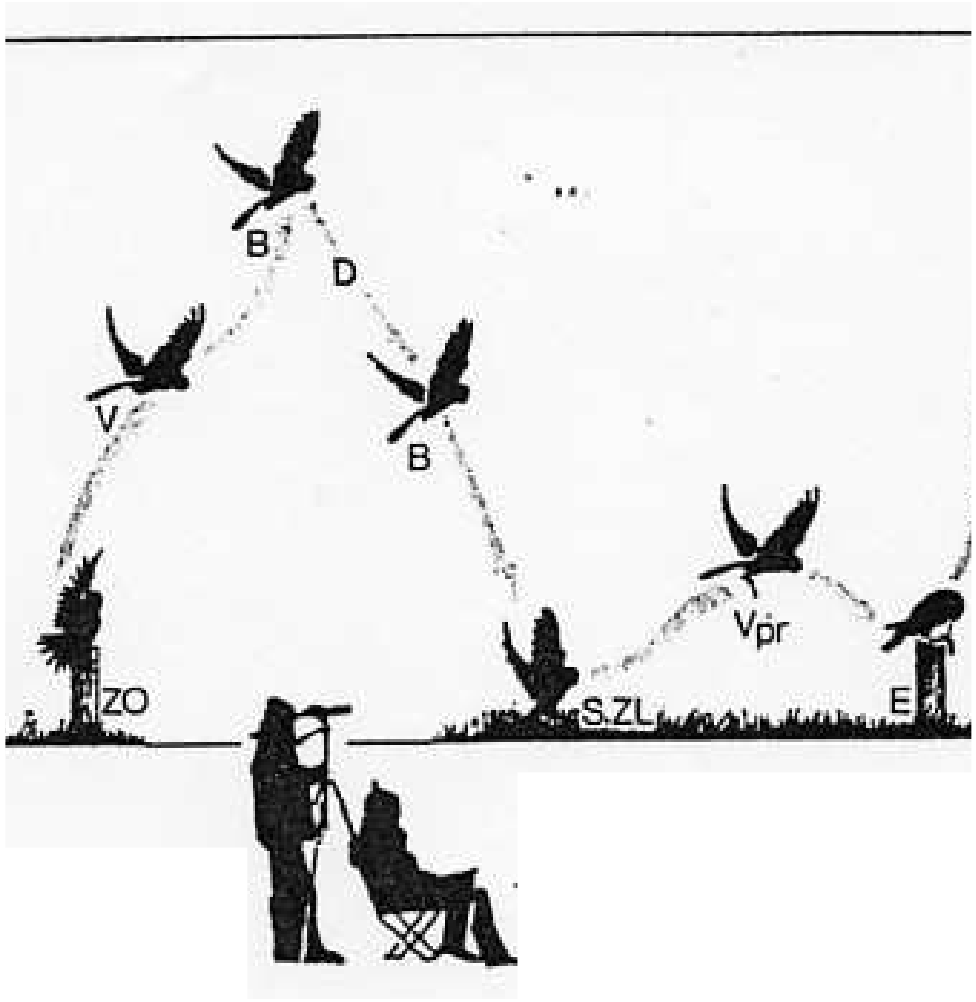
Time-Budget
(TB)



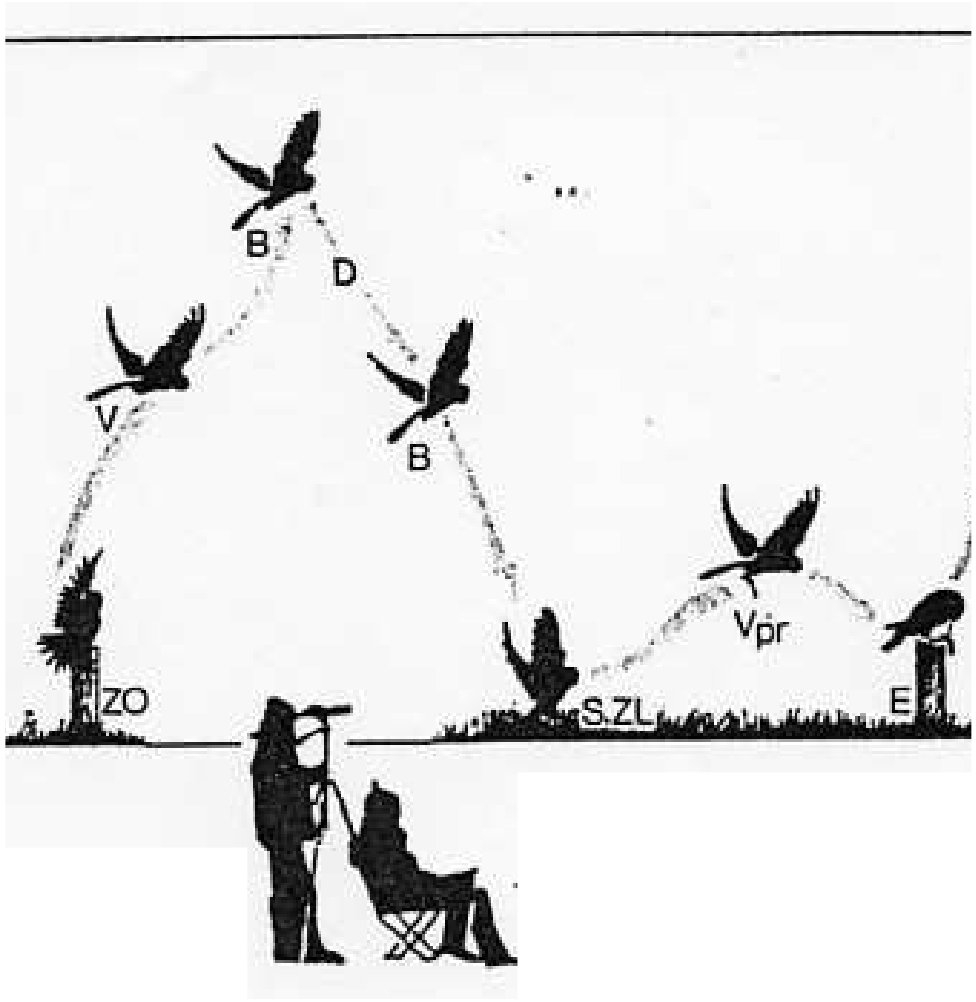
Exo et al. 1992



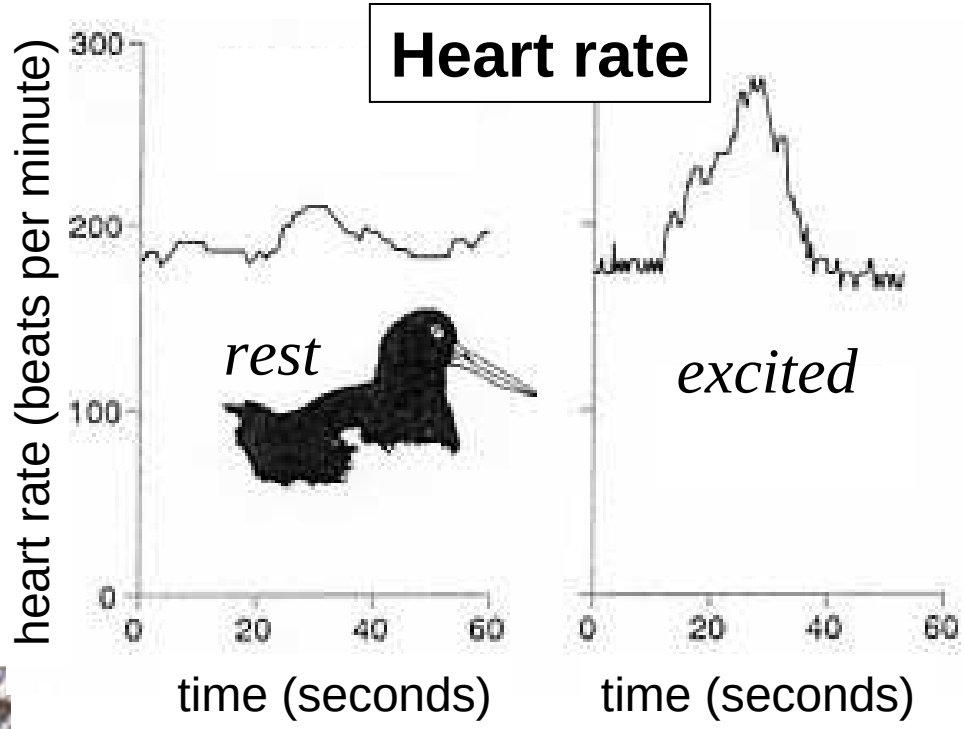
time budget

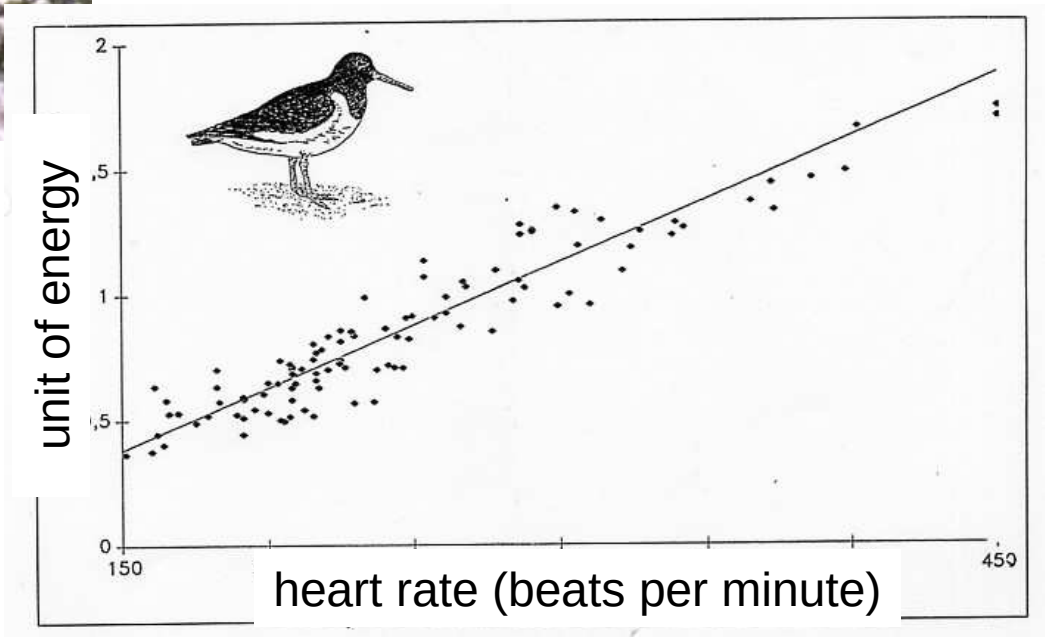
(% behavior per unit time, e.g. daylight period)

Activity	x BMR
Flight	
Aerial species	2,7 - 5,7
other birds, sustained flight	11
European Robin, short flights	23
Gliding	2
Terrestrial locomotion	1,5 - 5
Perch	
Rest	1
Alert	1,9 - 2,1
preening	1,6 - 2,3
eating	1,7 - 2,2
singing/calling	2,9
bathing	2,9

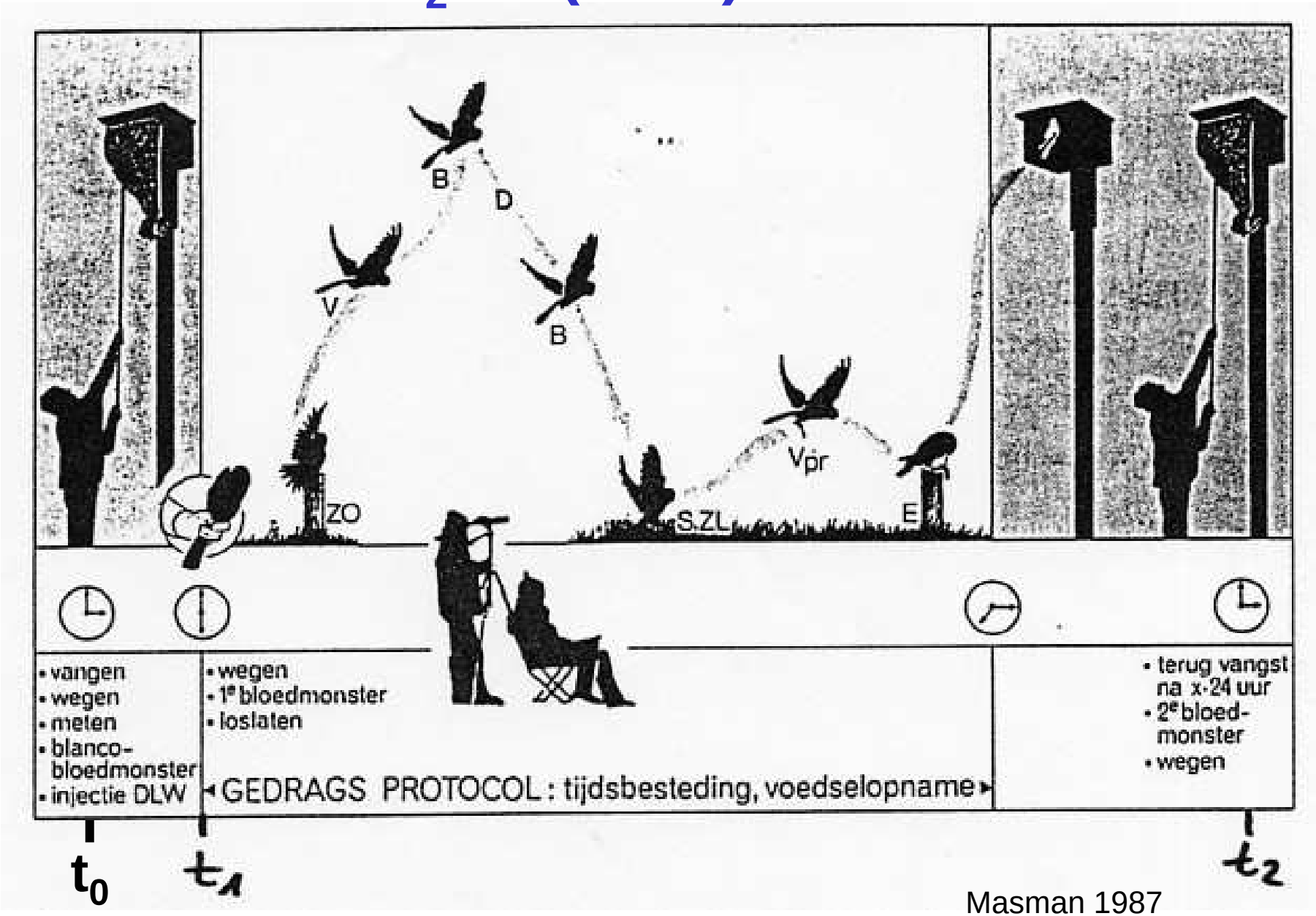


Time-Energy Budget
(TEB)


Heart rate
heart rate (beats per minute)
300
200
100
0
0
20
40
60
rest
excited
time (seconds)
time (seconds)

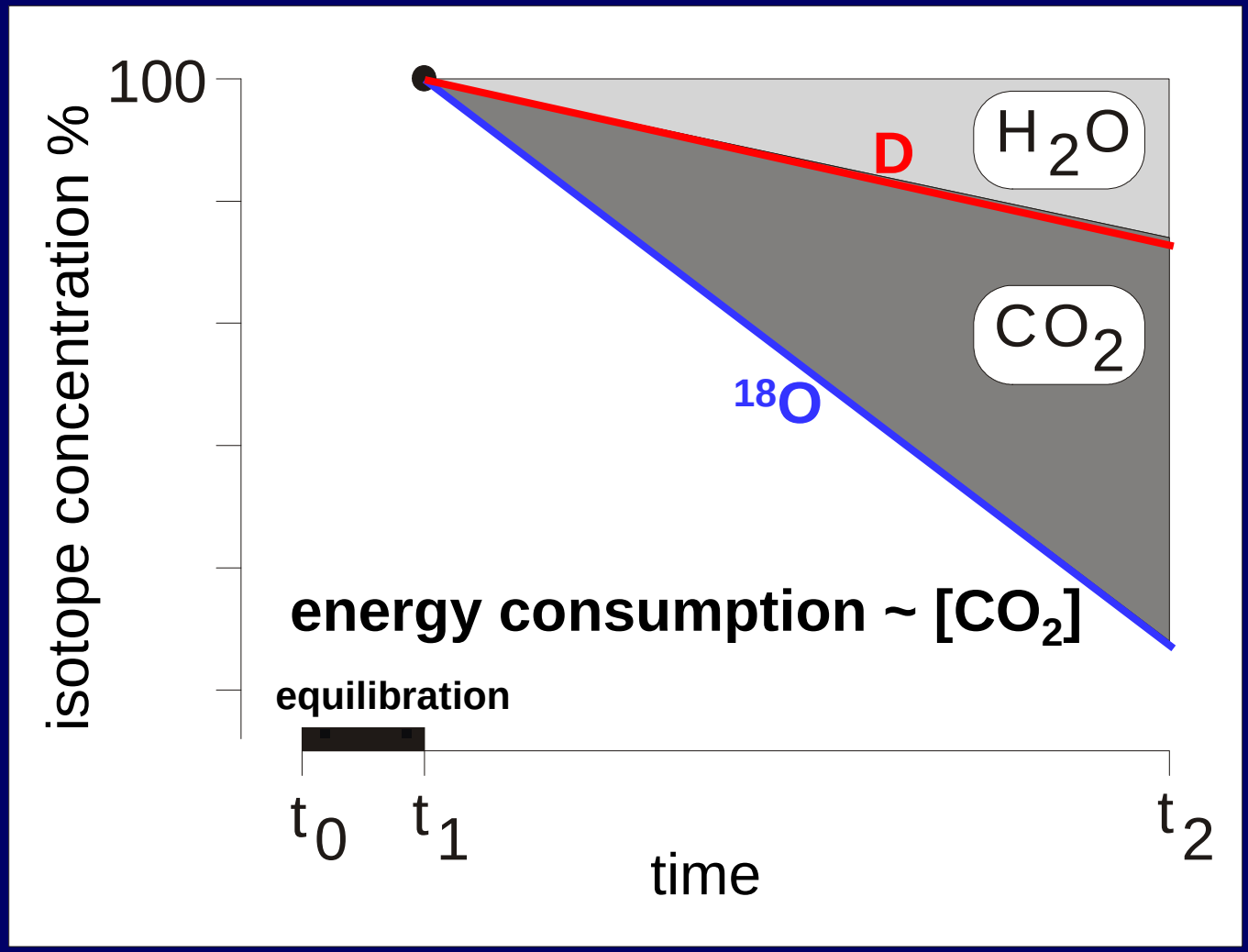

unit of energy
2
1,5
1
0,5
0
150
450
heart rate (beats per minute)

$D_2{}^{18}O$ (DLW)-method



Masman 1987

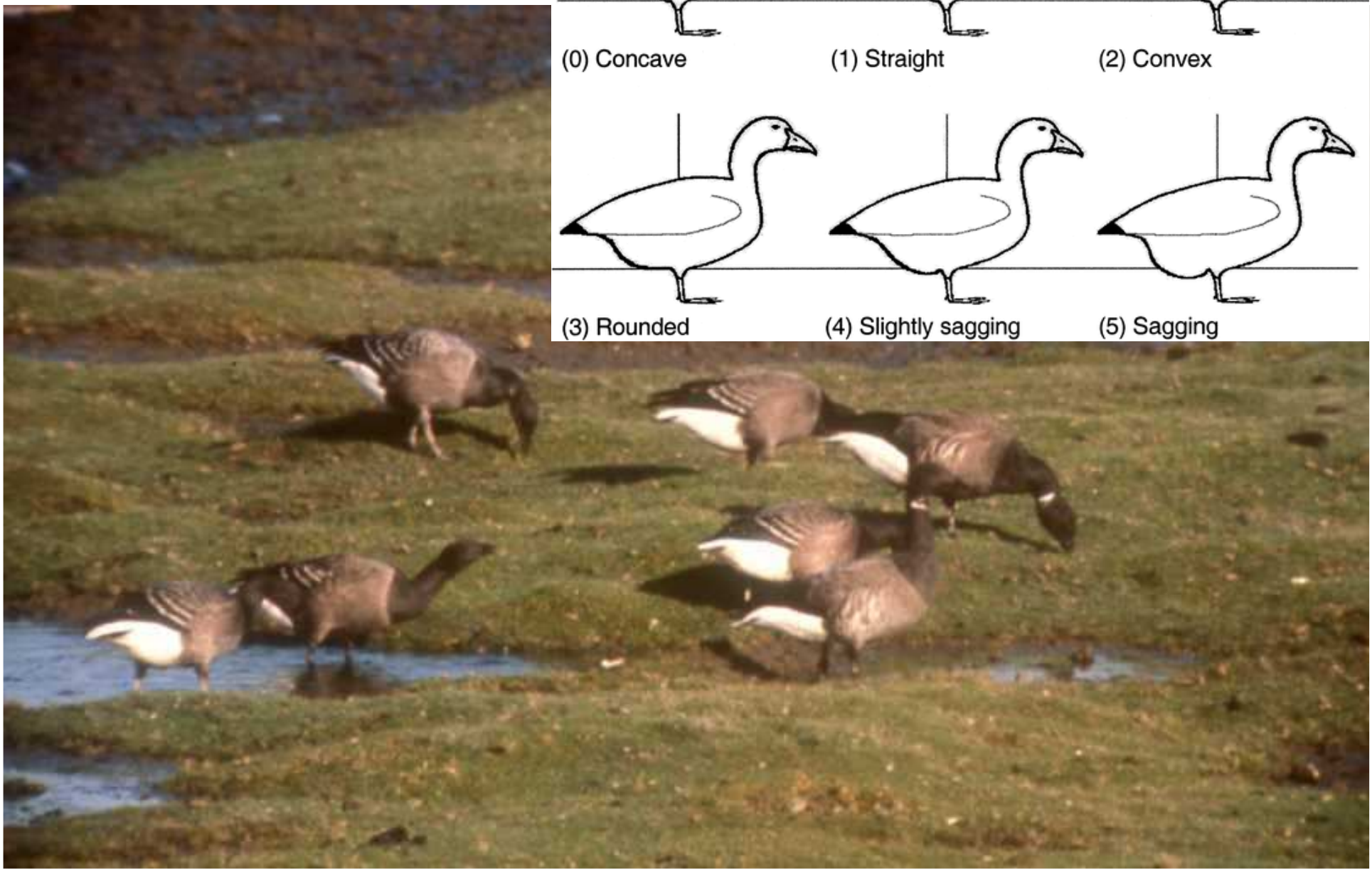
$D_2{}^{18}O$ (DLW)-method



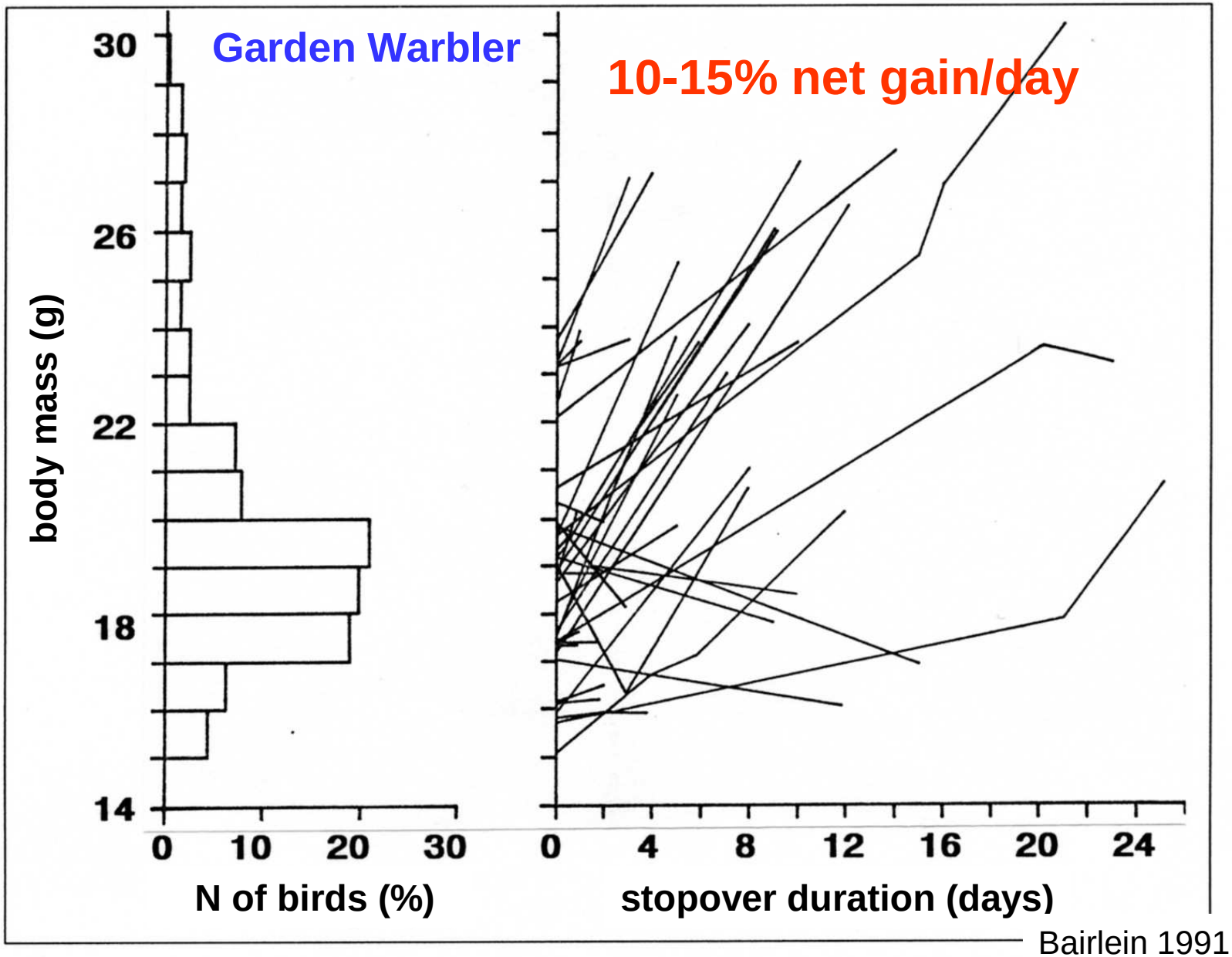
fat deposition

Garden Warbler

2-3 weeks

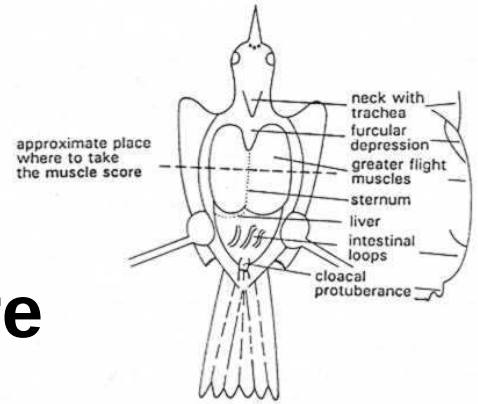


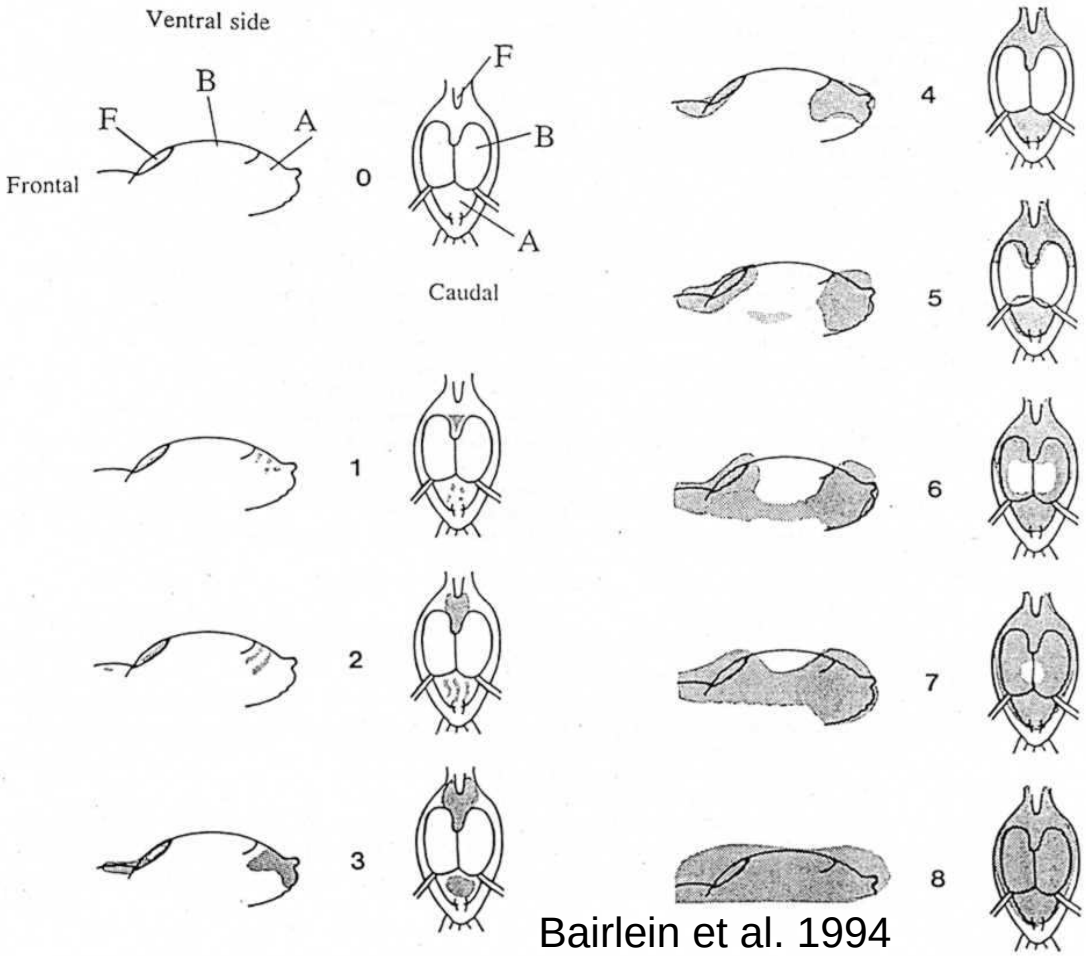
(0) Concave
(1) Straight
(2) Convex
(3) Rounded
(4) Slightly sagging
(5) Sagging



Bairlein 1991

fat score





Bairlein et al. 1994

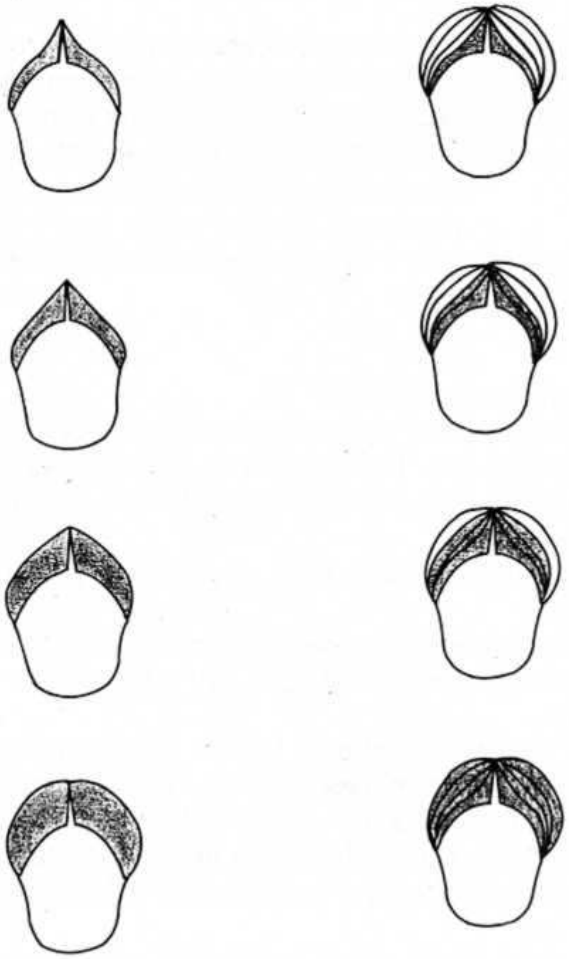
muscle score

score class **0**:
sternum sharp,
muscles depressed

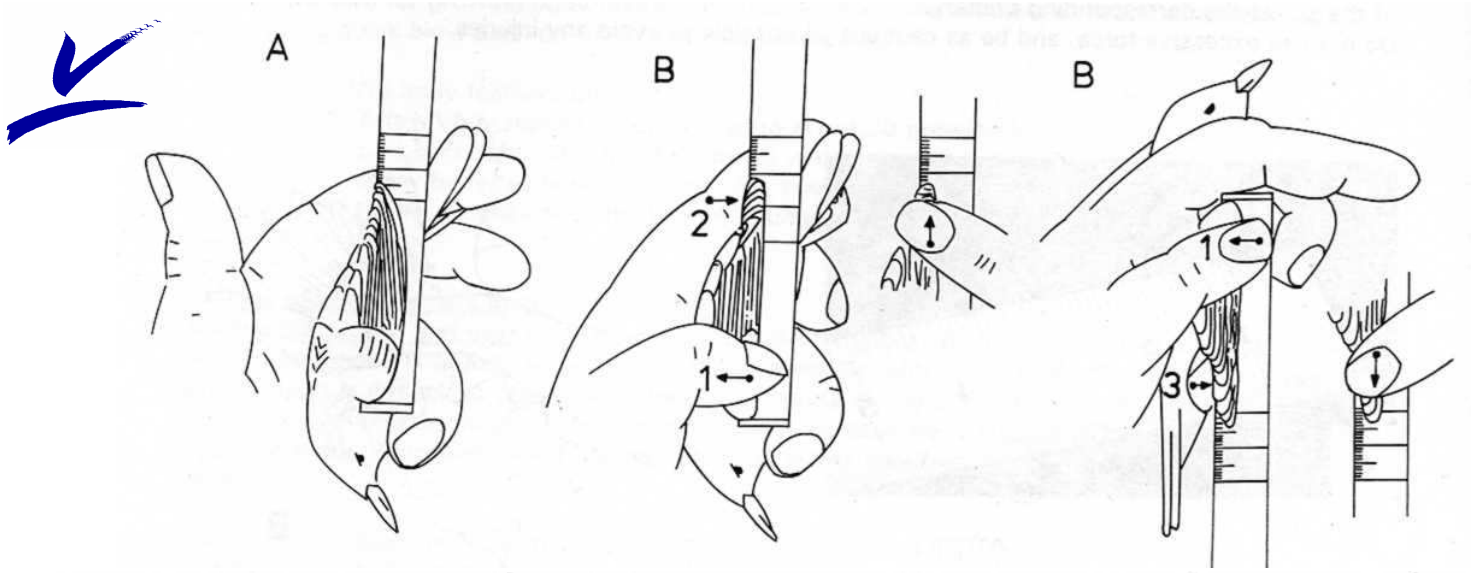
score class **1**:
sternum easy to distinguish
but not sharp;
muscles neither depressed nor
rounded

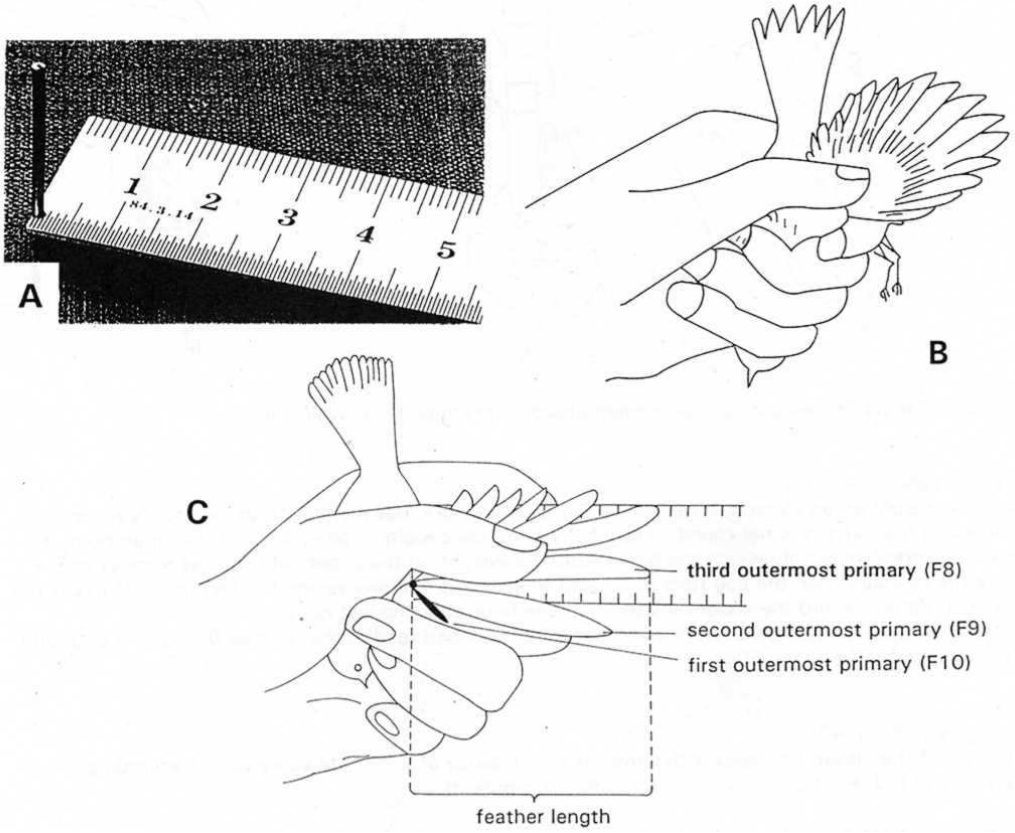
score class **2**:
sternum yet distiguishable,
muscles slightly rounded

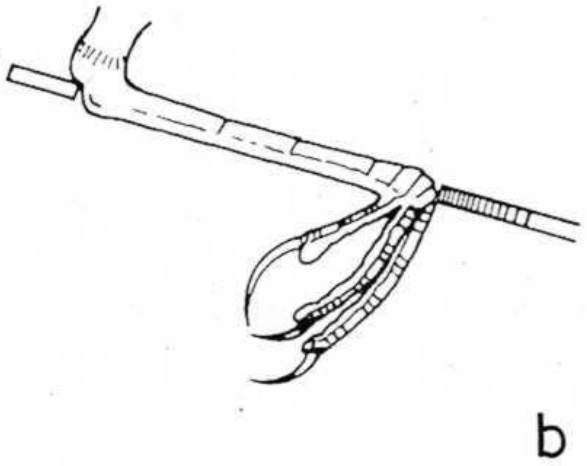
score class **3**:
sternum difficult to distinguish
due to rounded (full) muscles



Bairlein et al. 1994







Bairlein et al. 1994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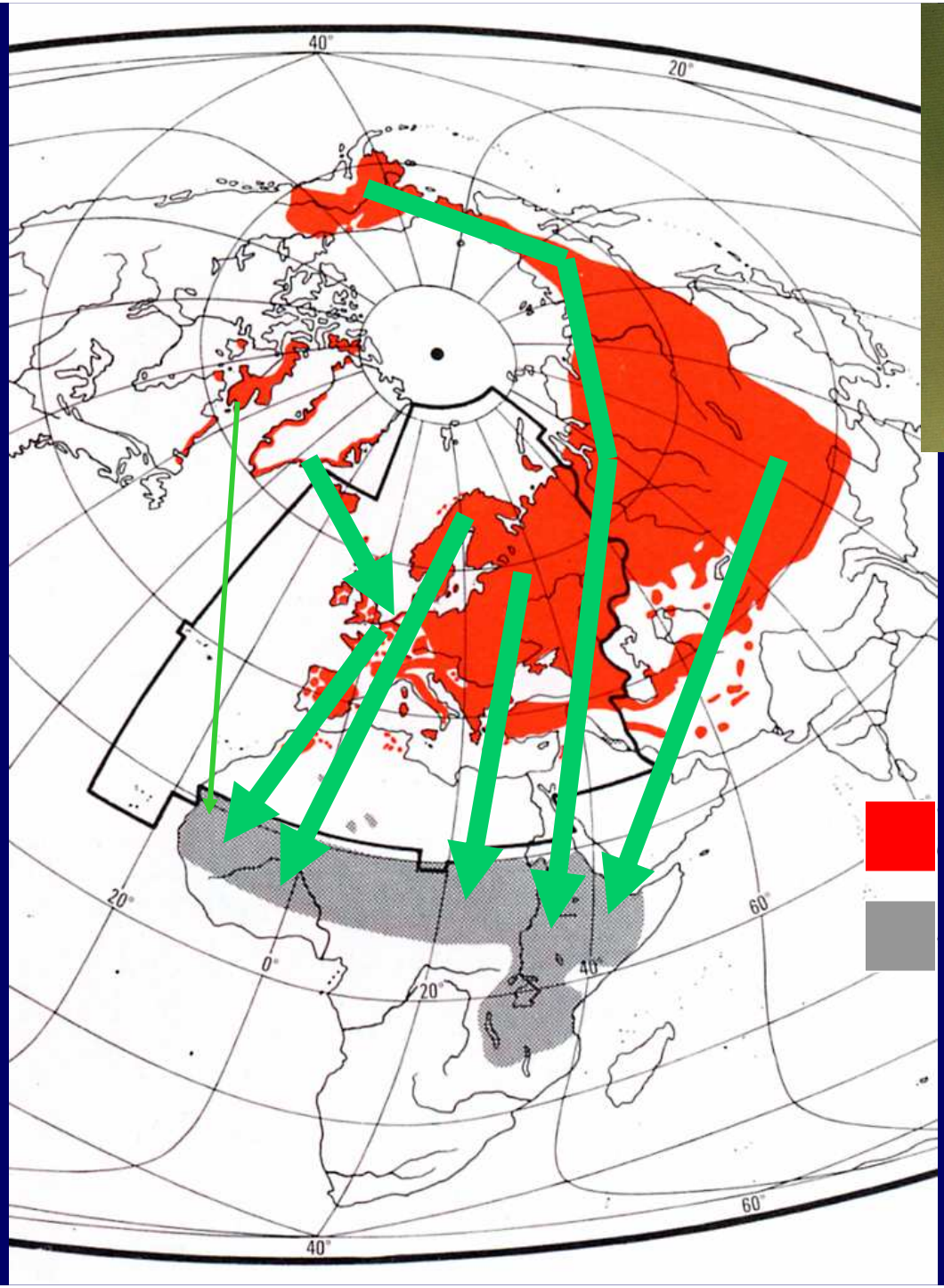


Northern Wheatear

Breeding

Wintering

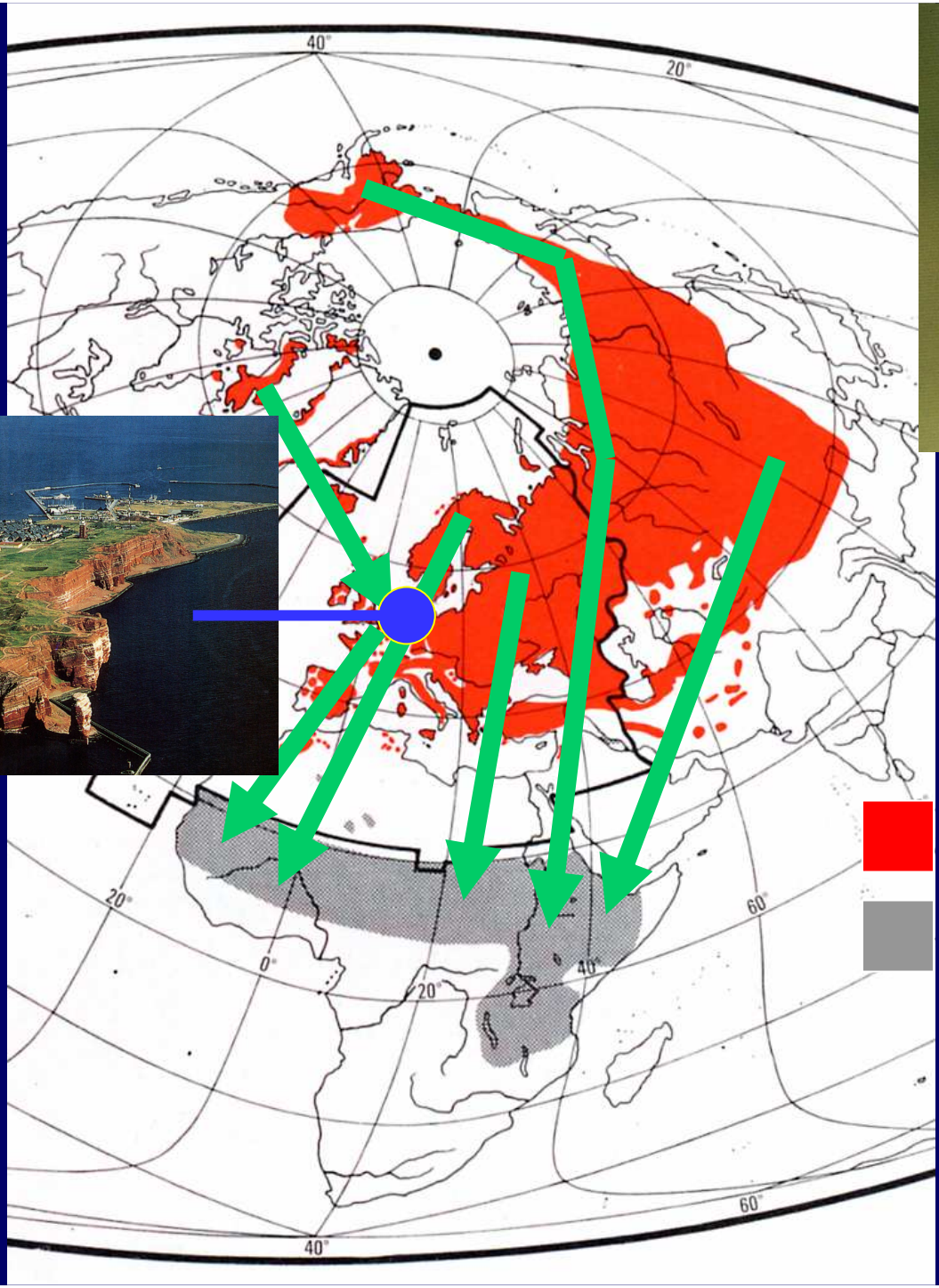
Stopover behavioral ecology

color banding
remote weighing
telemetry

© H. Schmaljohann

Connectivity

- Morphometrical data
- Stable isotopes
- Molecular markers

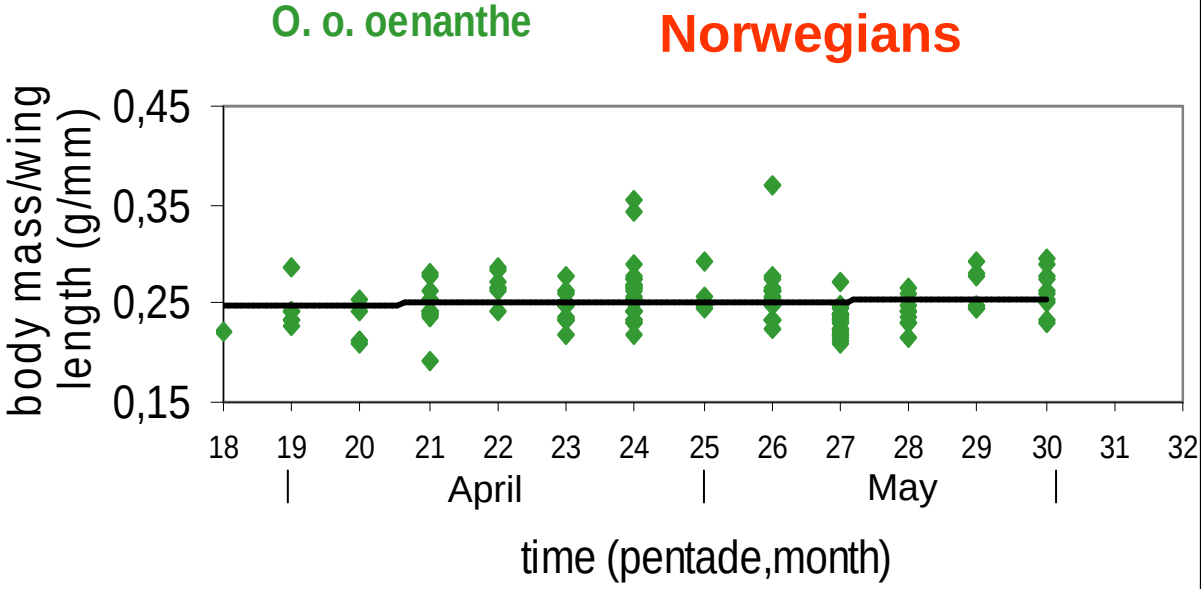


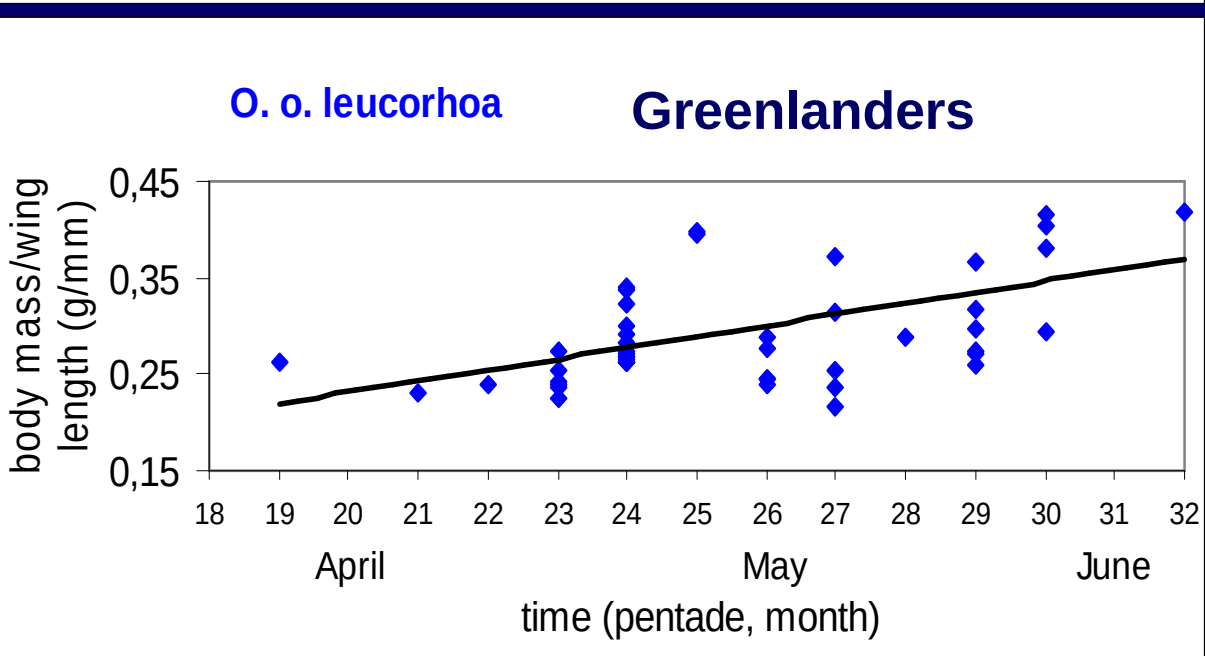
Breeding

Wintering

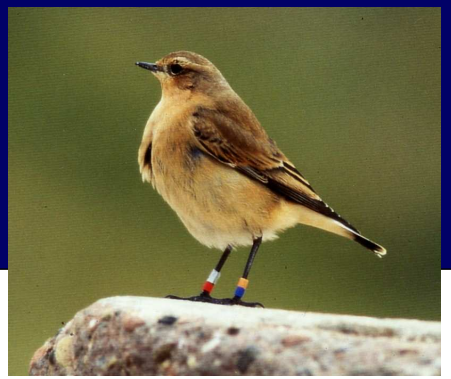
- two subspecies co-occur on passage
  - *Oenanthe o. oenanthe* from Scandinavia
  - *Oenanthe o. leucorhoa* from Iceland/Greenland
- no breeding birds
- easy access

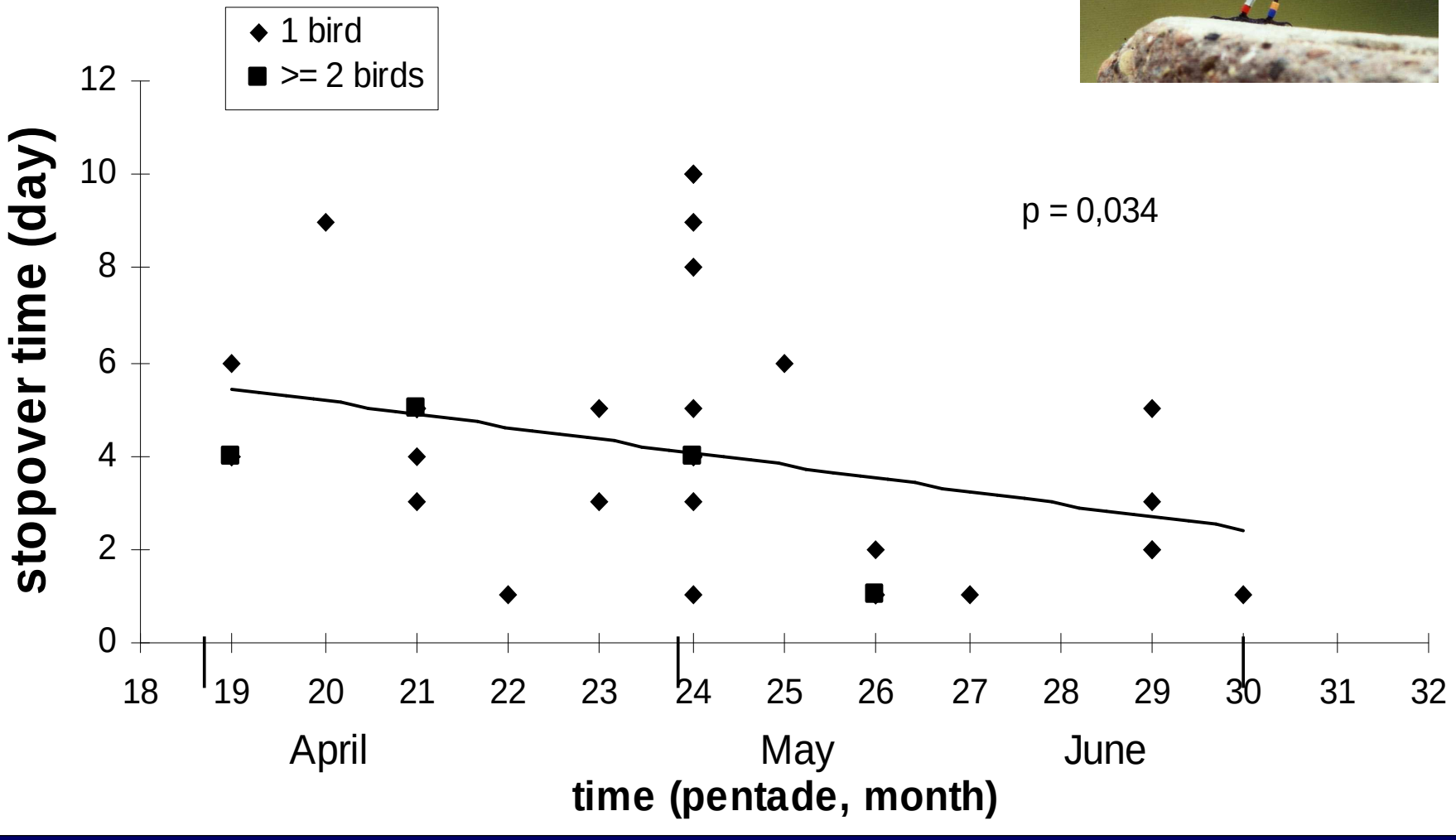
Helgoland

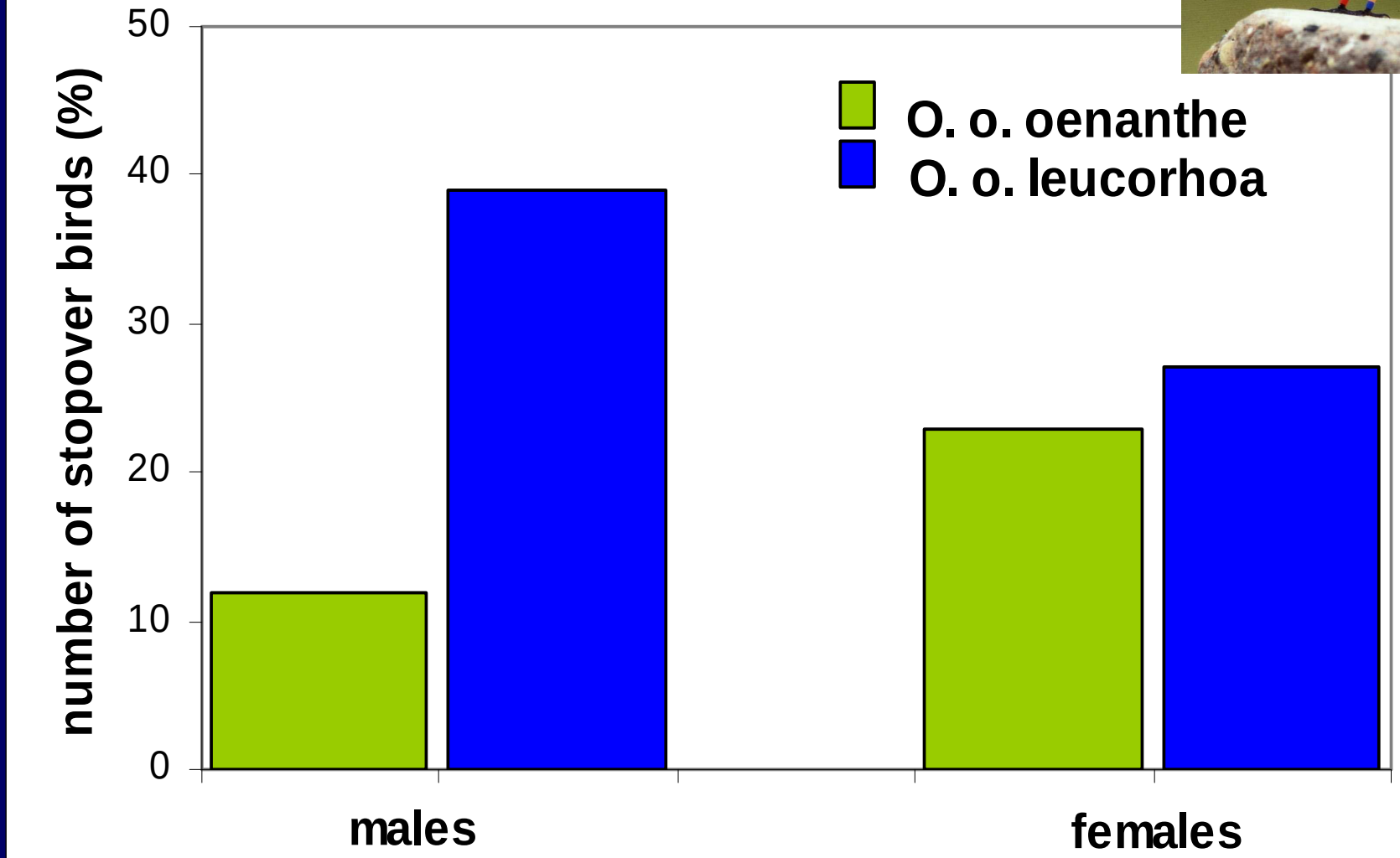

O. o. oenanthe
Norwegians
body mass/wing length (g/mm)
0,45
0,35
0,25
0,15
18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
April
May
time (pentade,month)

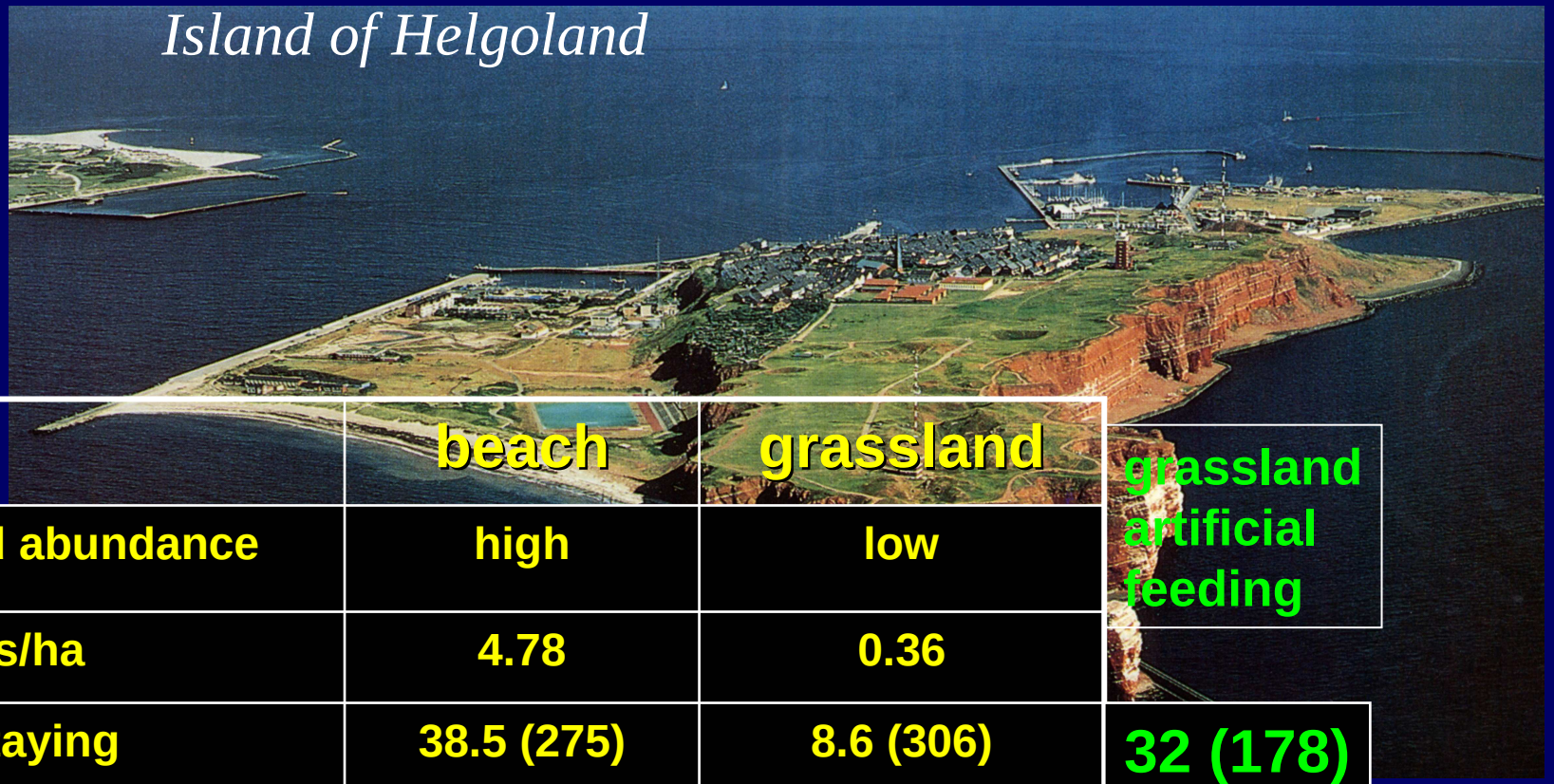

O. o. leucorhoa
Greenlanders
body mass/wing length (g/mm)
0,45
0,35
0,25
0,15
18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
April
May
June
time (pentade, month)

stopover duration






number of stopover birds (%)
50
40
30
20
10
0
O. o. oenanthe
O. o. leucorhoa
males
females



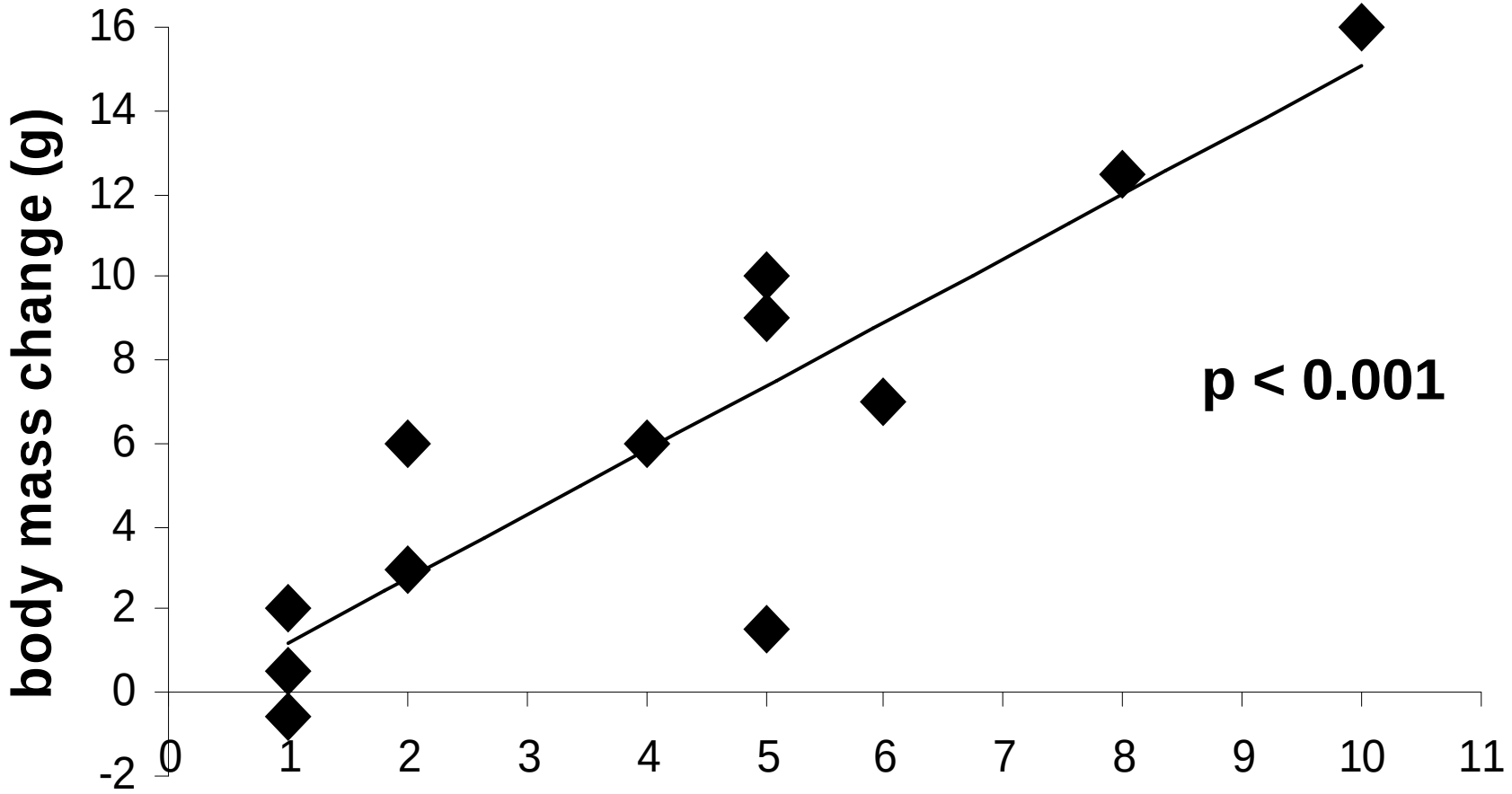
	beach	grassland
food abundance	high	low
birds/ha	4.78	0.36
% staying	38.5 (275)	8.6 (306)
mobility (>500m)	11 %	35 %
aggressive encounters	27.5 % (480)	3.5 % (86)

grassland artificial feeding

32 (178)

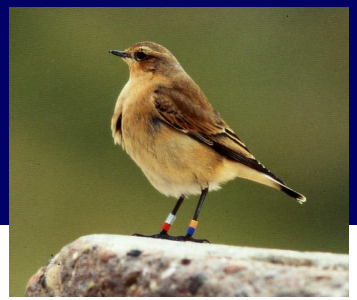
Greenlanders Norwegians

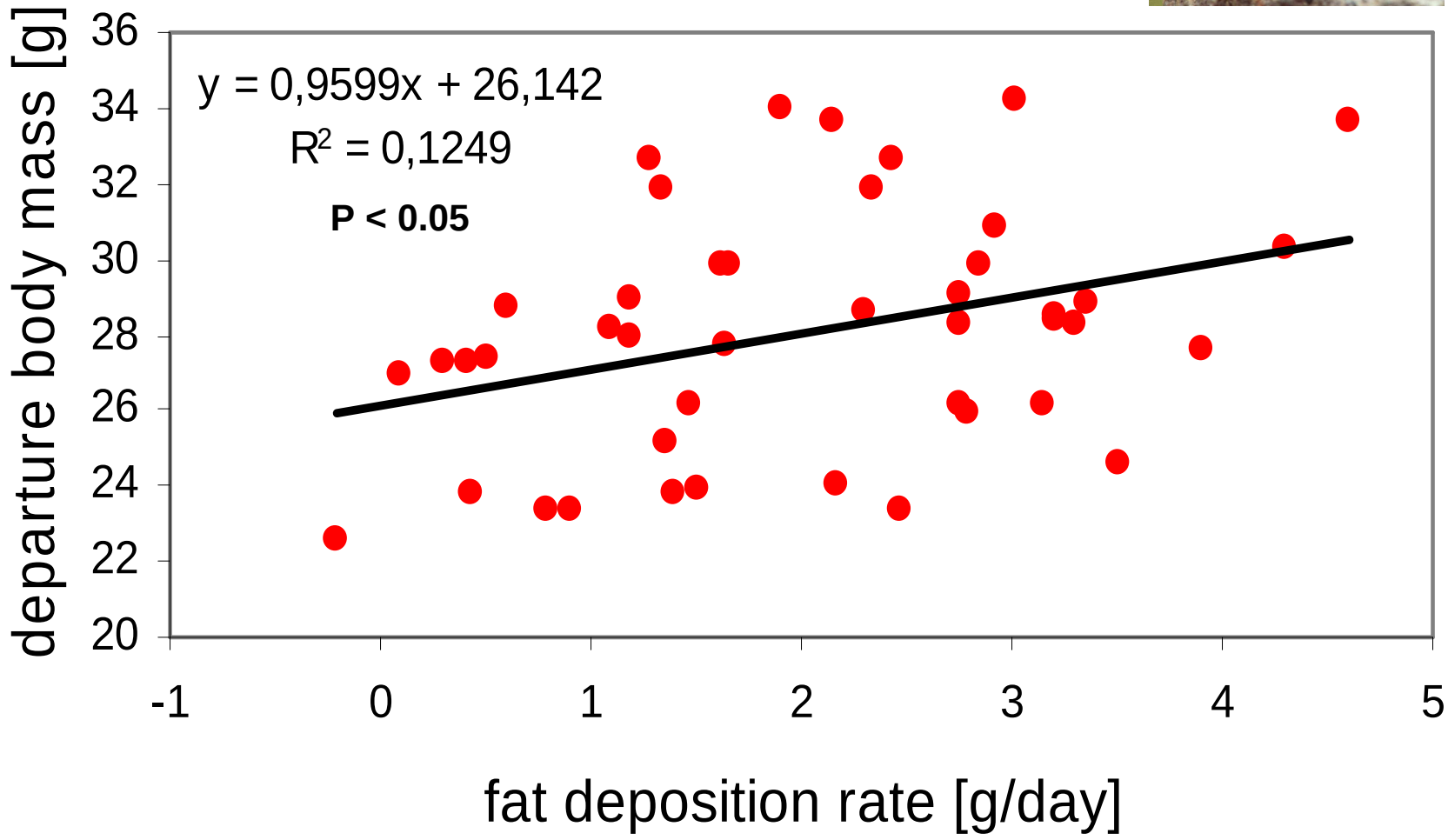
spring migration, Helgoland



V. Dierschke

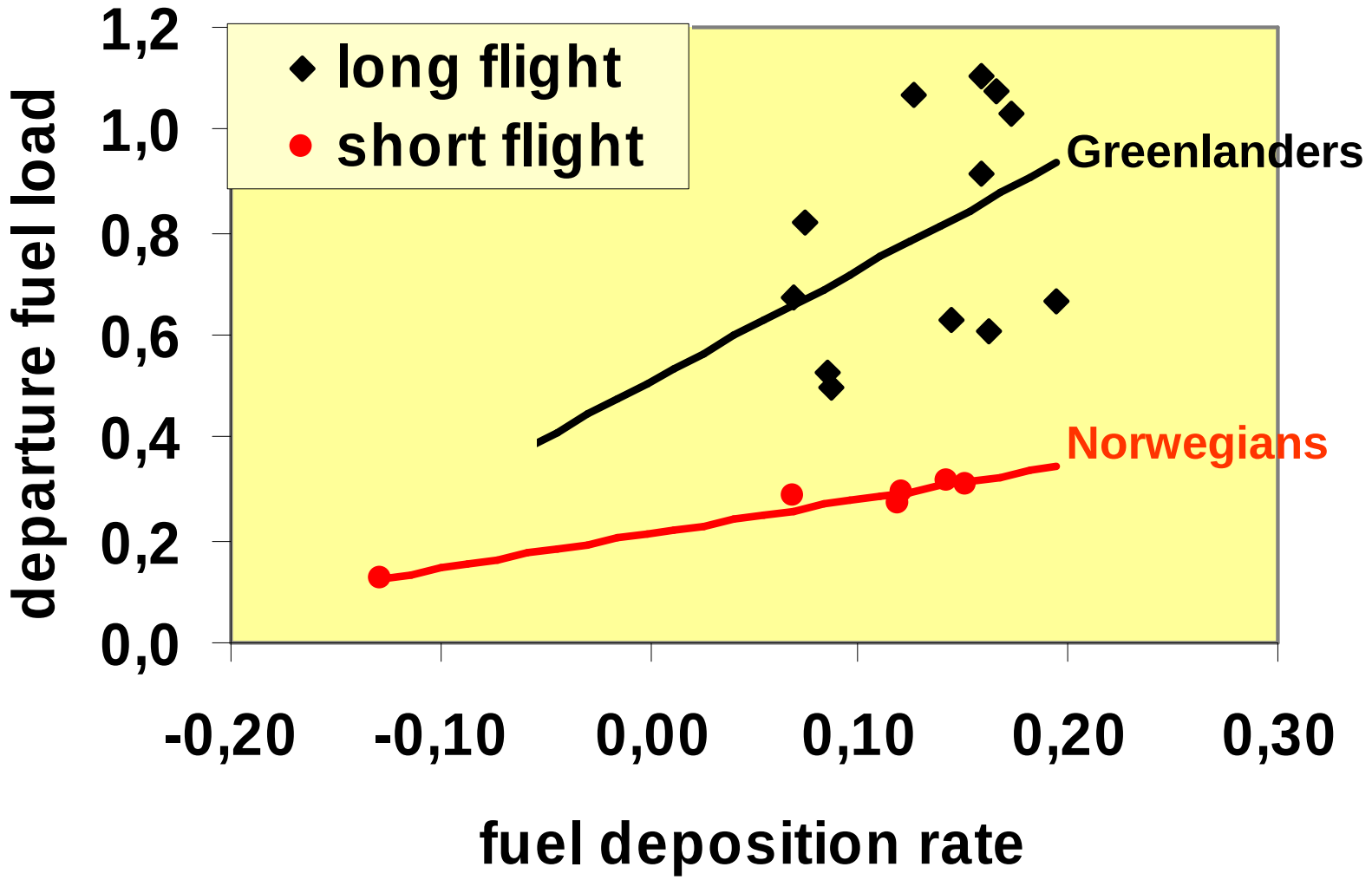
spring migration, Helgoland





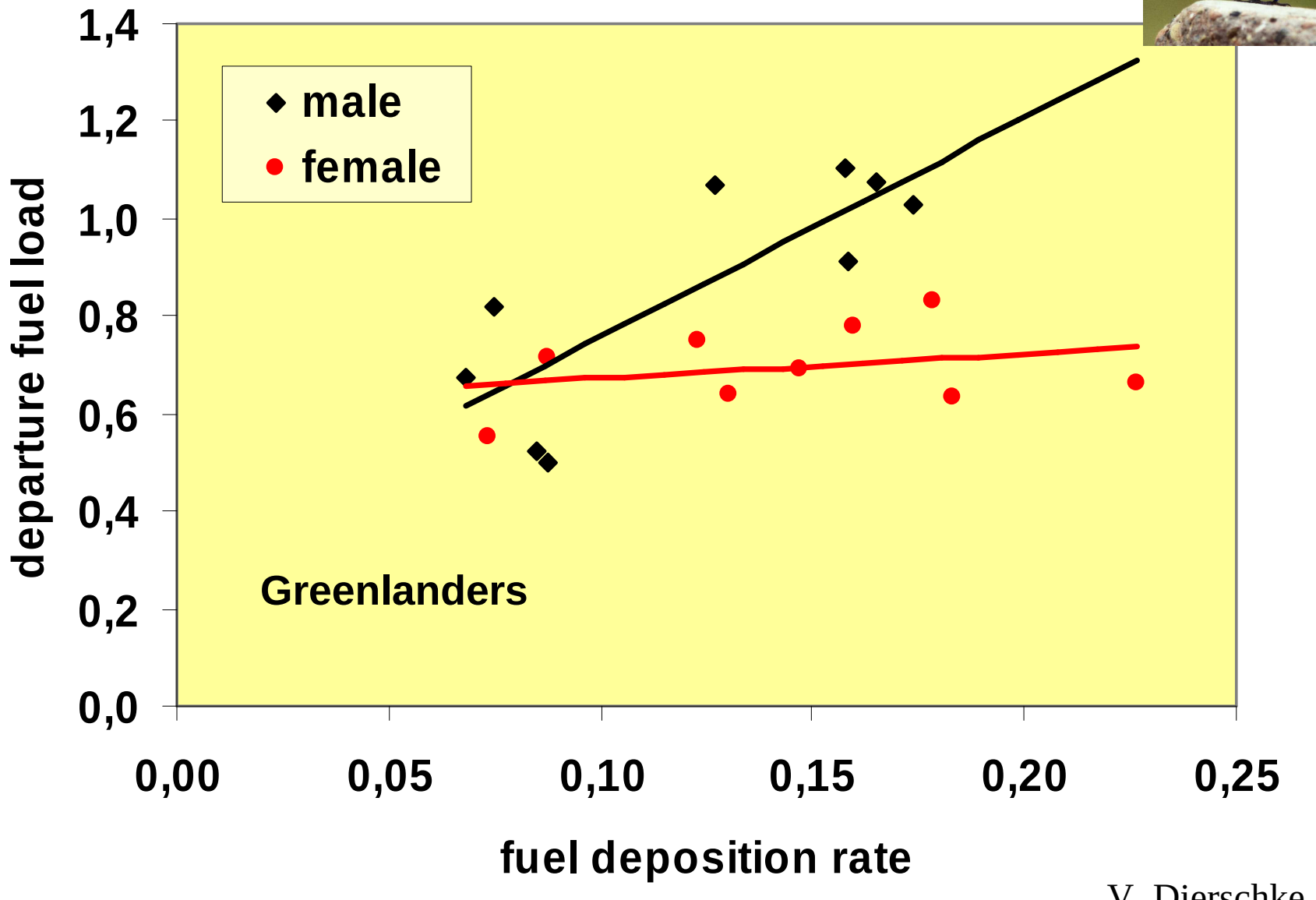
V. Dierschke

spring migration, Helgoland



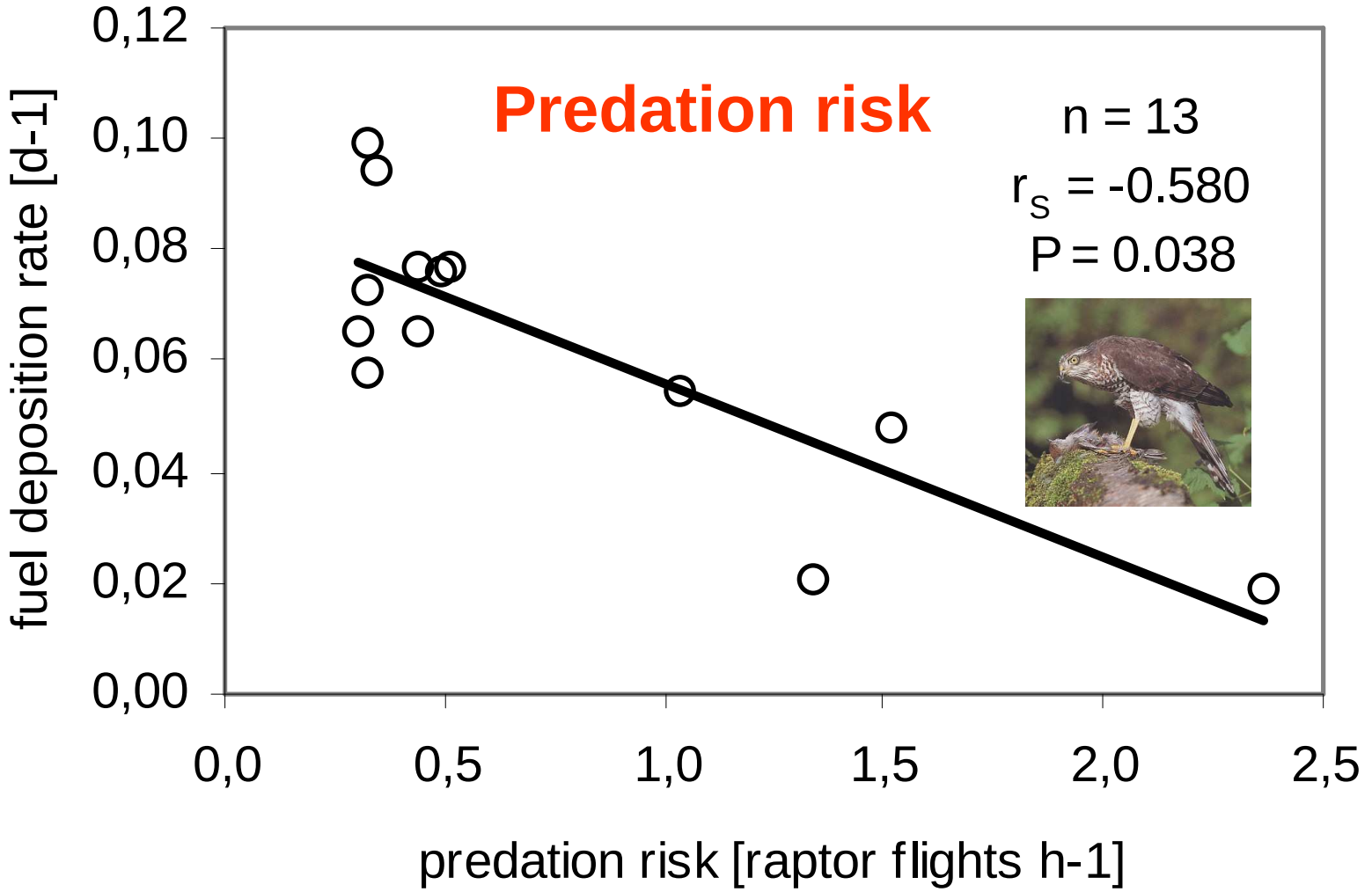
V. Dierschke

spring migration, Helgoland



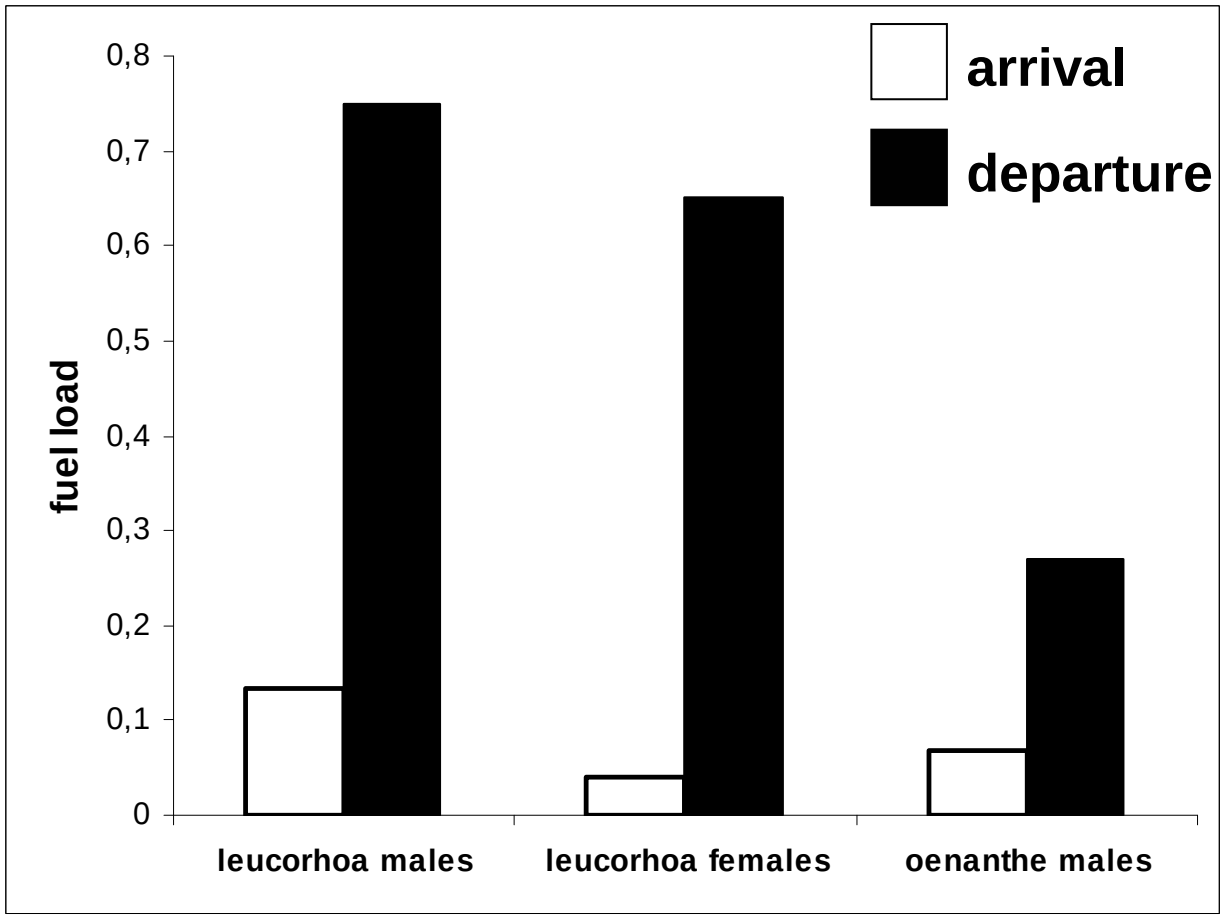
V. Dierschke

autumn migration, Helgoland

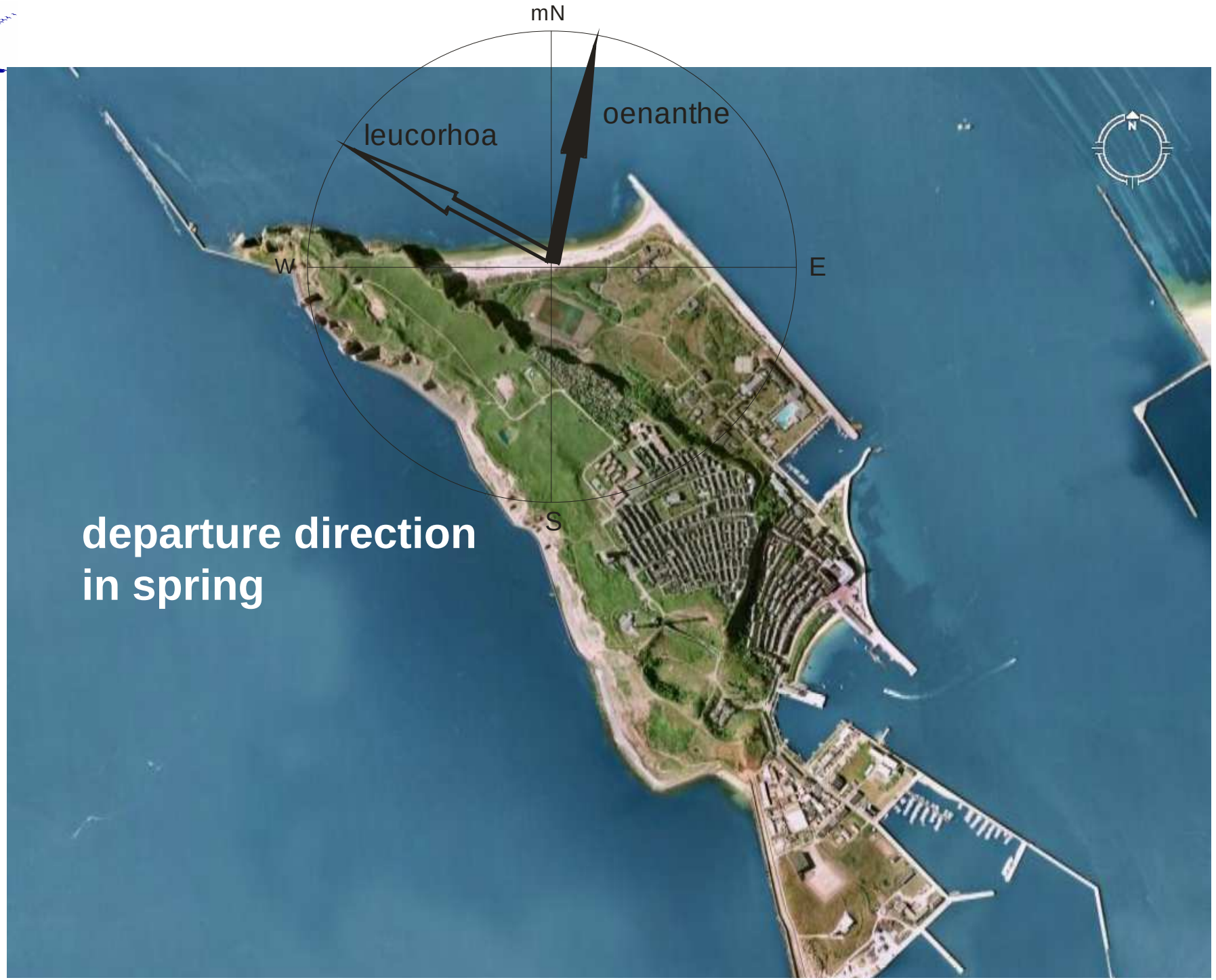


V. Dierschke

Spring passage, Helgoland



(Bairlein 2008)


mN
leucorhoa
oenanthe
W
E
S
departure direction
in spring

fuelling

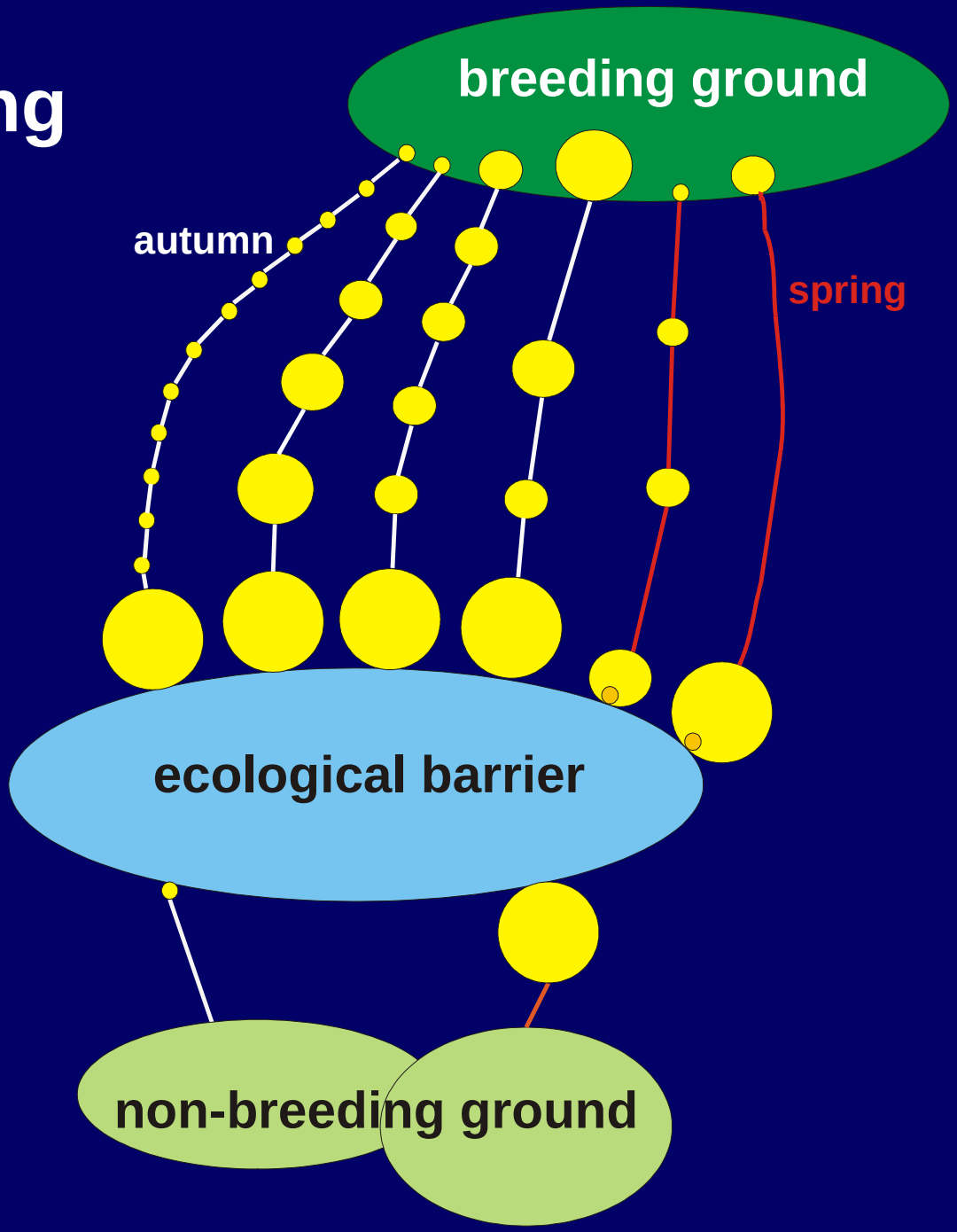

breeding ground
autumn
spring
ecological barrier
non-breeding ground

Foto: H. Schmaljohann

(Bairlein 2008)

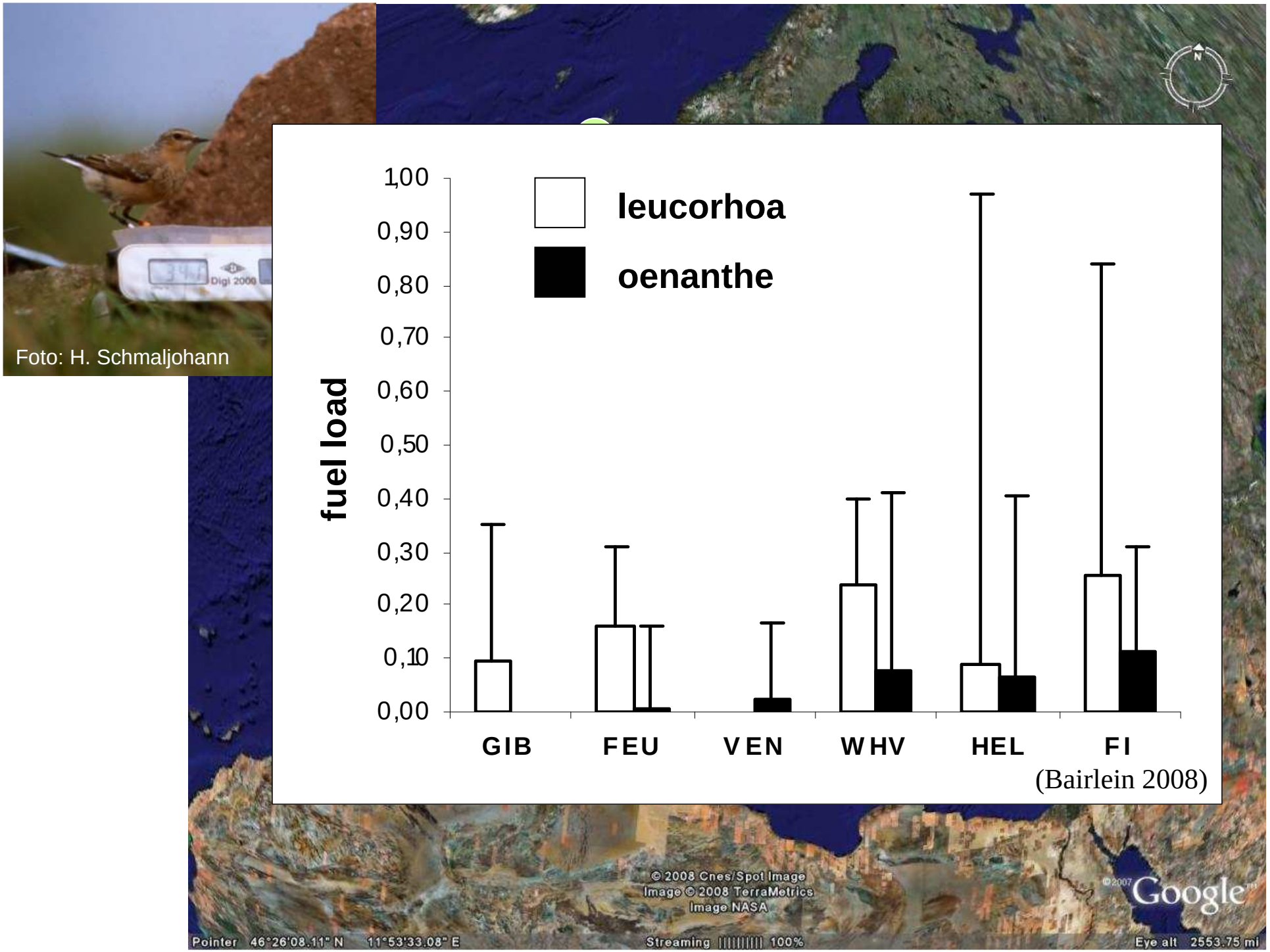
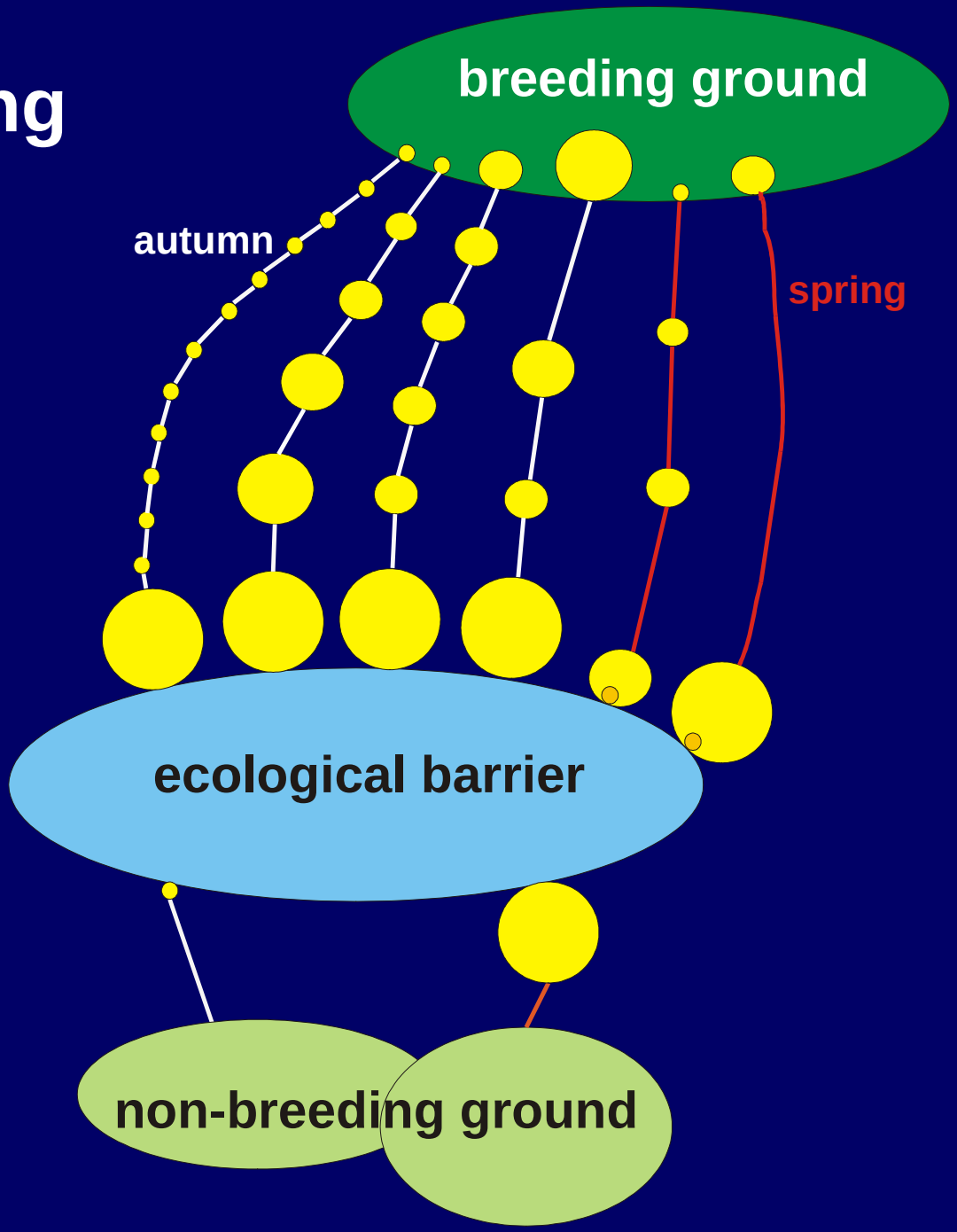
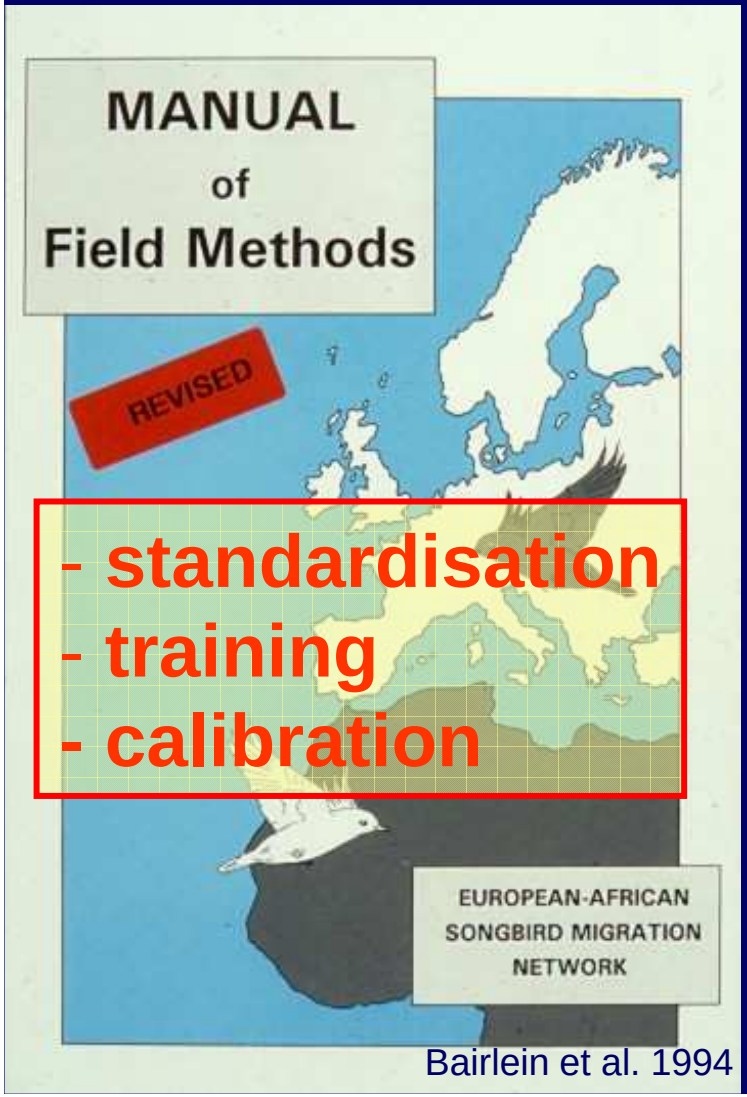


Foto: H. Schmaljohann
fuel load
1,00
0,90
0,80
0,70
0,60
0,50
0,40
0,30
0,20
0,10
0,00
leucorhoa
oenanthe
GIB
FEU
VEN
WHV
HEL
FI
(Bairlein 2008)
© 2008 Cnes/Spot Image
Image © 2008 TerraMetrics
Image NASA
Pointer 46°26'08.11" N 11°53'33.08" E
Streaming 100%
Eye alt 2553.75 mi

fuelling

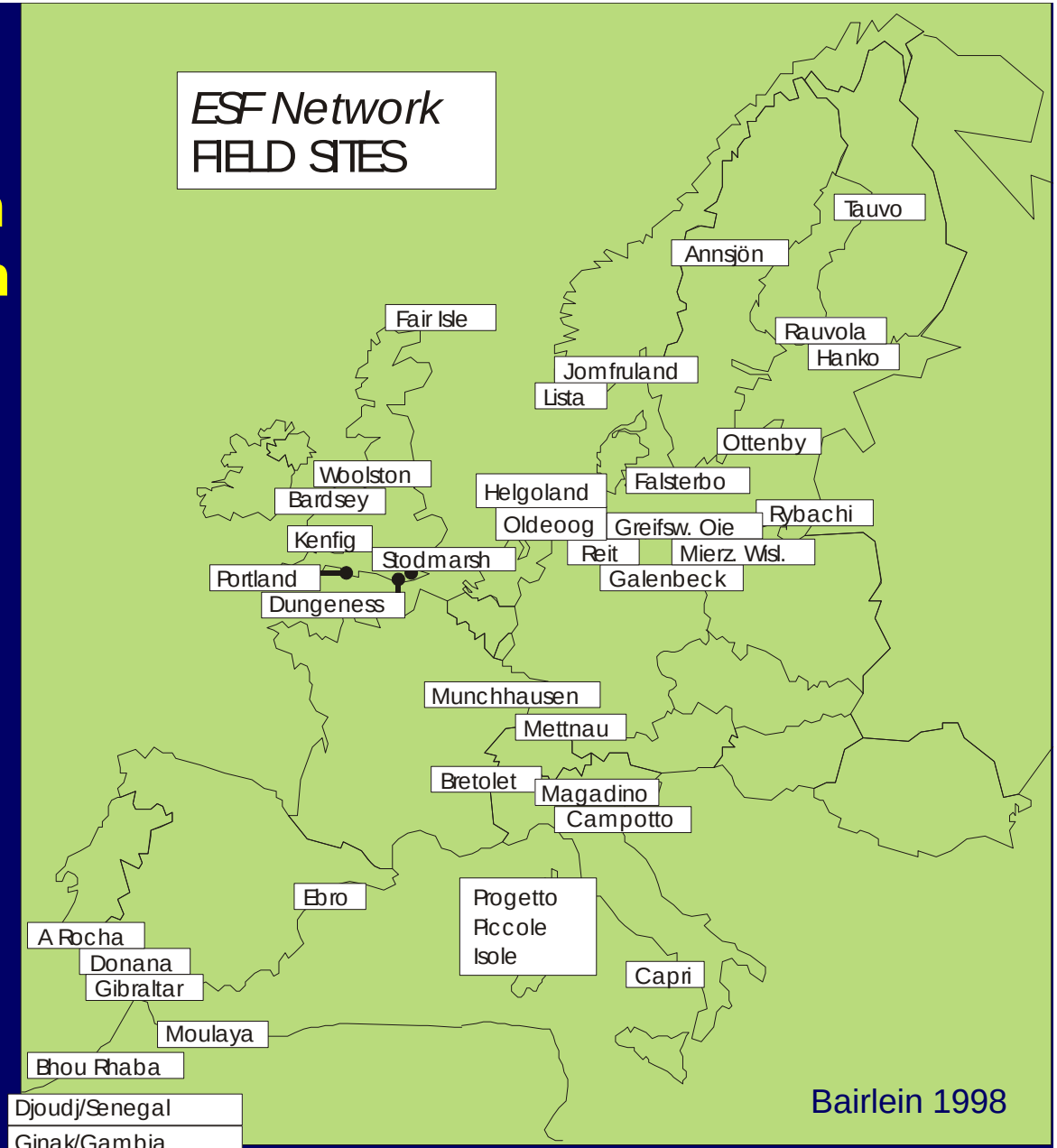

breeding ground
autumn
spring
ecological barrier
non-breeding ground

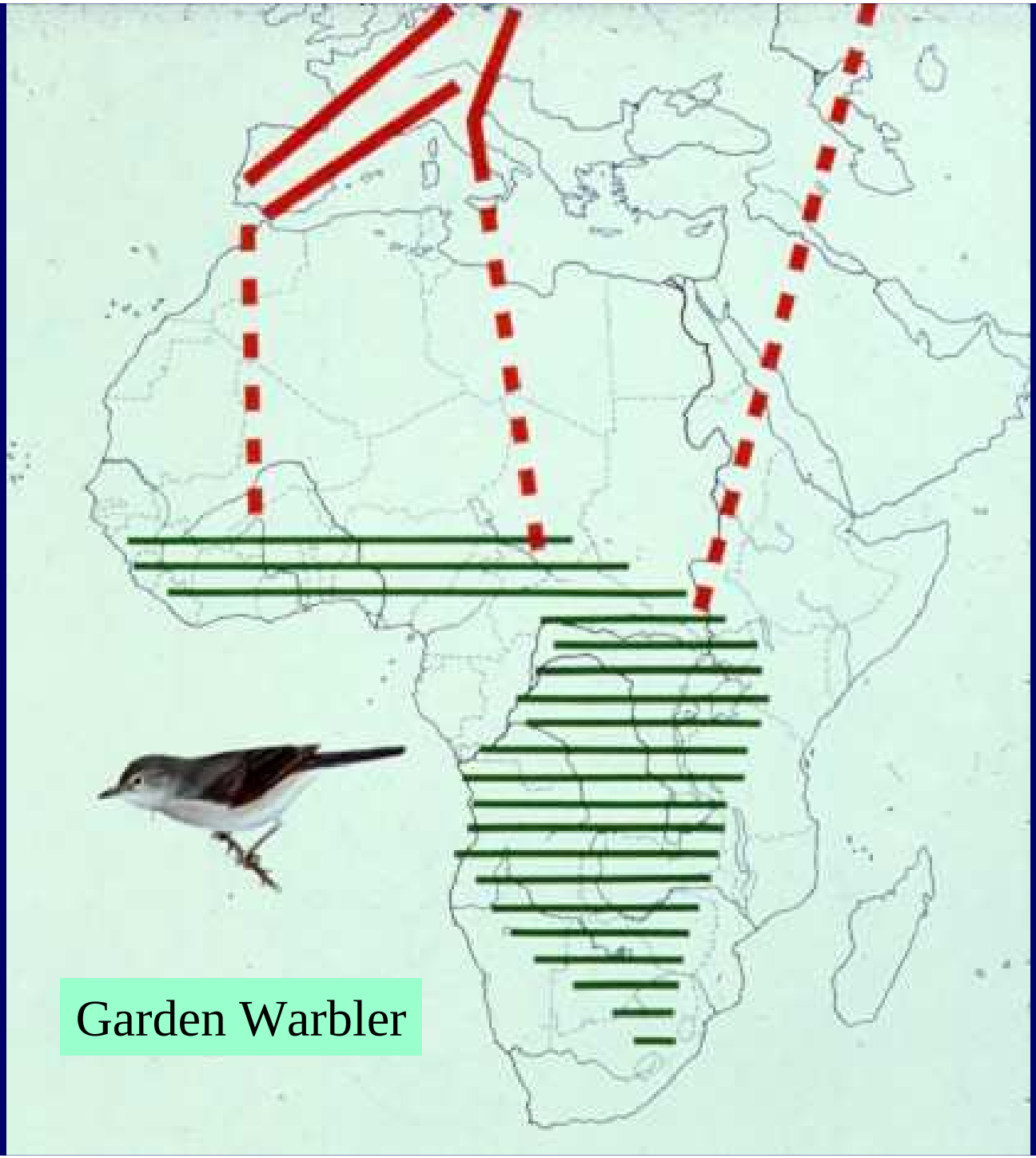
European Science Foundation Network
Palaearctic-African Songbird Migration



- standardisation
- training
- calibration

Bairlein et al. 1994




Garden Warbler

Garden Warbler

autumn
spring
* winter

body mass (g)

24
22
20
18
16

Hamburg
Lake of Constance
S-France
SW-Spain
N-Sahara
N-Algeria
Nigeria
* Ghana

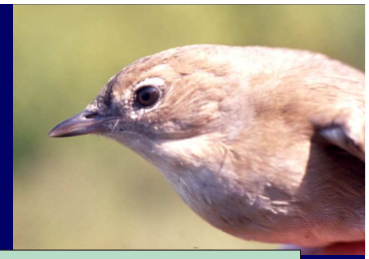
55 50 45 40 35 30 25 20 15 10 5 0

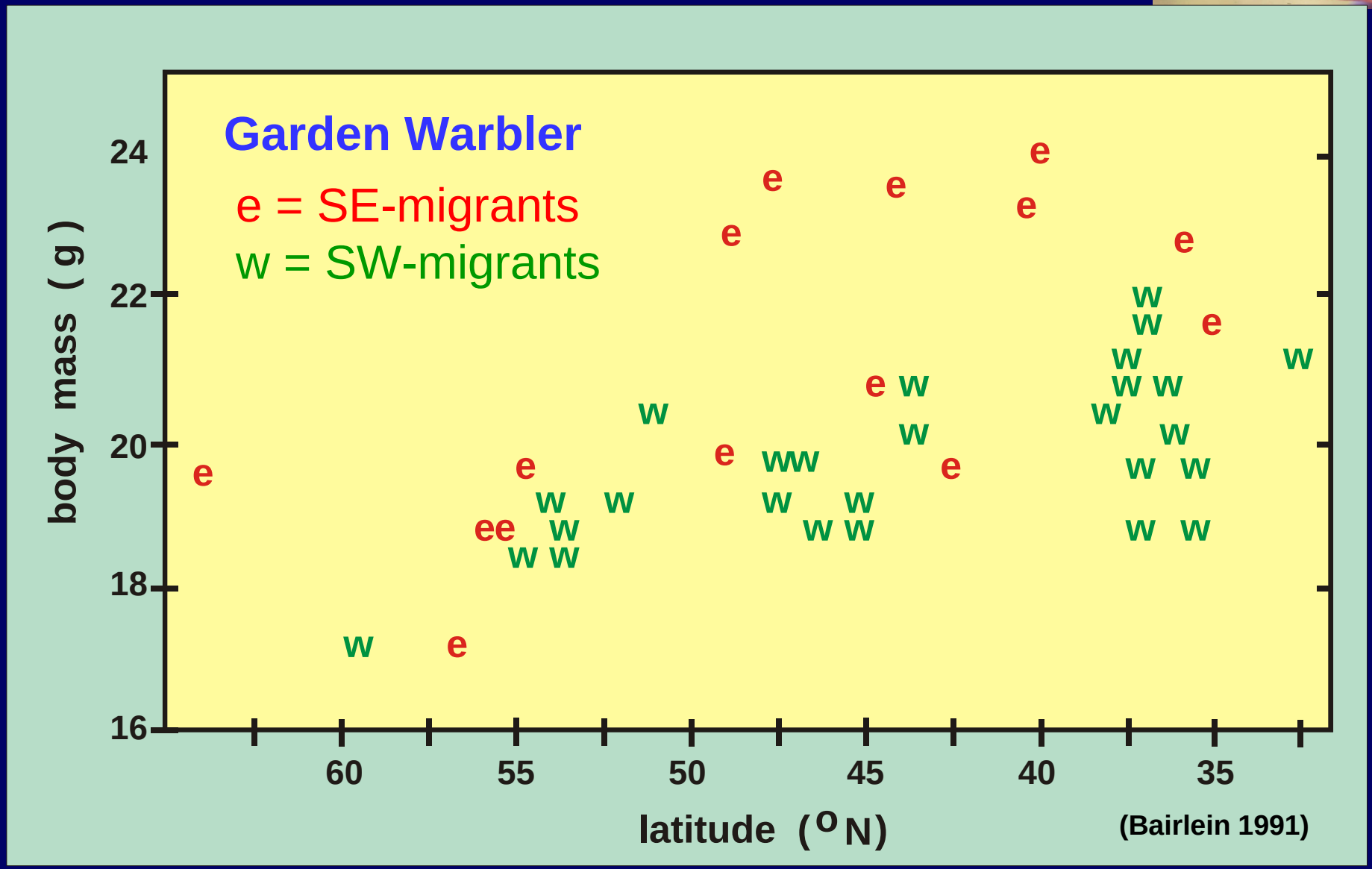
Sahara

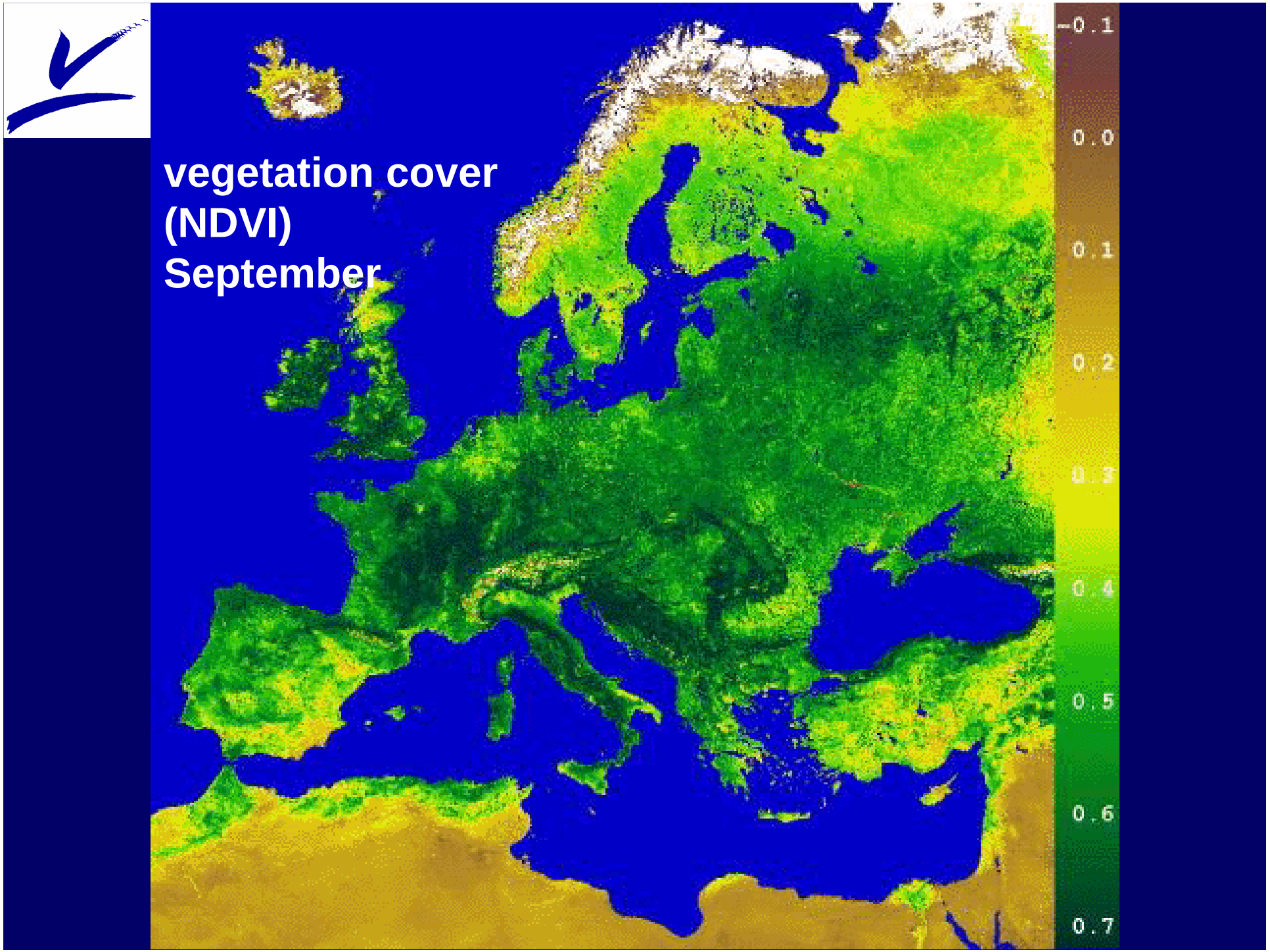
latitude

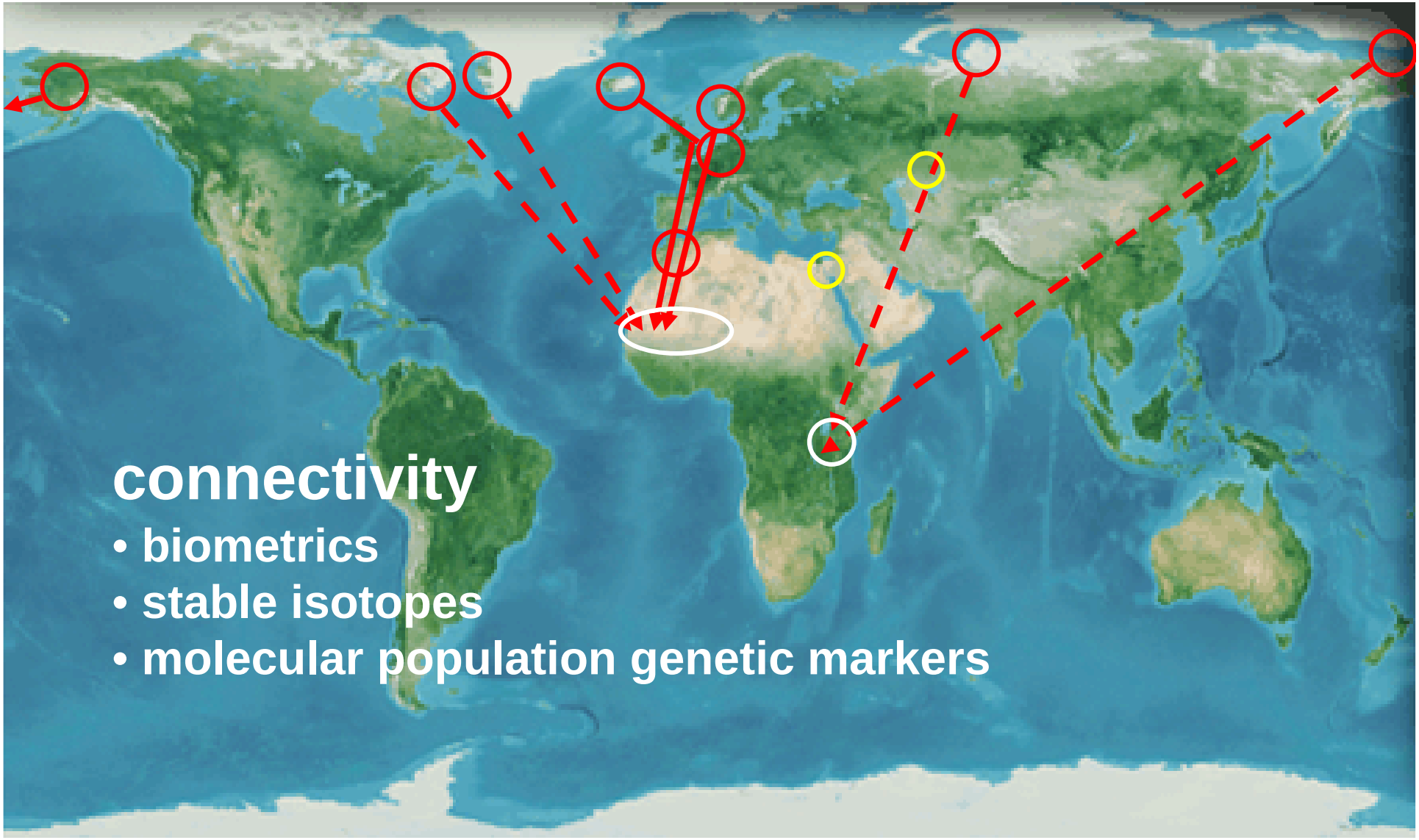
Bairlein 1991

fuelling



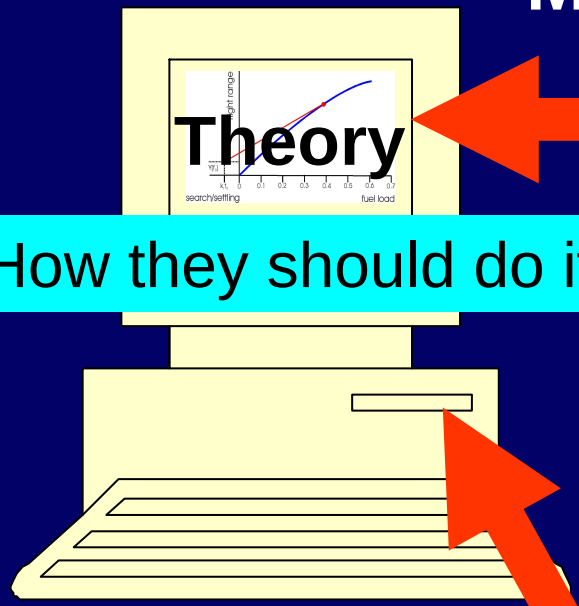

Garden Warbler
e = SE-migrants
w = SW-migrants
body mass (g)
24
22
20
18
16
60
55
50
45
40
35
latitude (°N)
(Bairlein 1991)

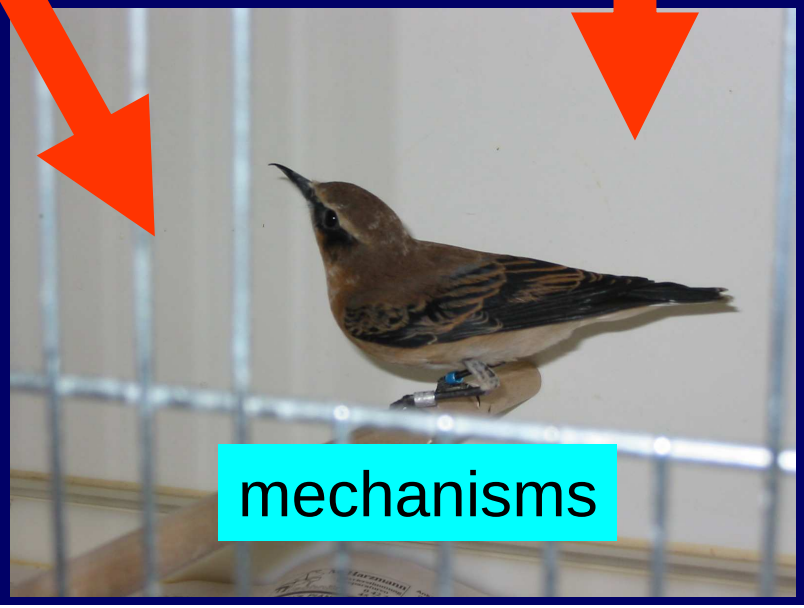

vegetation cover
(NDVI)
September
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7


connectivity
• biometrics
• stable isotopes
• molecular population genetic markers

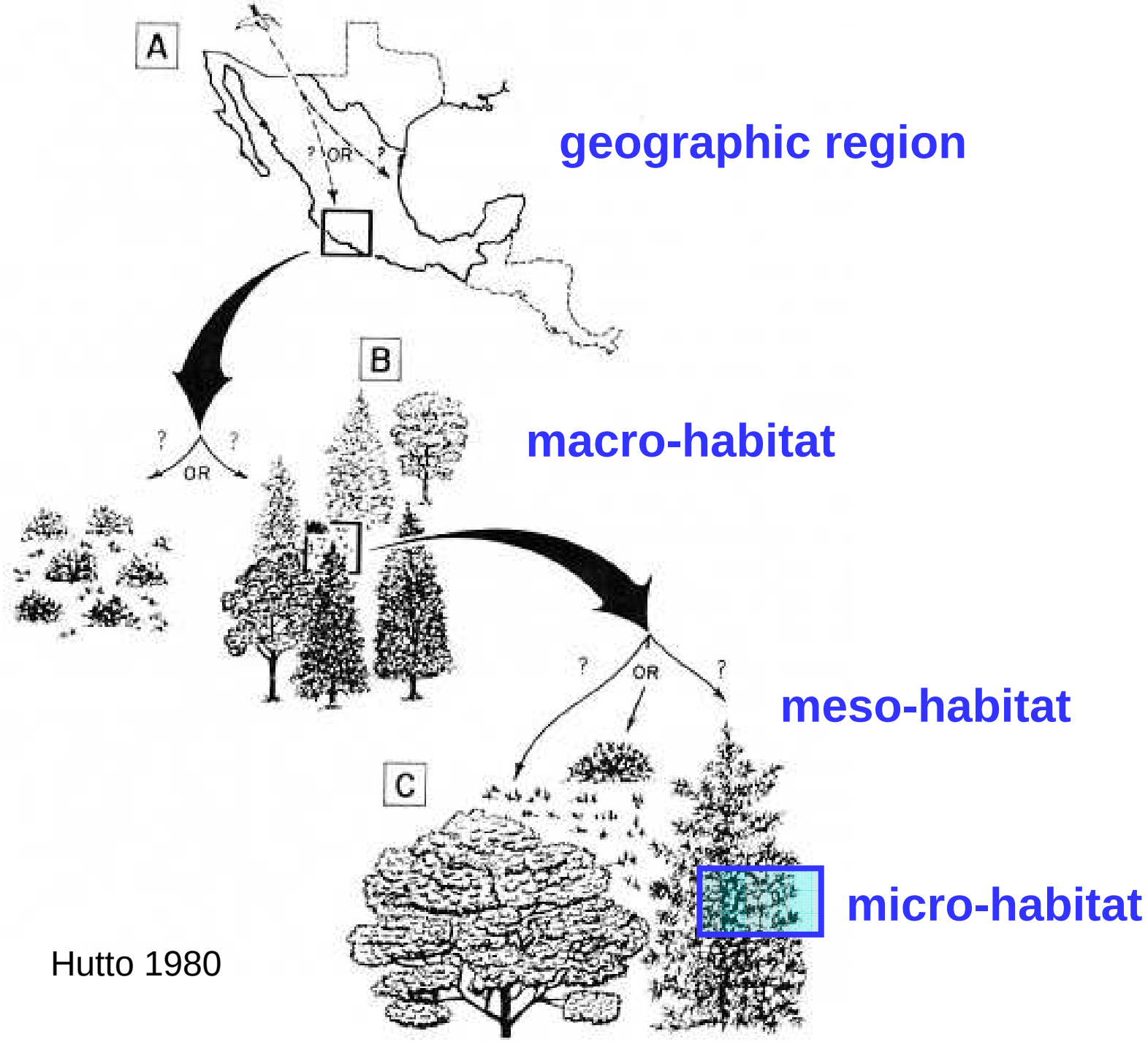
Integration

MIGRATION






habitat selection & habitat use
or, where do stopover migrants best and why



geographic region

macro-habitat

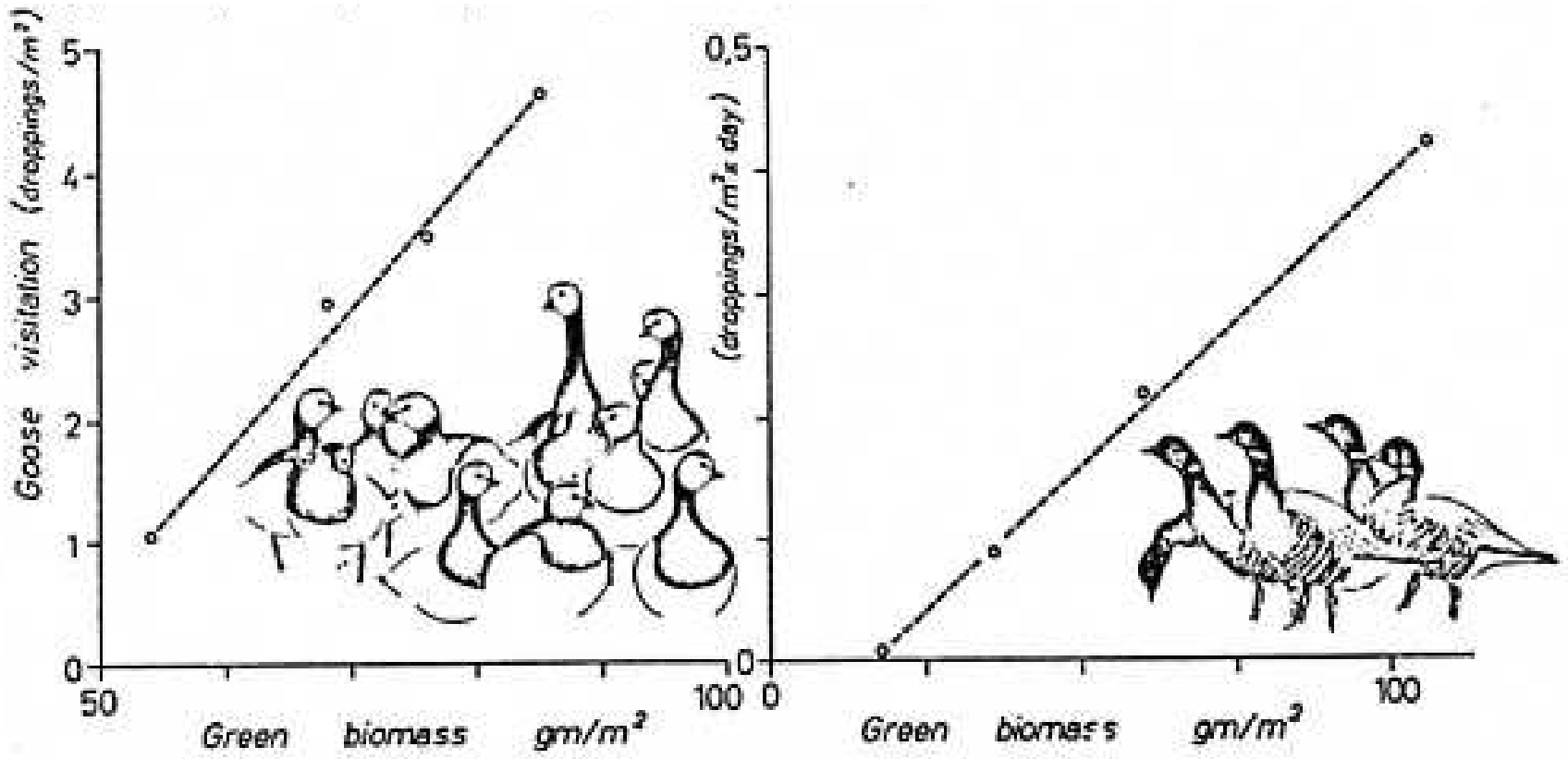
meso-habitat

micro-habitat

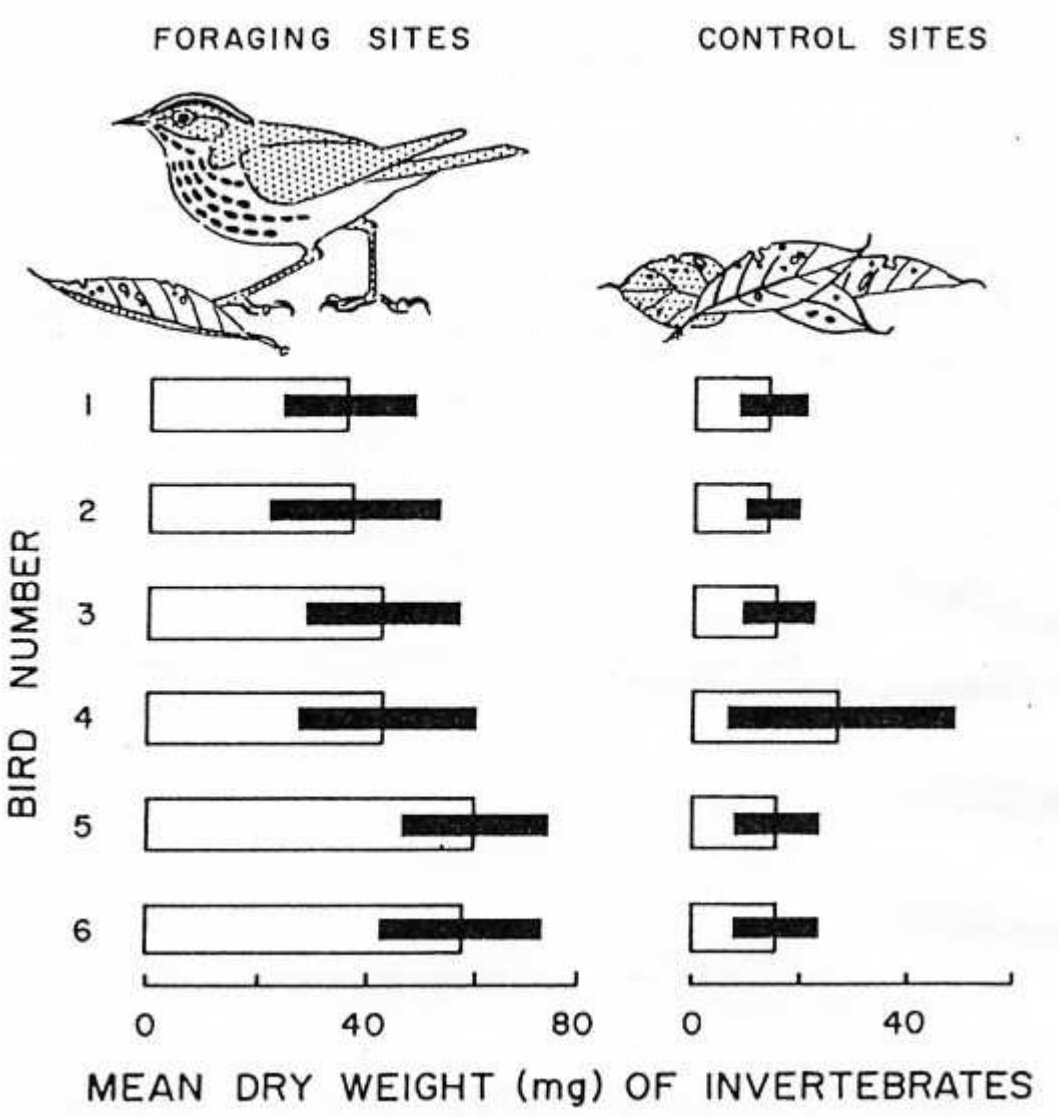
Hutto 1980

Barnacle Goose

Brent Goose

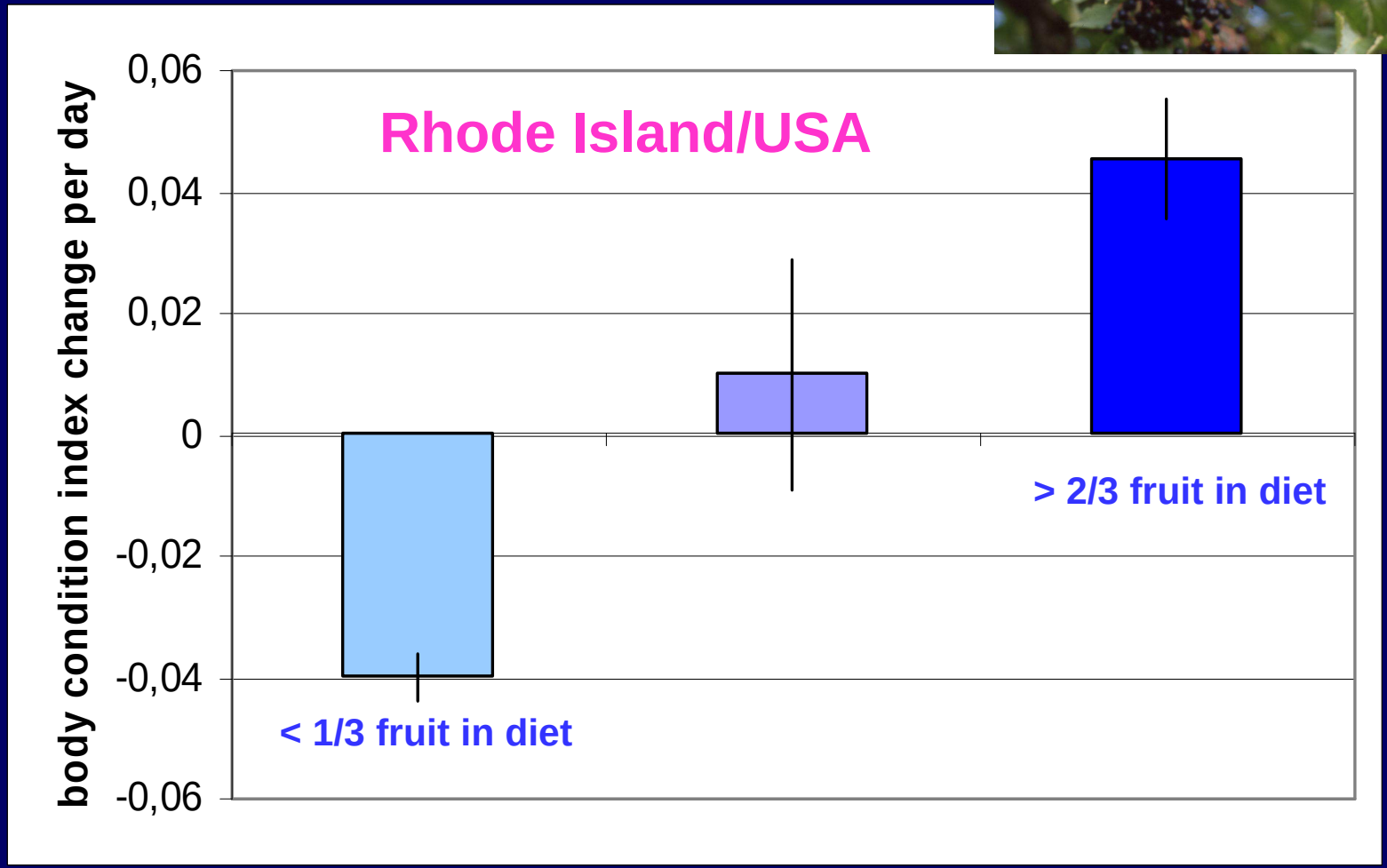


Seiurus aurocapillus
Worm-eating Warbler



Stopover and foraging ecology

fruit eating



(after Parrish et al. 1997)

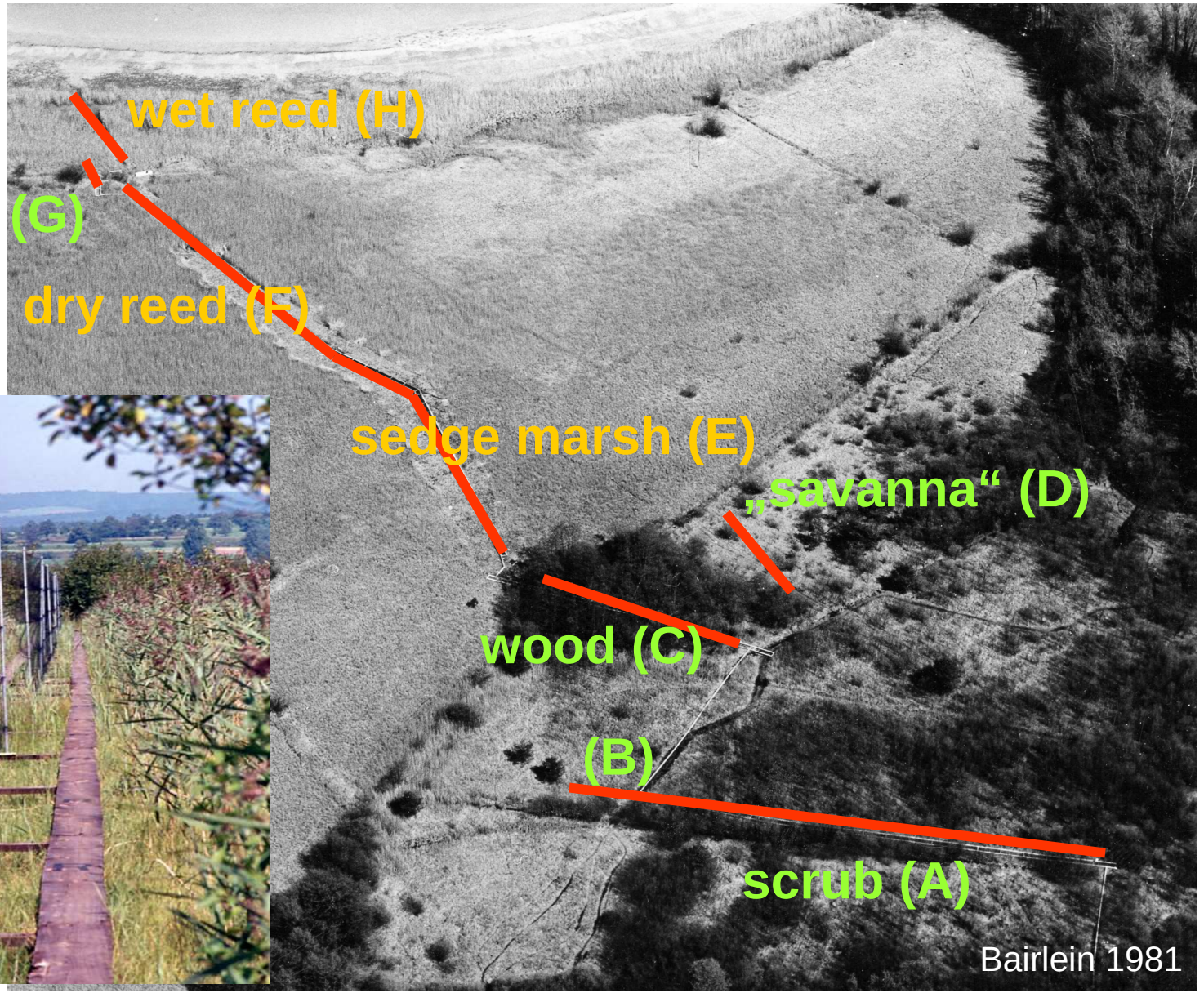
Stopover and foraging ecology

fruit eating

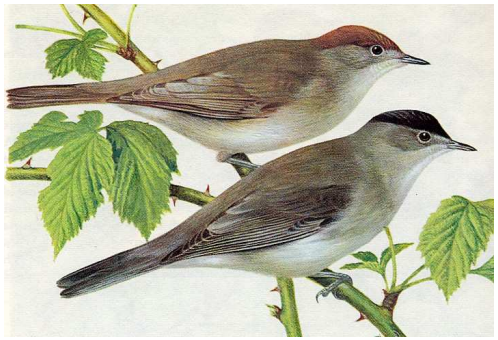
caught in fig trees	caught elsewhere	reference
23.8 ± 4.5 (21)*	19.7 ± 2.9 (31)	Thomas 1979 [Portugal]
24.2 ± 3.4 (120)**	20.2 ± 2.2 (116)	Baccetti et al. 1985 [Italy]
20.9 ± 3.6 (55)*	19.4 ± 2.5 (302)	Bairlein 1991 [Algeria]

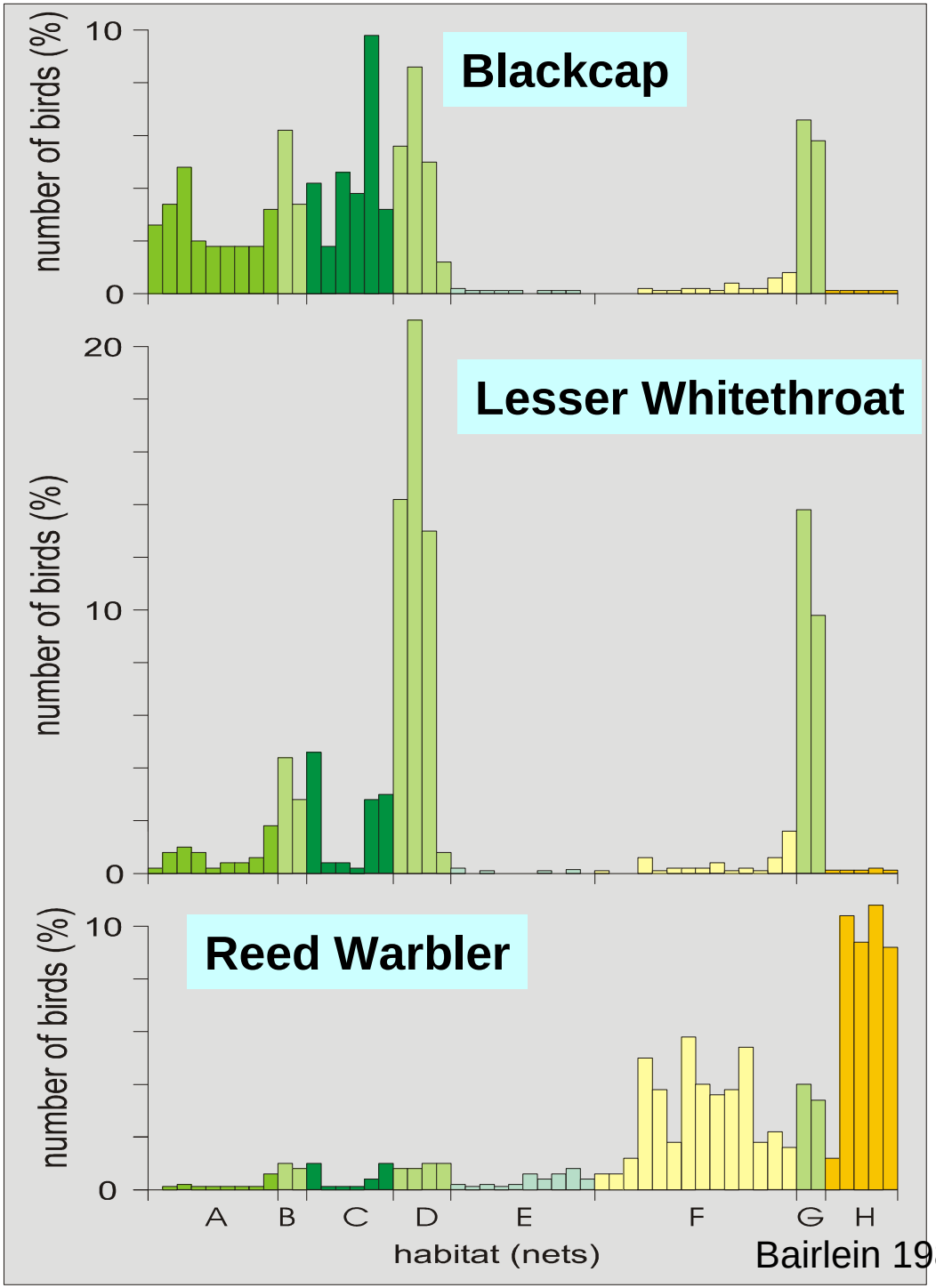
** $p < 0.01$
* $p < 0.05$

habitat selection & habitat use



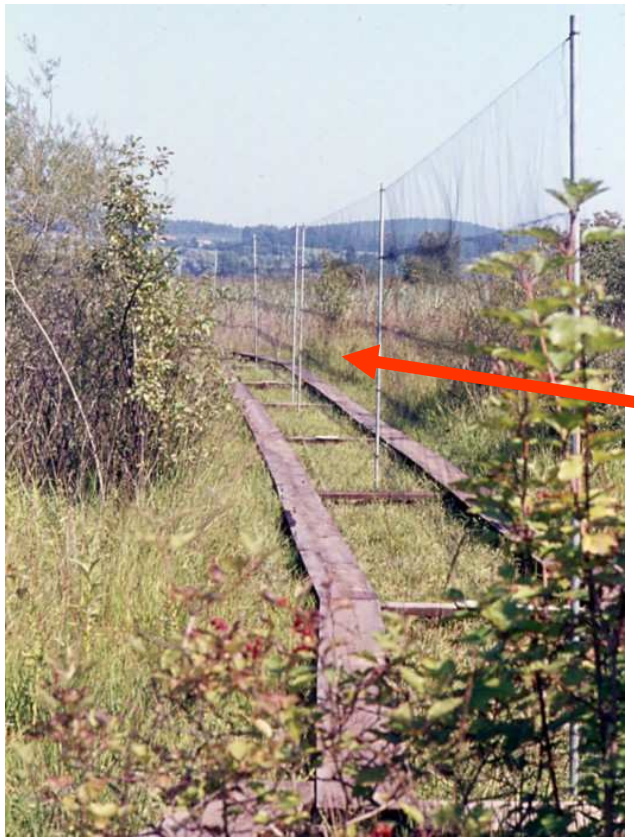
habitat selection

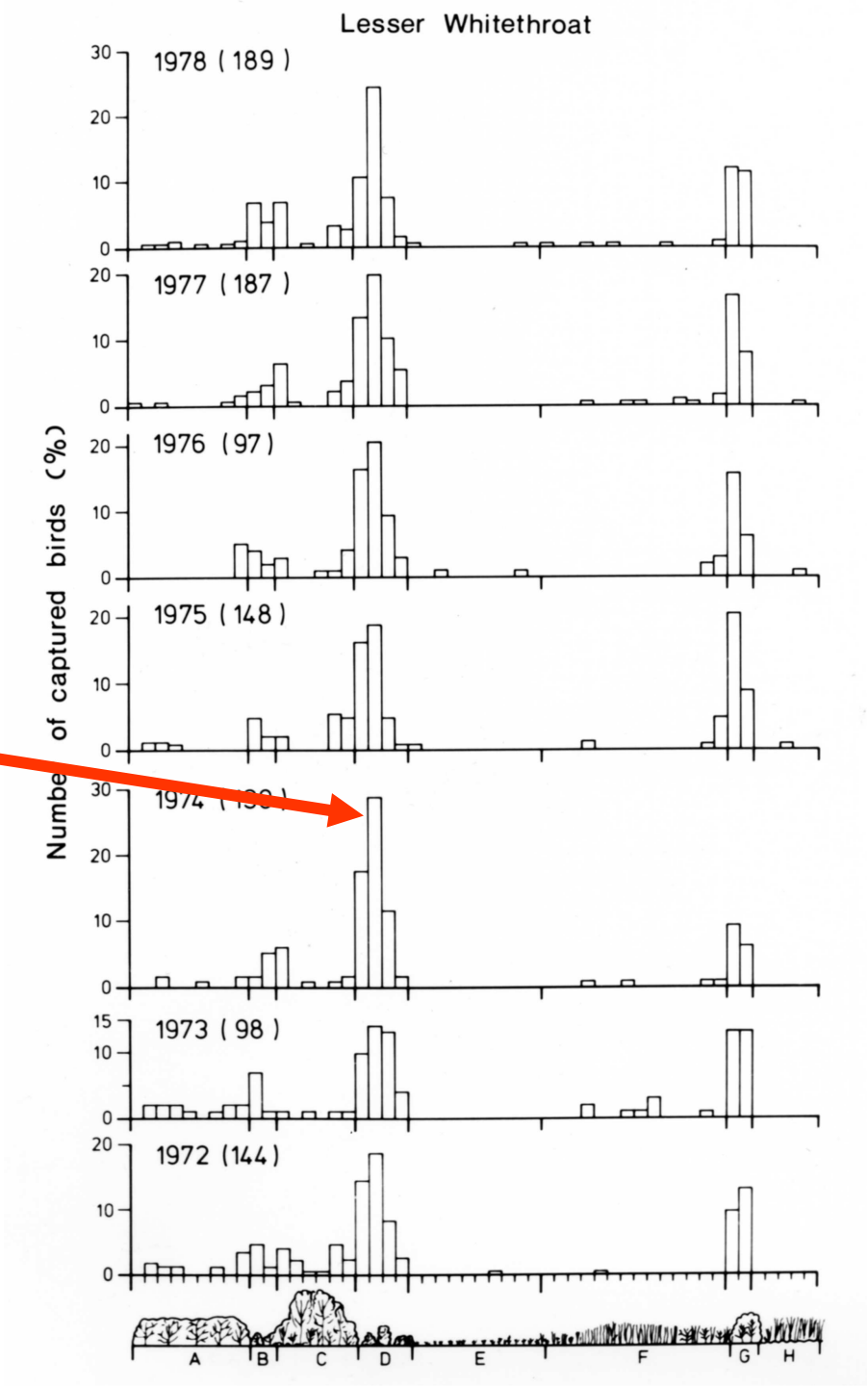




Bairlein 1981

habitat selection
year-to-year

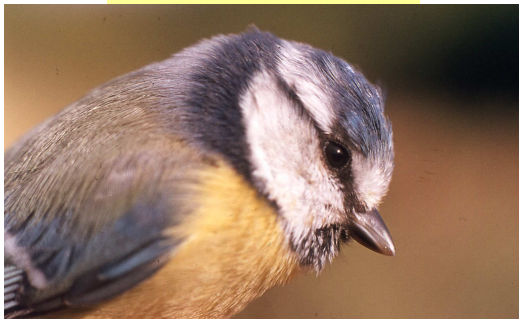


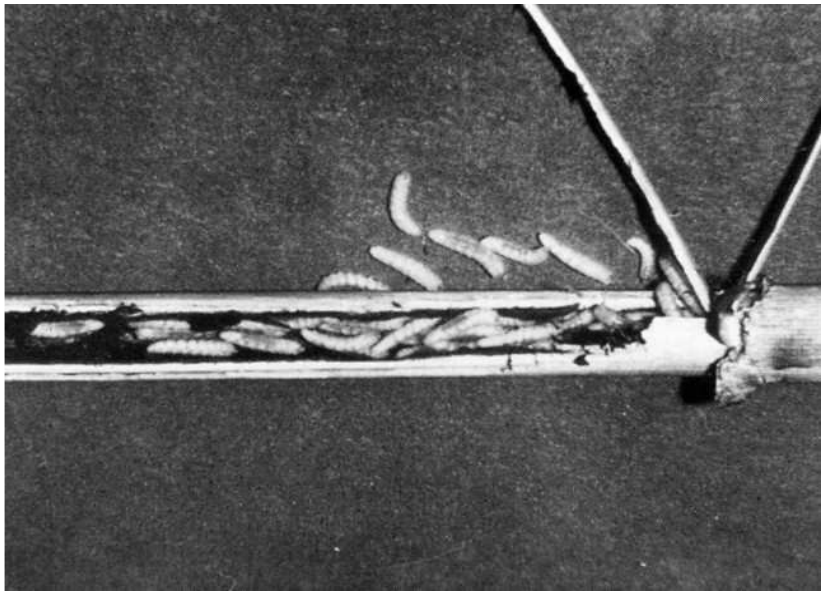


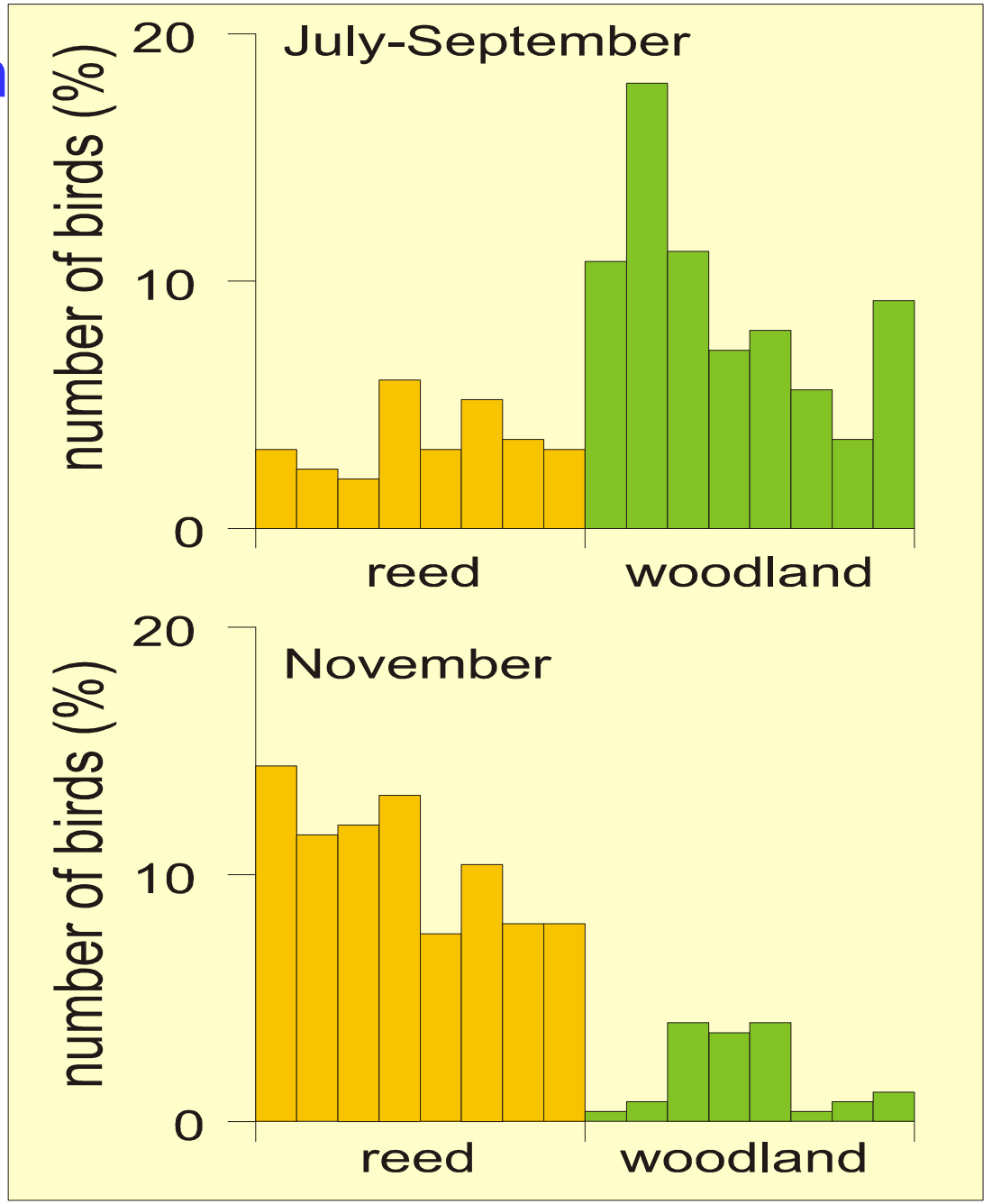
Bairlein 1981

habitat selection
seasonal

Blue Tit



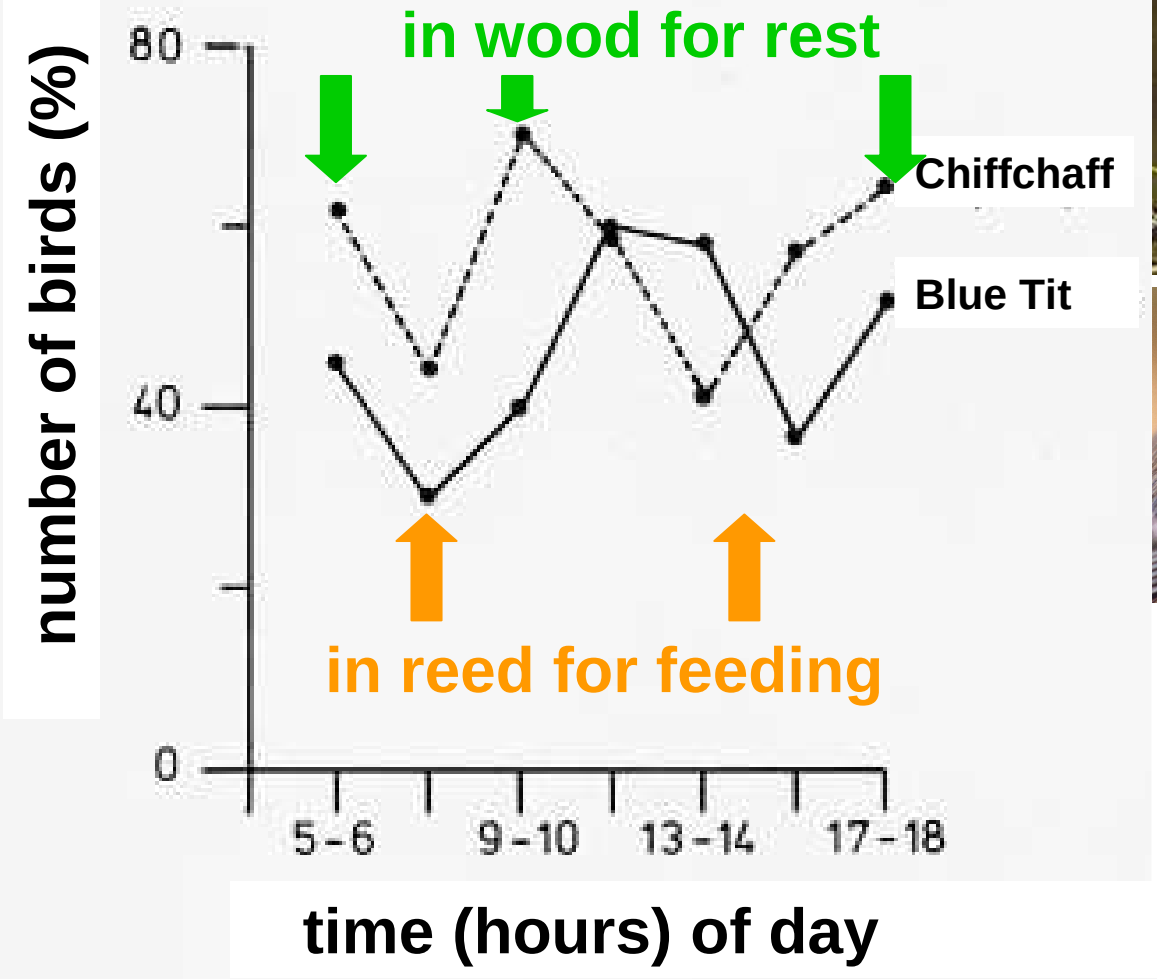




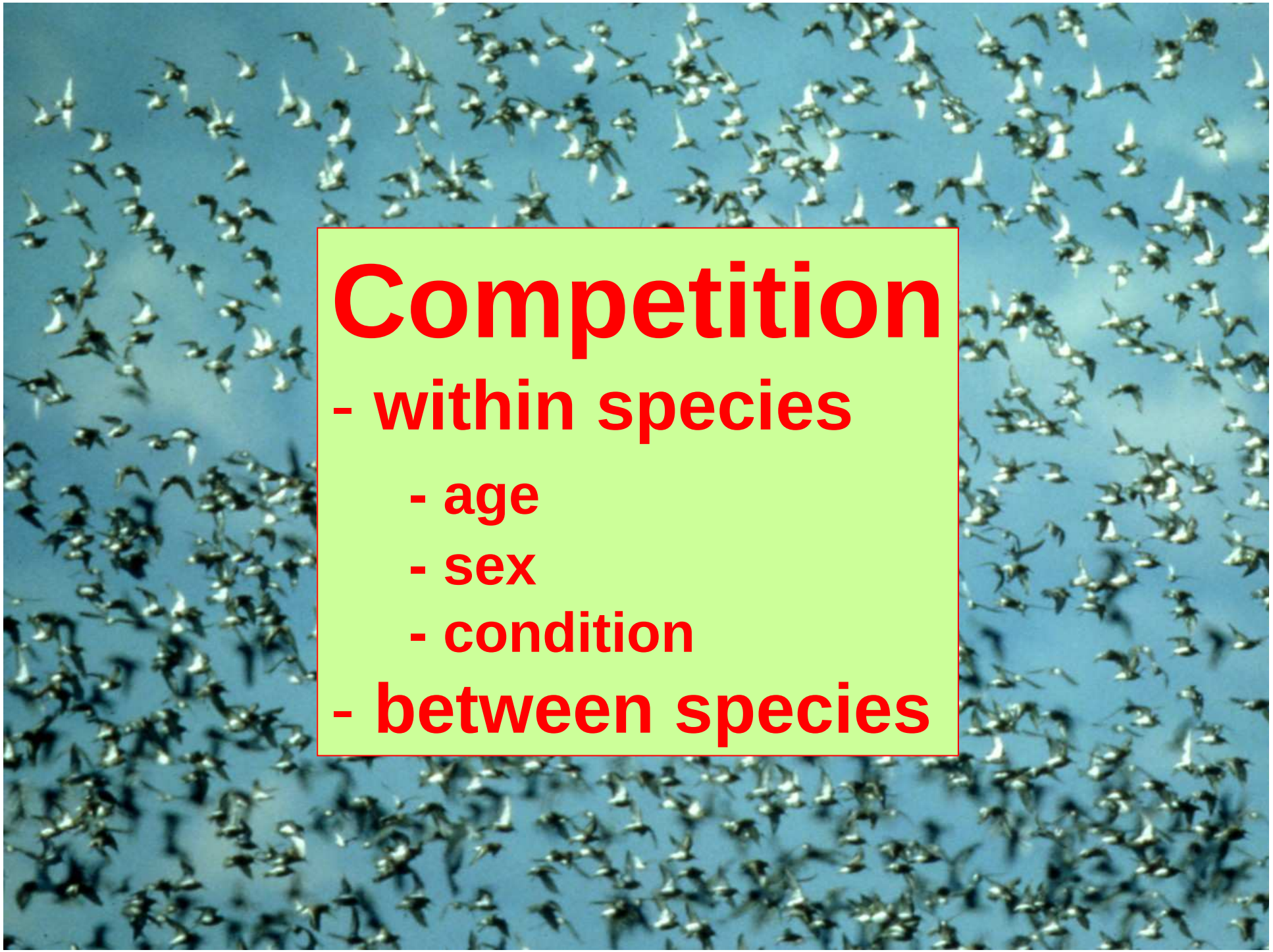
Bairlein 1980

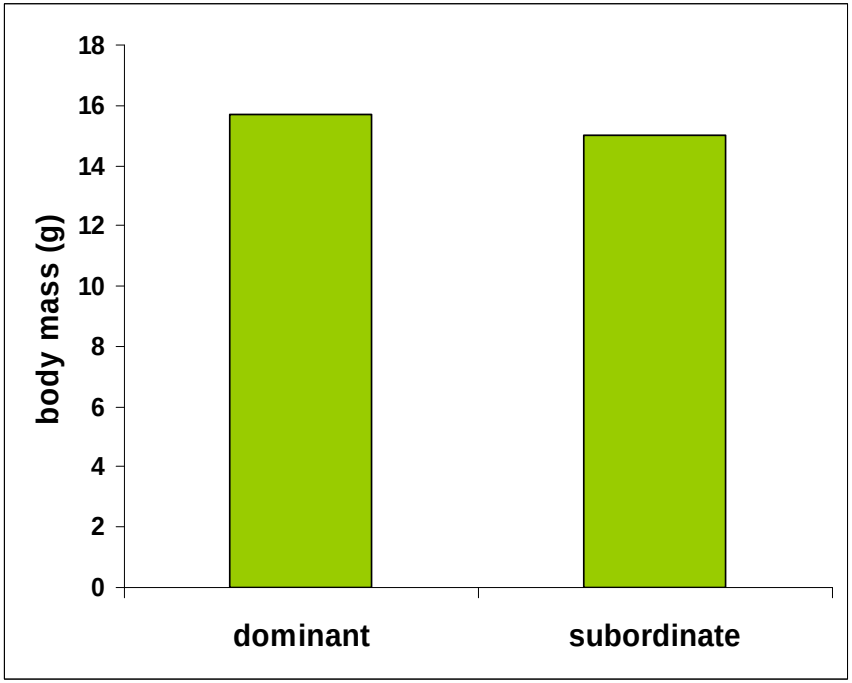
habitat selection
diurnal

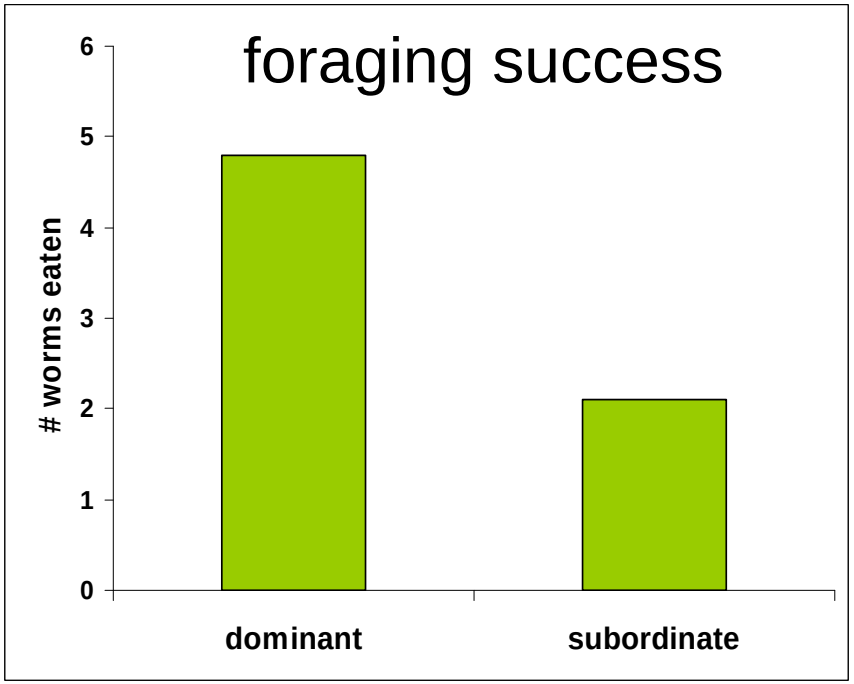
proportian of birds in woodland
***versus* in reed**



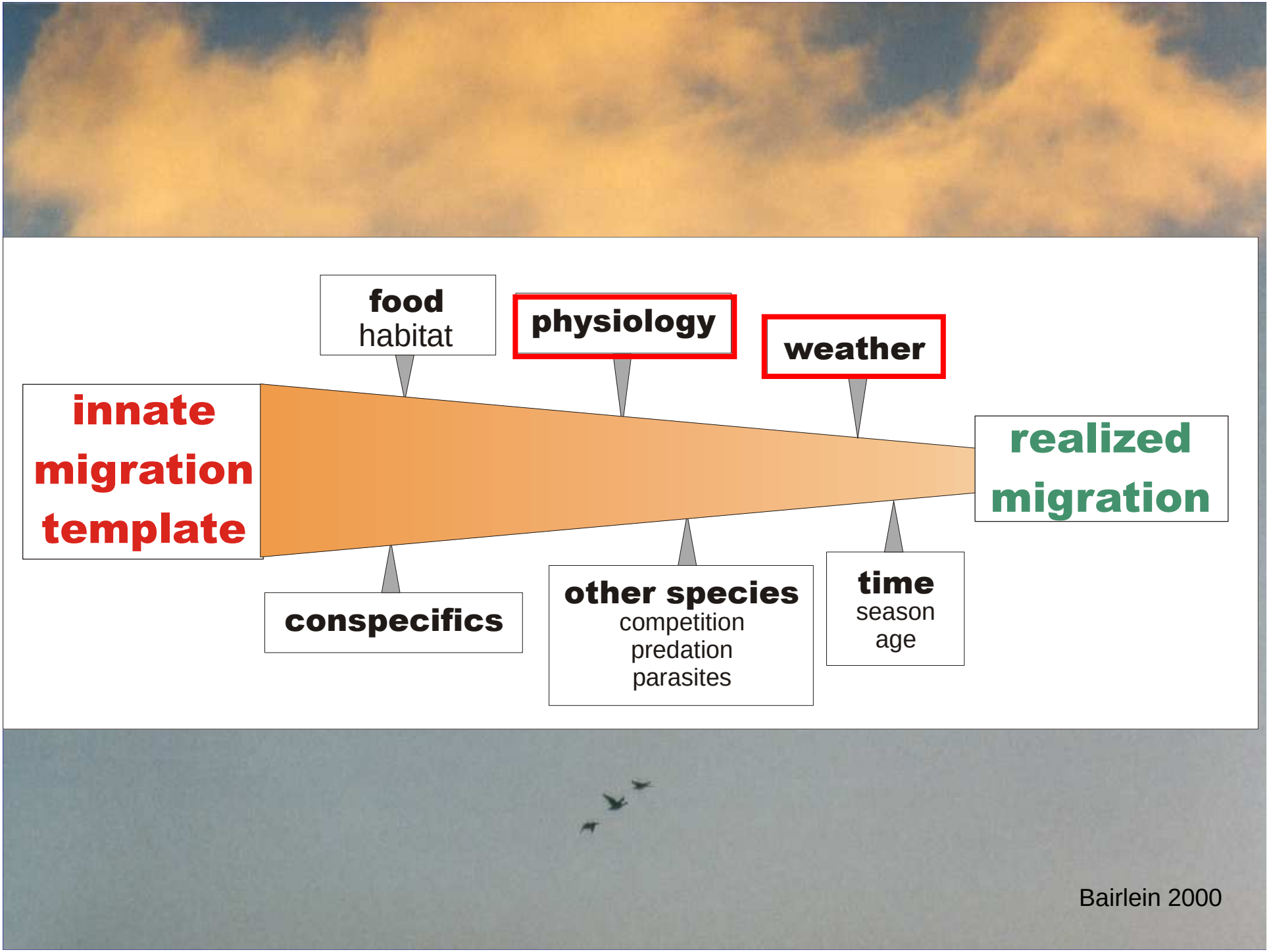
Bairlein 1980

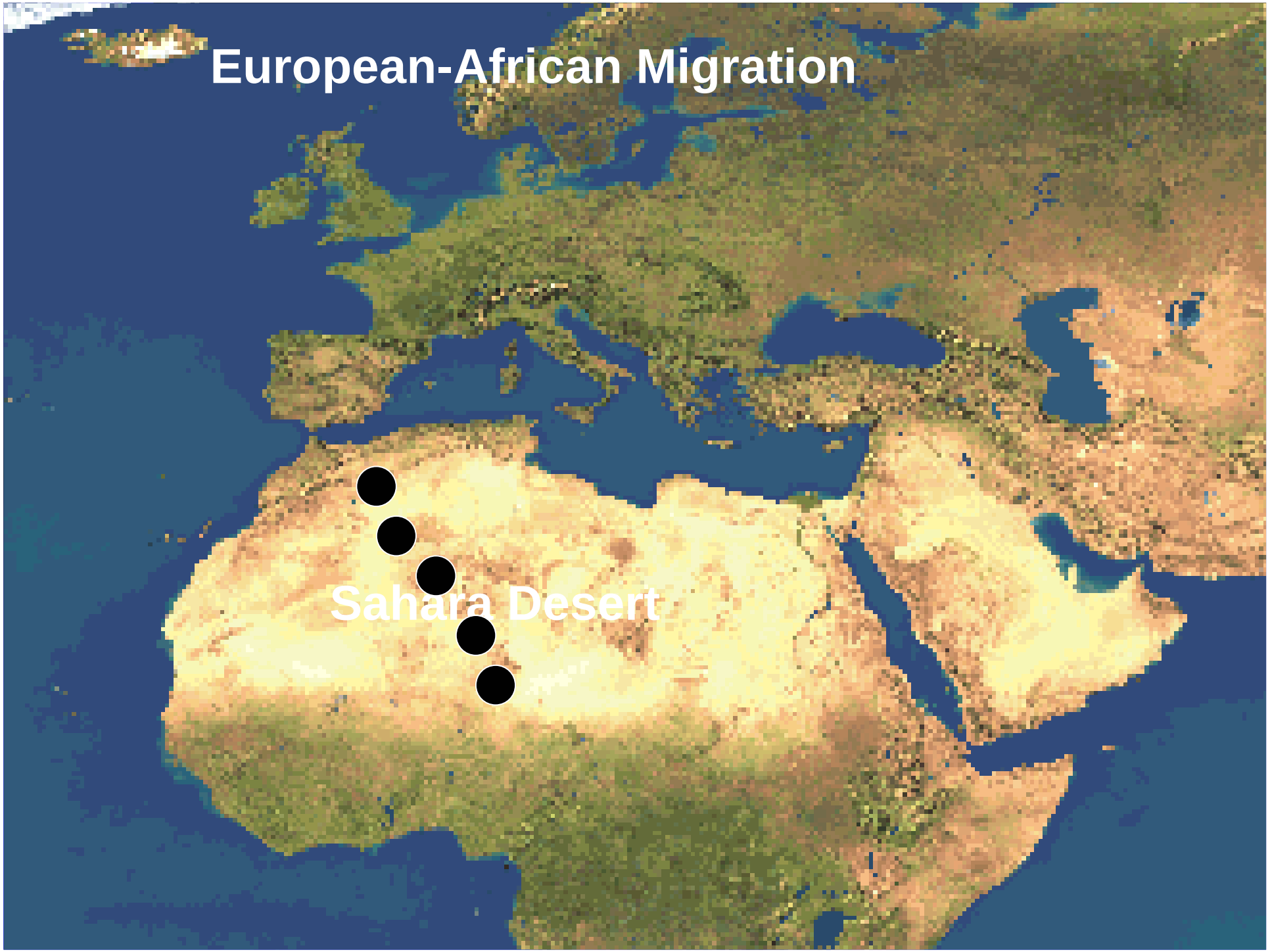

Competition
- within species
- age
- sex
- condition
- between species

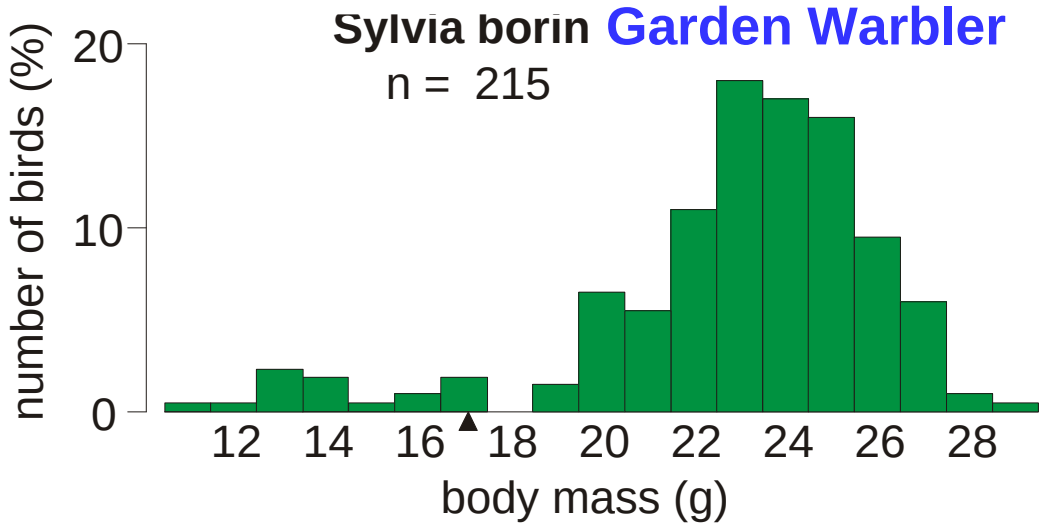


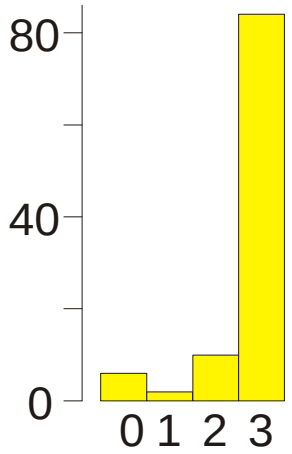


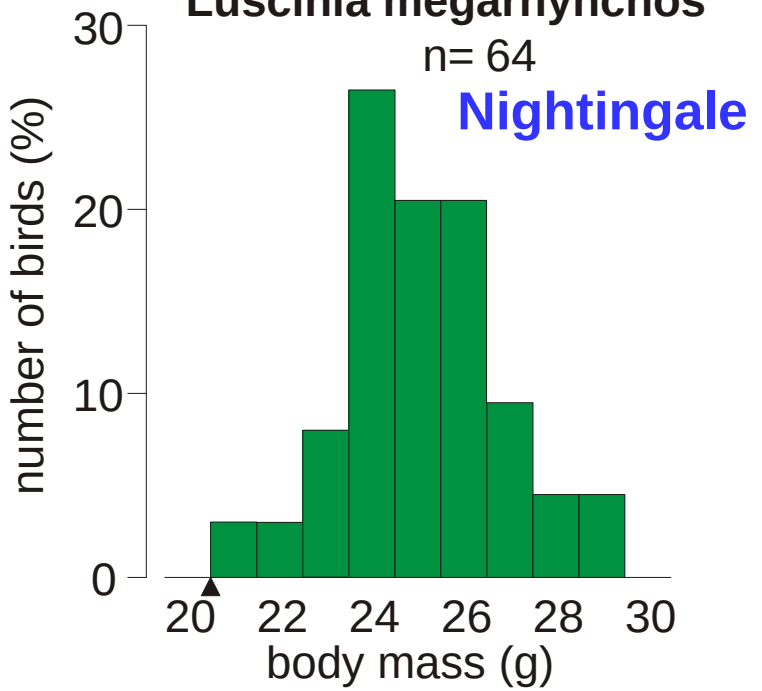
Moore et al. 2003

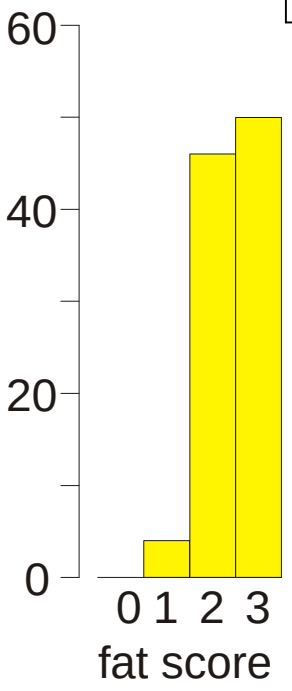

food
habitat
physiology
weather
innate migration template
realized migration
conspecifics
other species
competition
predation
parasites
time
season
age
Bairlein 2000


European-African Migration
Sahara Desert



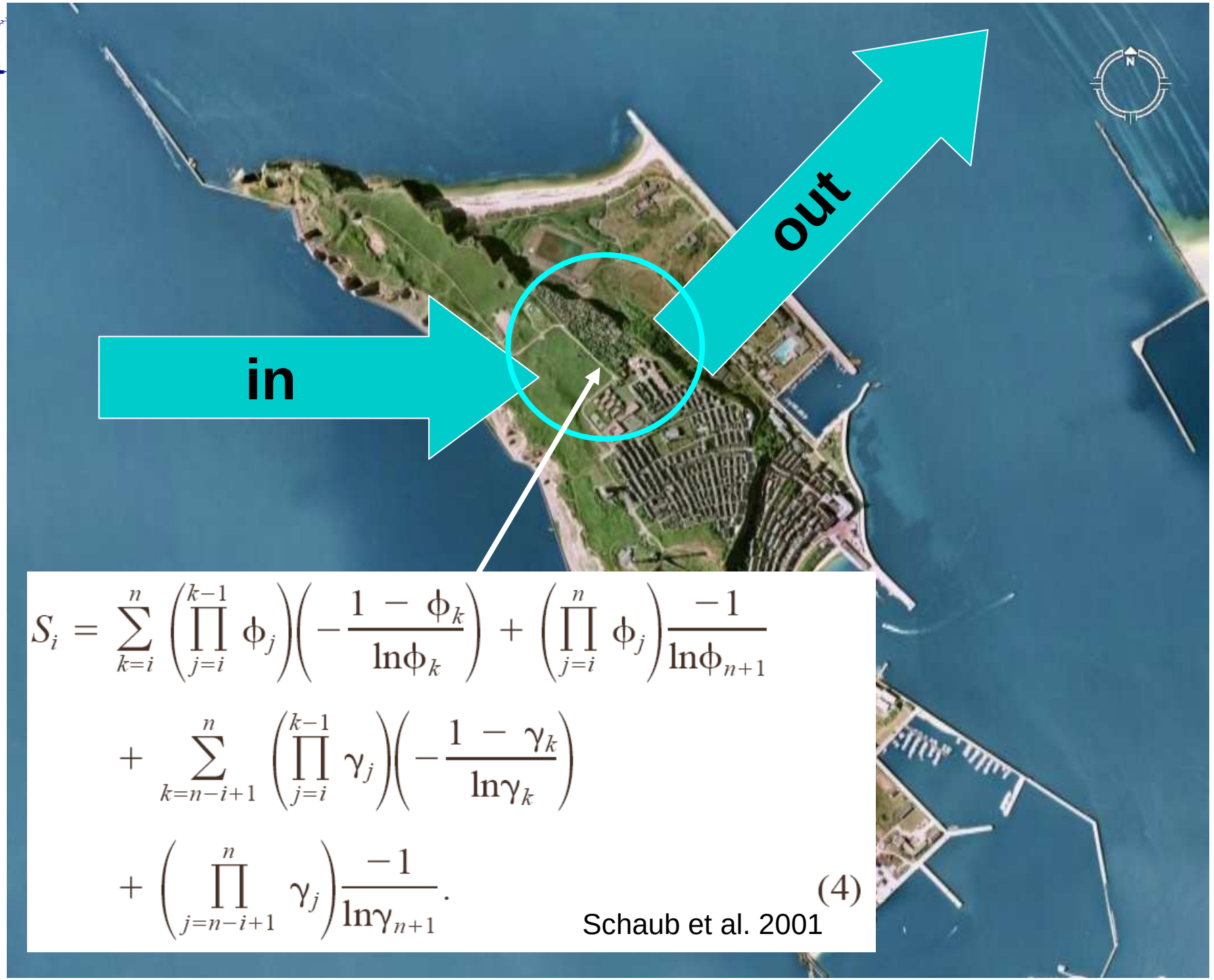






Bairlein 1985


out
in
- stopover duration
- turnover rate

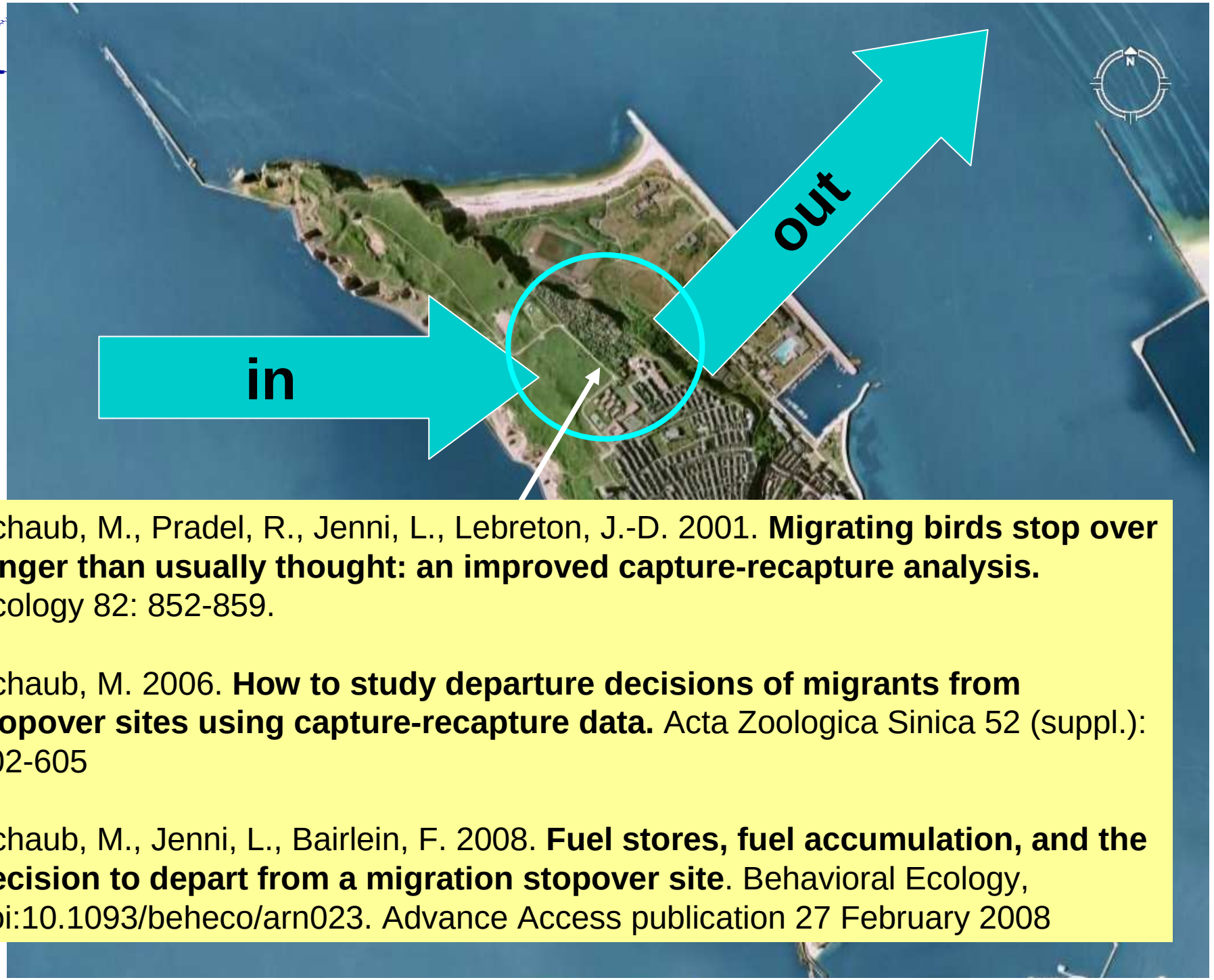


$$S_i = \sum_{k=i}^{n} \left(\prod_{j=i}^{k-1} \phi_j \right) \left(-\frac{1-\phi_k}{\ln \phi_k} \right) + \left(\prod_{j=i}^{n} \phi_j \right) \frac{-1}{\ln \phi_{n+1}}$$

$$+ \sum_{k=n-i+1}^{n} \left(\prod_{j=i}^{k-1} \gamma_j \right) \left(-\frac{1-\gamma_k}{\ln \gamma_k} \right)$$

$$+ \left(\prod_{j=n-i+1}^{n} \gamma_j \right) \frac{-1}{\ln \gamma_{n+1}}. \qquad (4)$$

Schaub et al. 2001

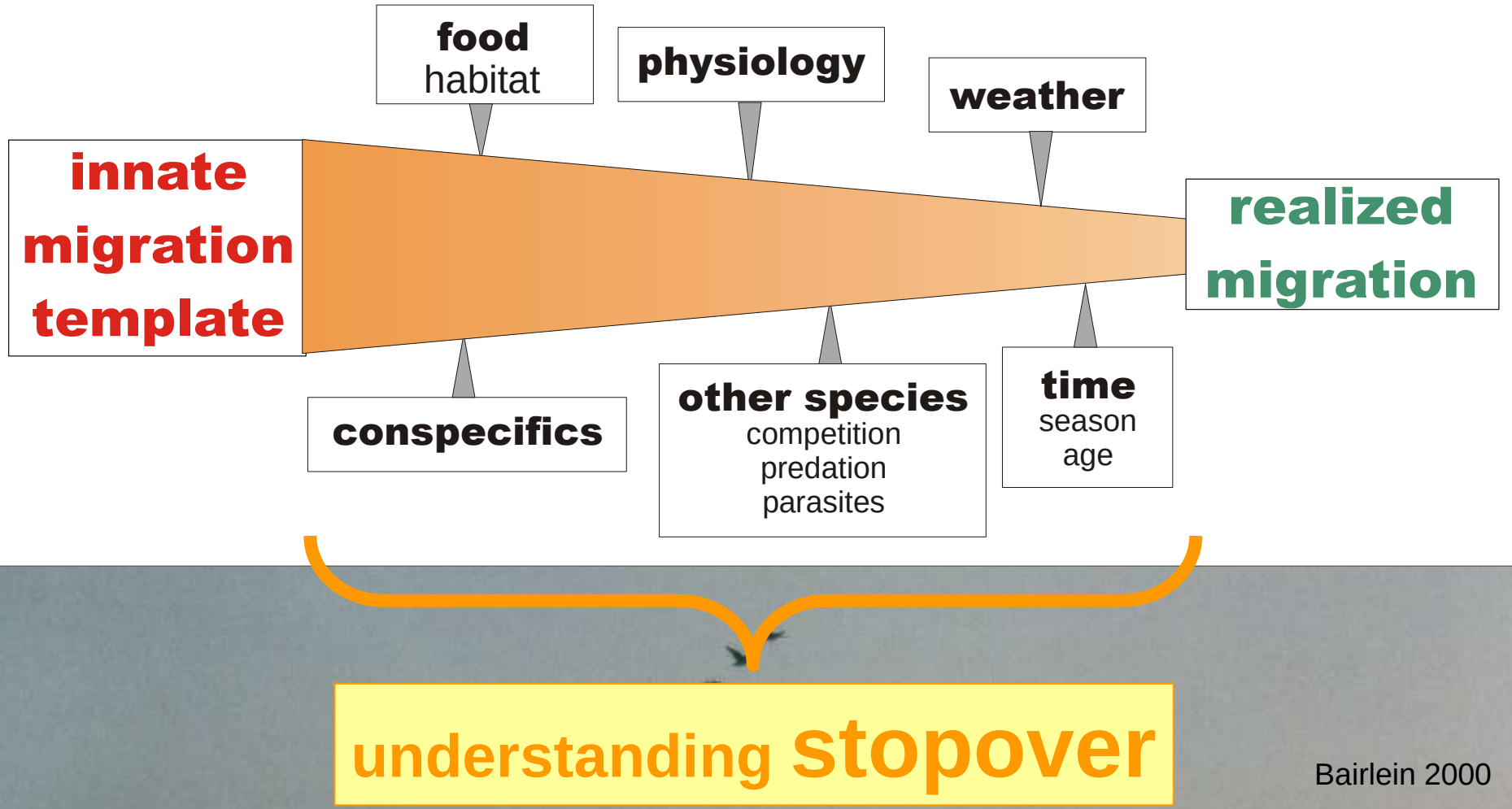


Schaub, M., Pradel, R., Jenni, L., Lebreton, J.-D. 2001. **Migrating birds stop over longer than usually thought: an improved capture-recapture analysis.** Ecology 82: 852-859.

Schaub, M. 2006. **How to study departure decisions of migrants from stopover sites using capture-recapture data.** Acta Zoologica Sinica 52 (suppl.): 602-605

Schaub, M., Jenni, L., Bairlein, F. 2008. **Fuel stores, fuel accumulation, and the decision to depart from a migration stopover site**. Behavioral Ecology, doi:10.1093/beheco/arn023. Advance Access publication 27 February 2008

How birds migrate –



Bairlein 2000