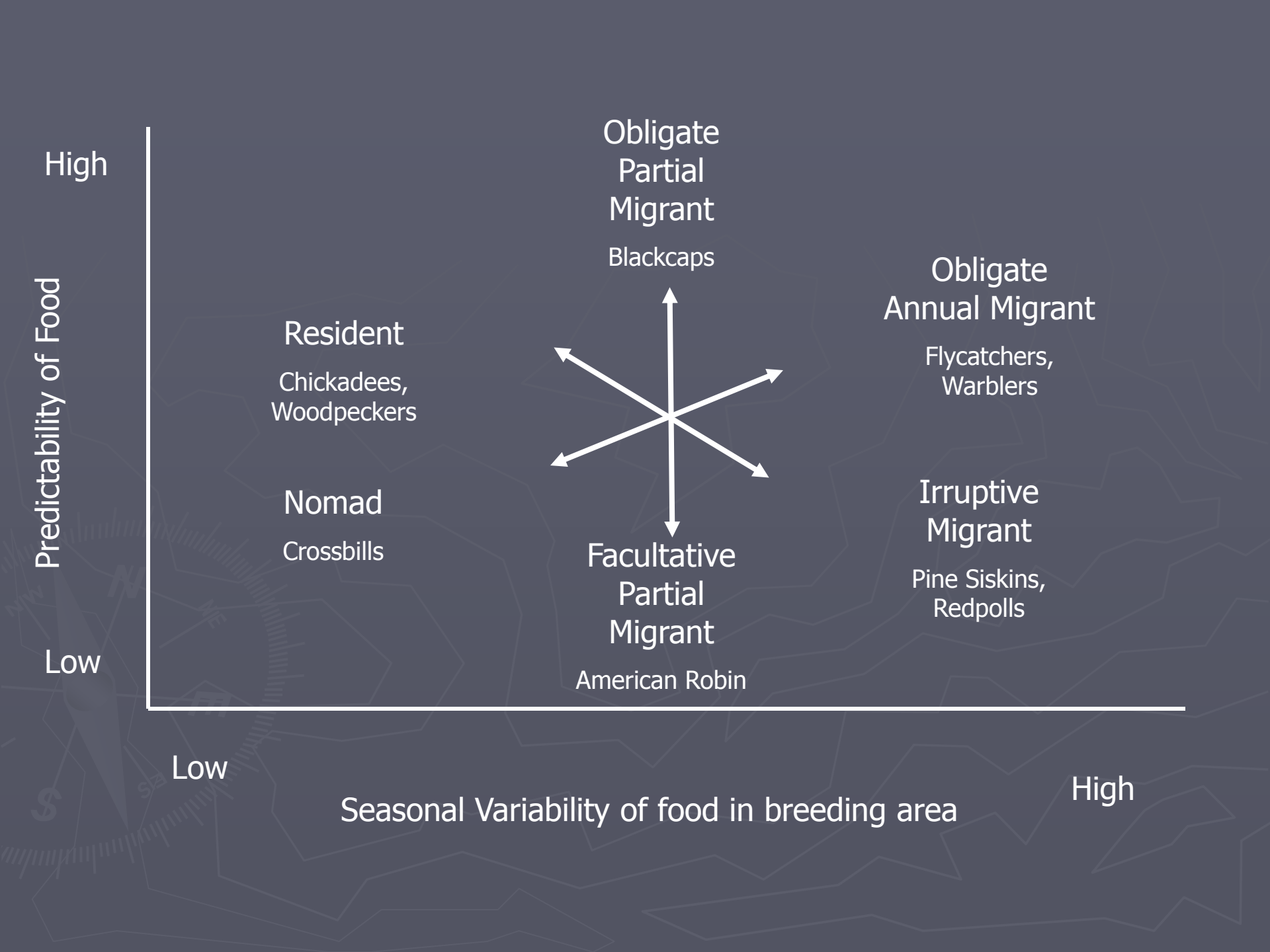
Evolution (continued)

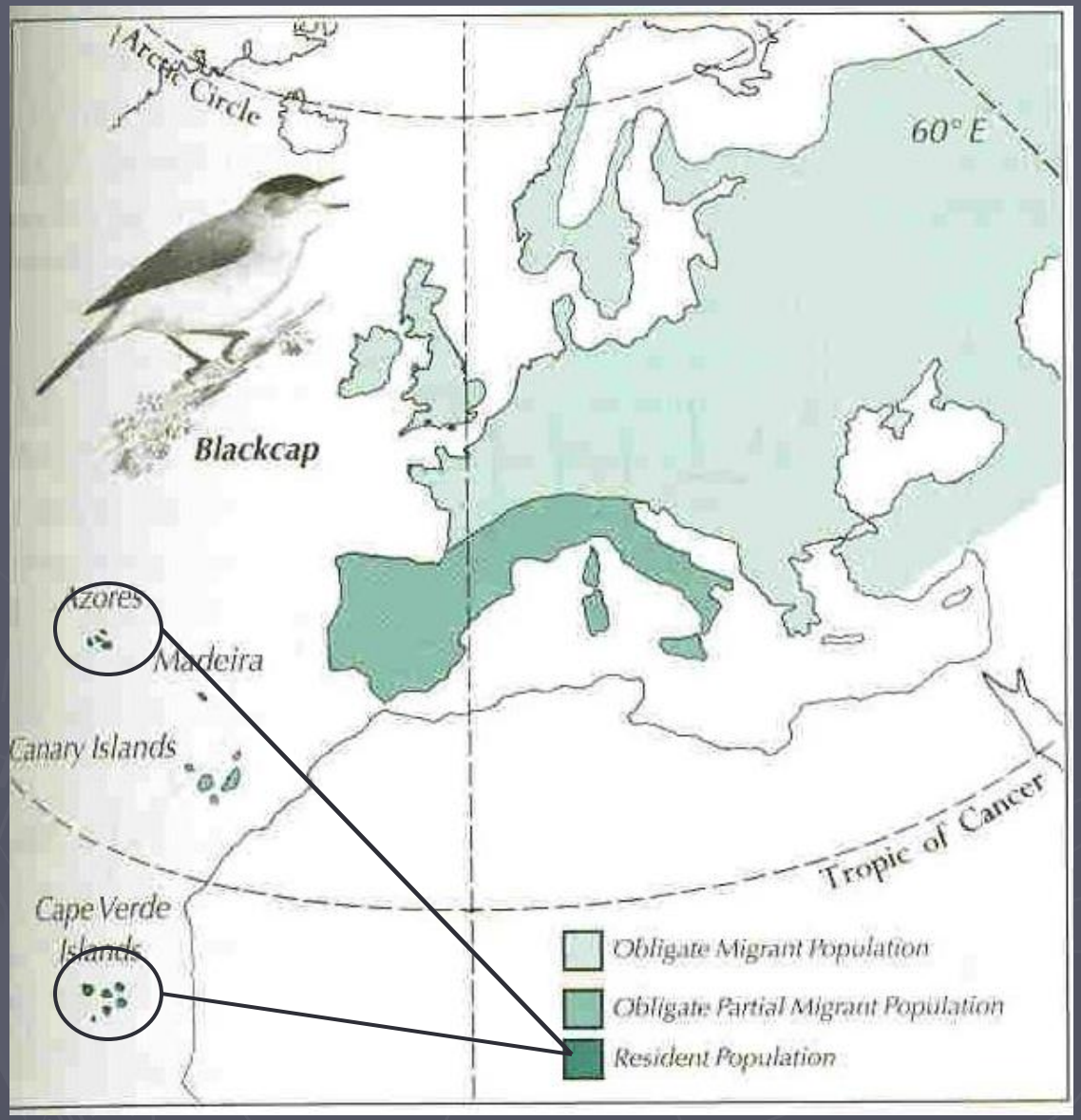
Model for evolution of different migratory strategies


High
Predictability of Food
Low
Obligate Partial Migrant
Blackcaps
Resident
Chickadees, Woodpeckers
Obligate Annual Migrant
Flycatchers, Warblers
Nomad
Crossbills
Irruptive Migrant
Pine Siskins, Redpolls
Facultative Partial Migrant
American Robin
Low
High
Seasonal Variability of food in breeding area

Genetic Control

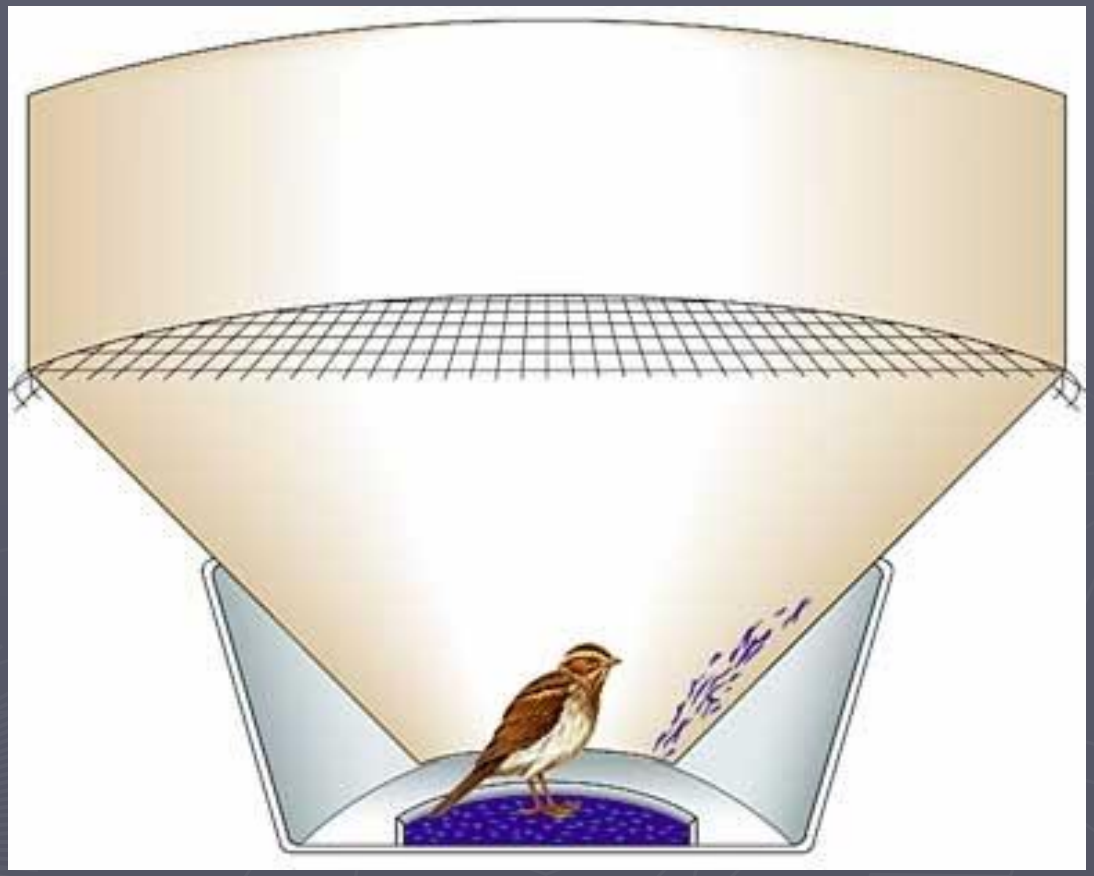
Long believed that variation in migratory behavior is under genetic control but not good data.

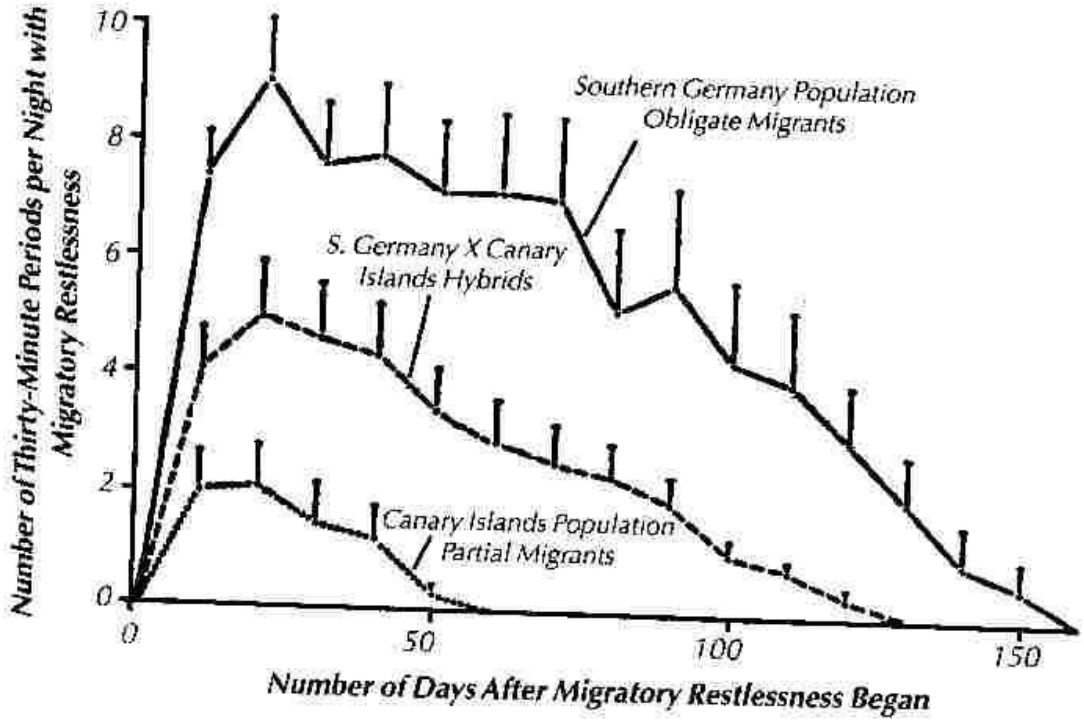
Eurasian Warbler - Blackcap

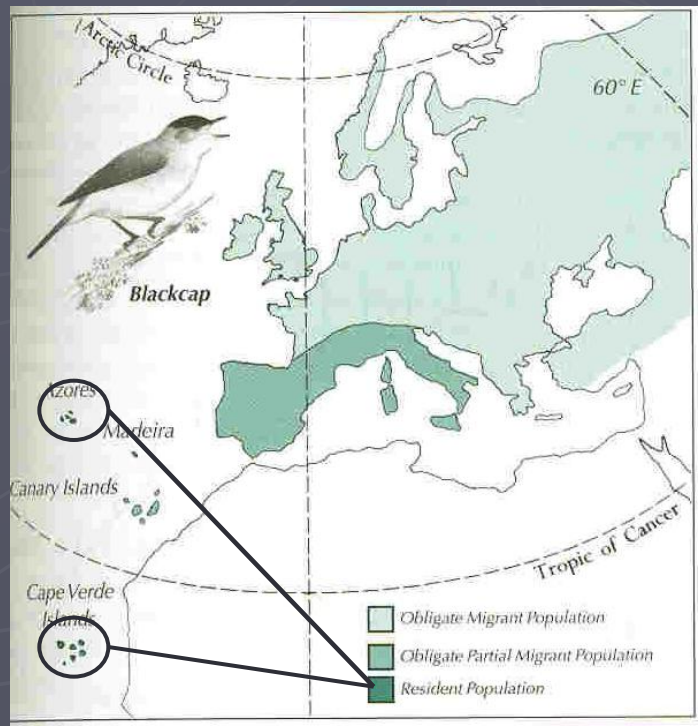

Arctic Circle
60° E
Blackcap
Azores
Madeira
Canary Islands
Tropic of Cancer
Cape Verde Islands
Obligate Migrant Population
Obligate Partial Migrant Population
Resident Population

Zugunruhe

- Migratory restlessness – nightly unrest because it occurs during the dark period of the day.
- Captive birds demonstrate a daily rhythm
  - Bird sleeps (15min – 2 hrs) then awakens and hops around in cage with increasing vigor until shortly after midnight.




Number of Thirty-Minute Periods per Night with Migratory Restlessness
10
8
6
4
2
0
Southern Germany Population
Obligate Migrants
S. Germany X Canary
Islands Hybrids
Canary Islands Population
Partial Migrants
0
50
100
150
Number of Days After Migratory Restlessness Began


Arctic Circle
60° E
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Obligate Migrant Population
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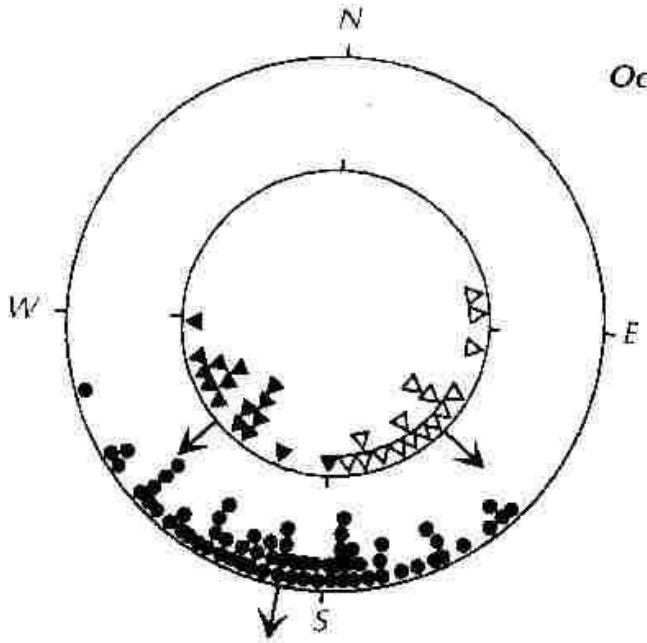
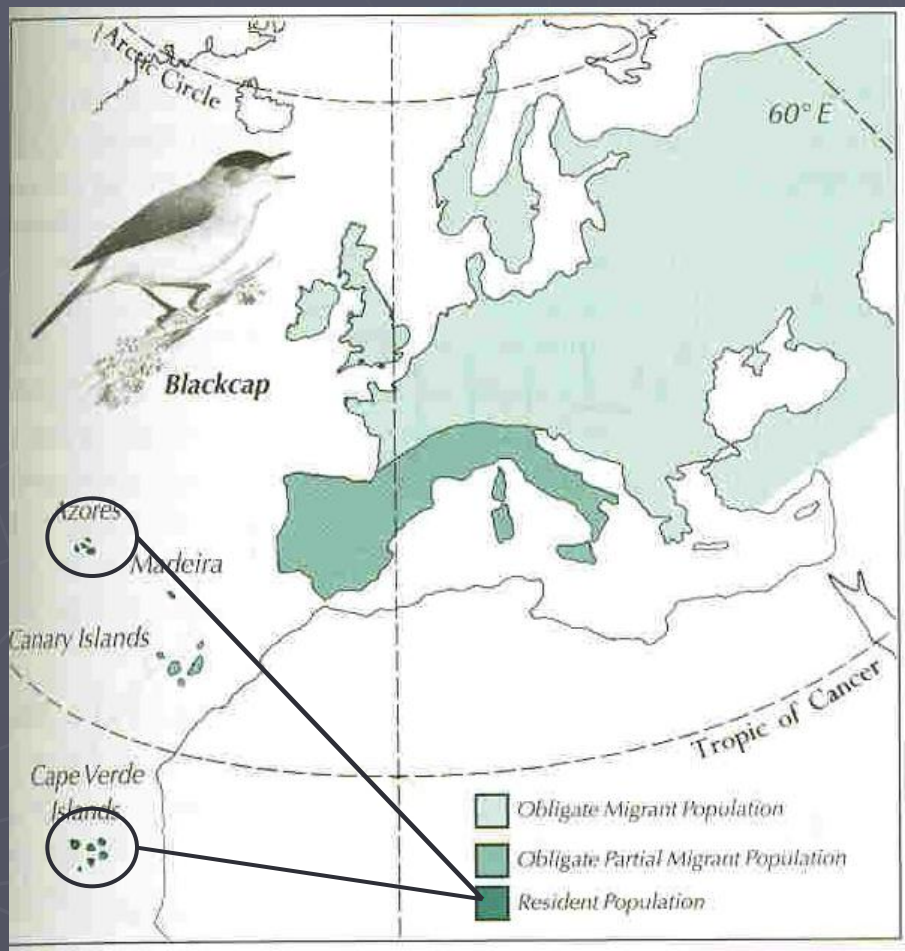

N
October
W
E
S
▼ Blackcaps From Western Europe
▽ Blackcaps From Eastern Europe
● Hybrids


Arctic Circle
60° E
Blackcap
Azores
Madeira
Canary Islands
Tropic of Cancer
Cape Verde Islands
Obligate Migrant Population
Obligate Partial Migrant Population
Resident Population

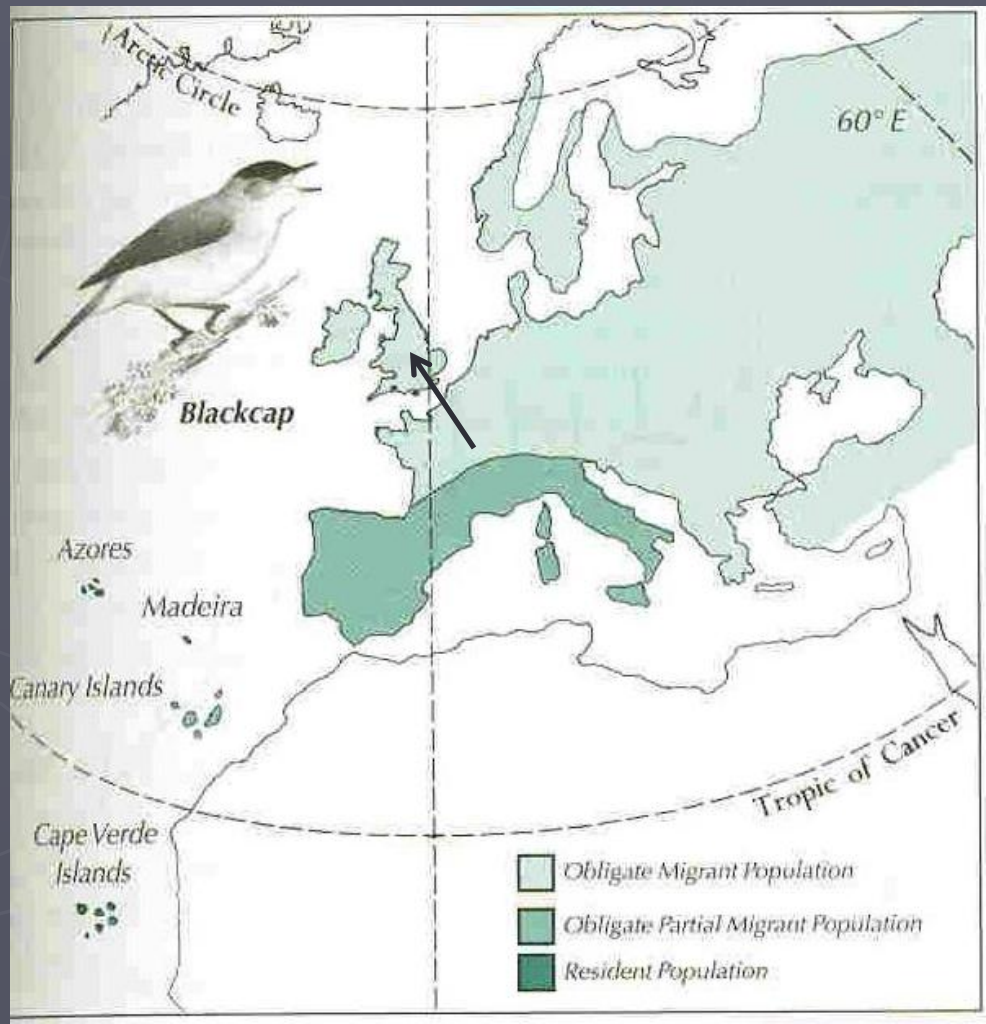
- only 3 generations of selective breeding resulted in a population of all migrants

- 6 generations eliminated all migratory behavior and produced all residents

- thus many aspects of migration have the potential to evolve rapidly

• over last 25 yrs Blackcaps of central Europe begun migrating NW

• success likely due to increase of bird feeders



Premigratory State

I. Shift in Behavior and Physiology

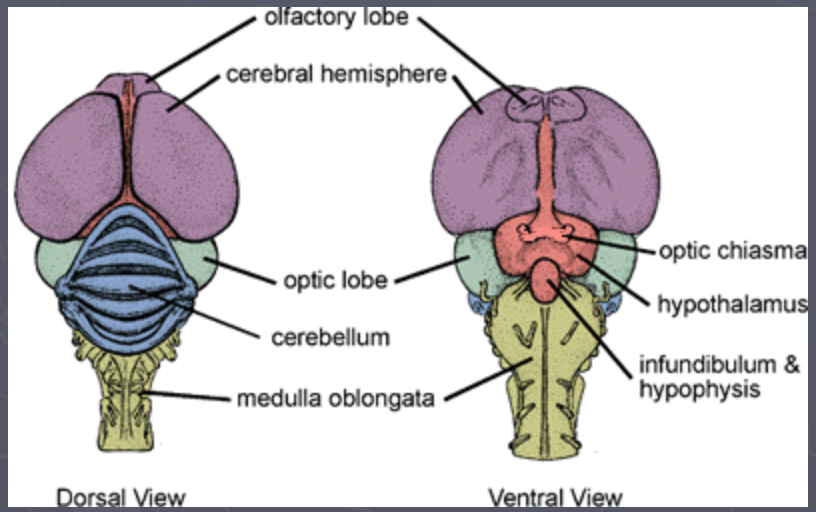
2x each year migratory species undergo marked change in their physiology and behavior.

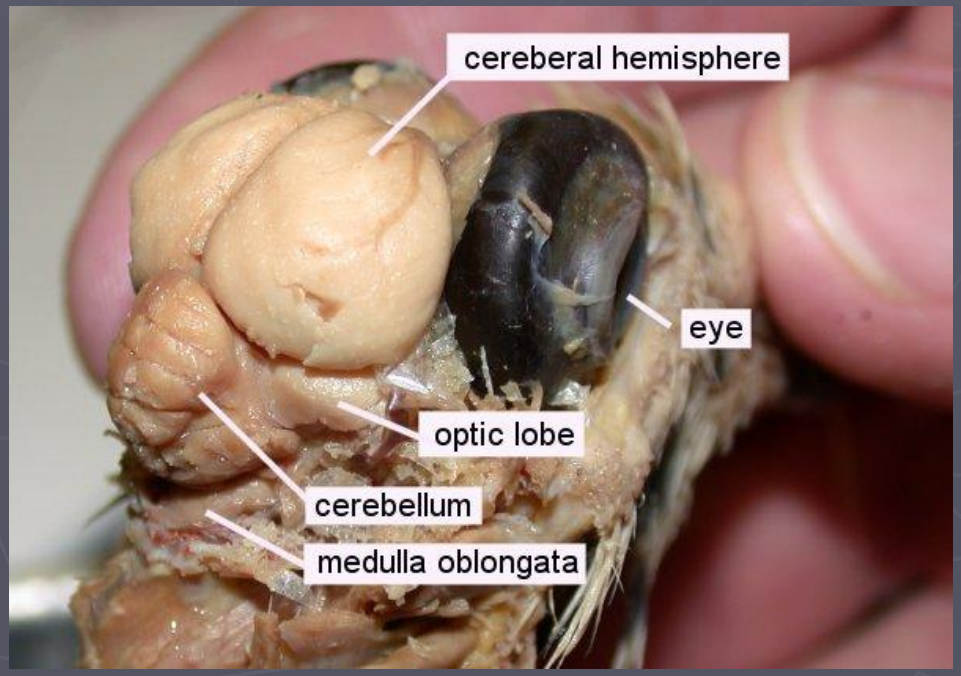
A. Weight Gain

1. Why?

- Birds gain weight for a variety of energetically expensive activities
  - winter thermoregulation
  - prolonged fasting during incubation (arctic geese, emperor penguins incubate for a month without feeding)

- In the case of premigratory fattening there is a shift in the Hypothalamic control centers for hunger and satiety so that the birds become <u>hyperphagic</u>





- Food intake of premigratory birds increases by about 40%
- In small species wght increases at a rate of 1 – 1.5 g /day and the period of weight gain extends about 2 wks.

- The surplus of this energy income is stored as lipid not carbohydrate.
- In fact there is a shift away from carbohydrate production; the amount of glycogen in the liver actually decreases during the period of fat deposition.

- In non-migratory passerines (or migrants during the non-migratory period) fat comprises about 3 – 5 % of wet wght.

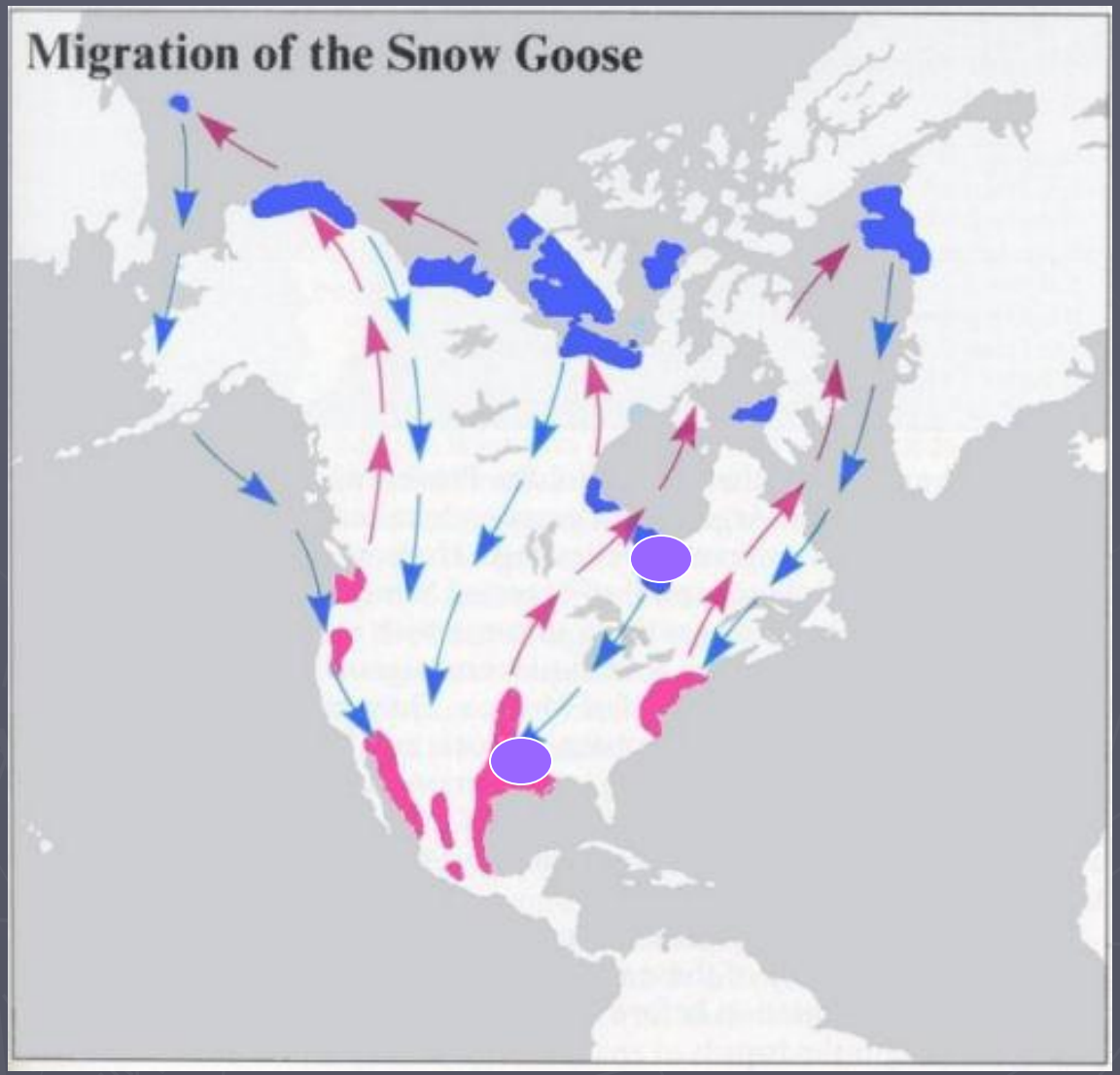
- In short to middle distance migrants fats comprise 13 – 15 % of wet wght

- And in long distance migrants especially those species which migrate long distances in a single flight (across the Mediterranean, Sahara Desert, Gulf of Mexico) lipids comprise 30 – 47% of wet wght.

Examples

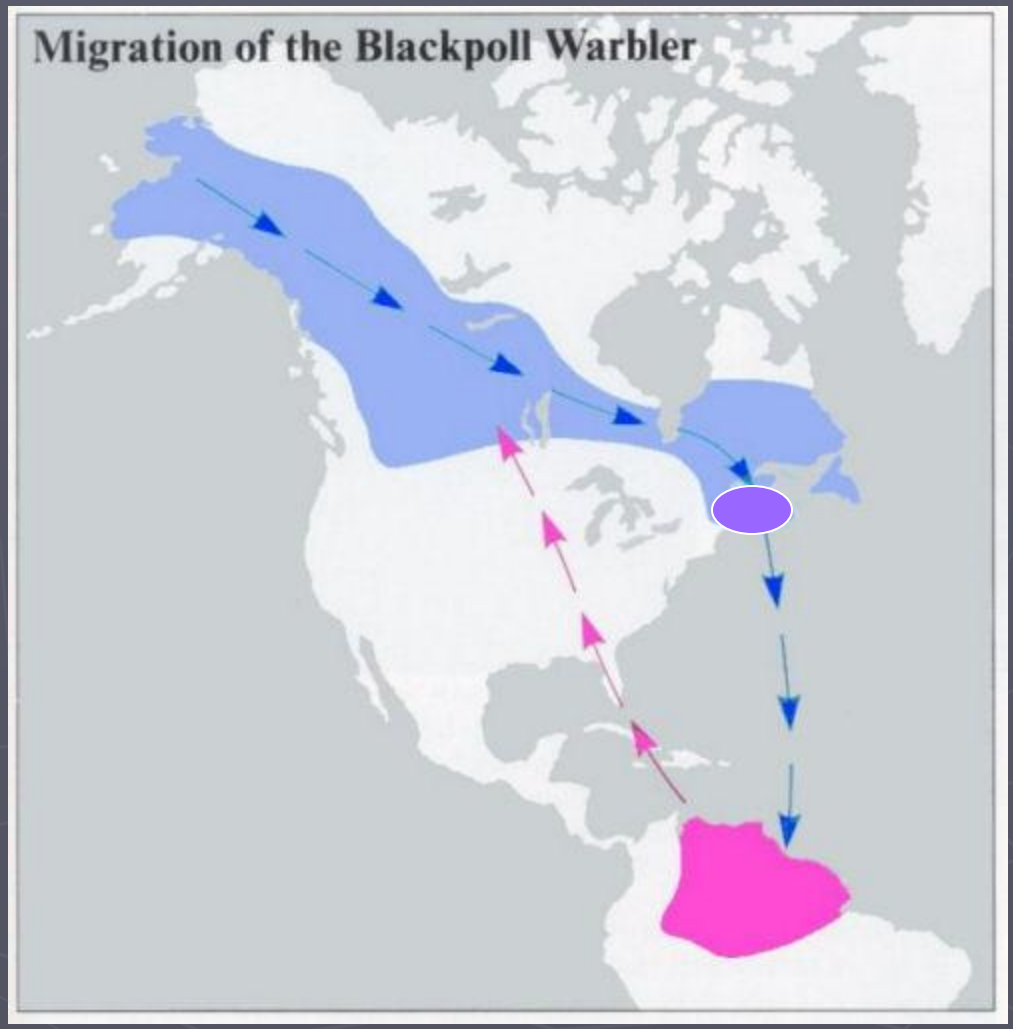
- Snow Goose – 1700 miles from James Bay to Louisiana, a 60 hr non-stop flight at average speeds of 30 mph

http://www.humzoo.com/videos/player/?vid=1503


Migration of the Snow Goose

- Blackpoll Warbler (31g) – 2480 miles from the Northeast Coast to South America

Fly nonstop, day & night for 4+ days



- The limit to migratory flight distance seems to be dehydration rather than energy stores.

- Of the lipids stored for migration, 35 – 50% are in cutaneous and subcutaneous deposits –

Furcular depression fills up, and abdomen but also increases in liver and in the pectoral muscles.

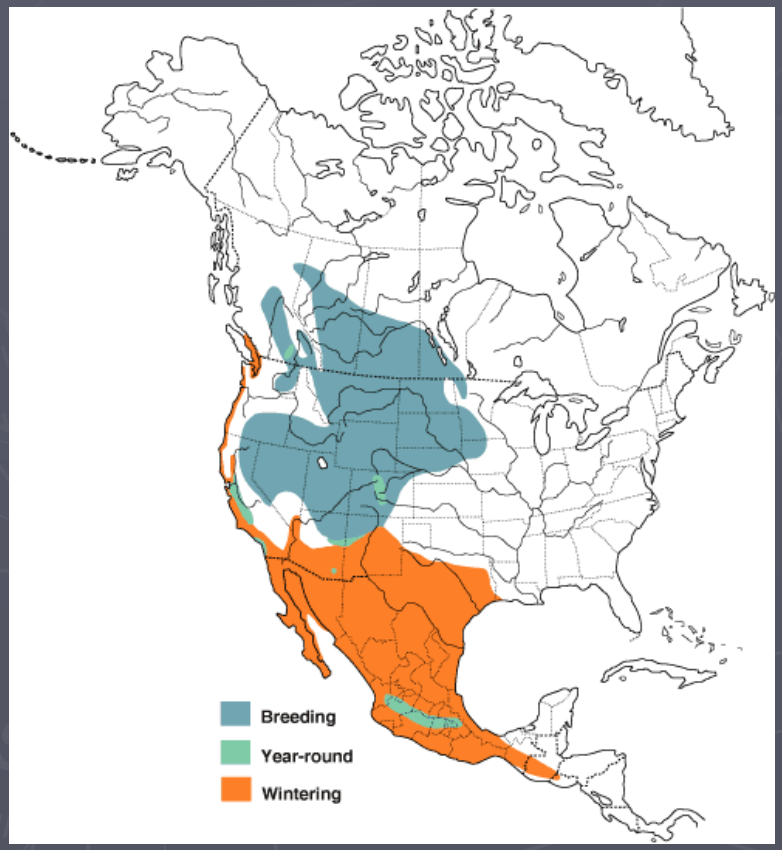
- Mean stop over time for White-crowned sparrows in Maine was 4.5 days
  - length of the stop was inversely proportional to the fat level at arrival; that is leaner birds lay over longer.

- Some male and female Northern Waterthrush defend territories during stop over.
- There was a significantly greater weight increase over 3 days for territory holders compared to nonterritorial birds.

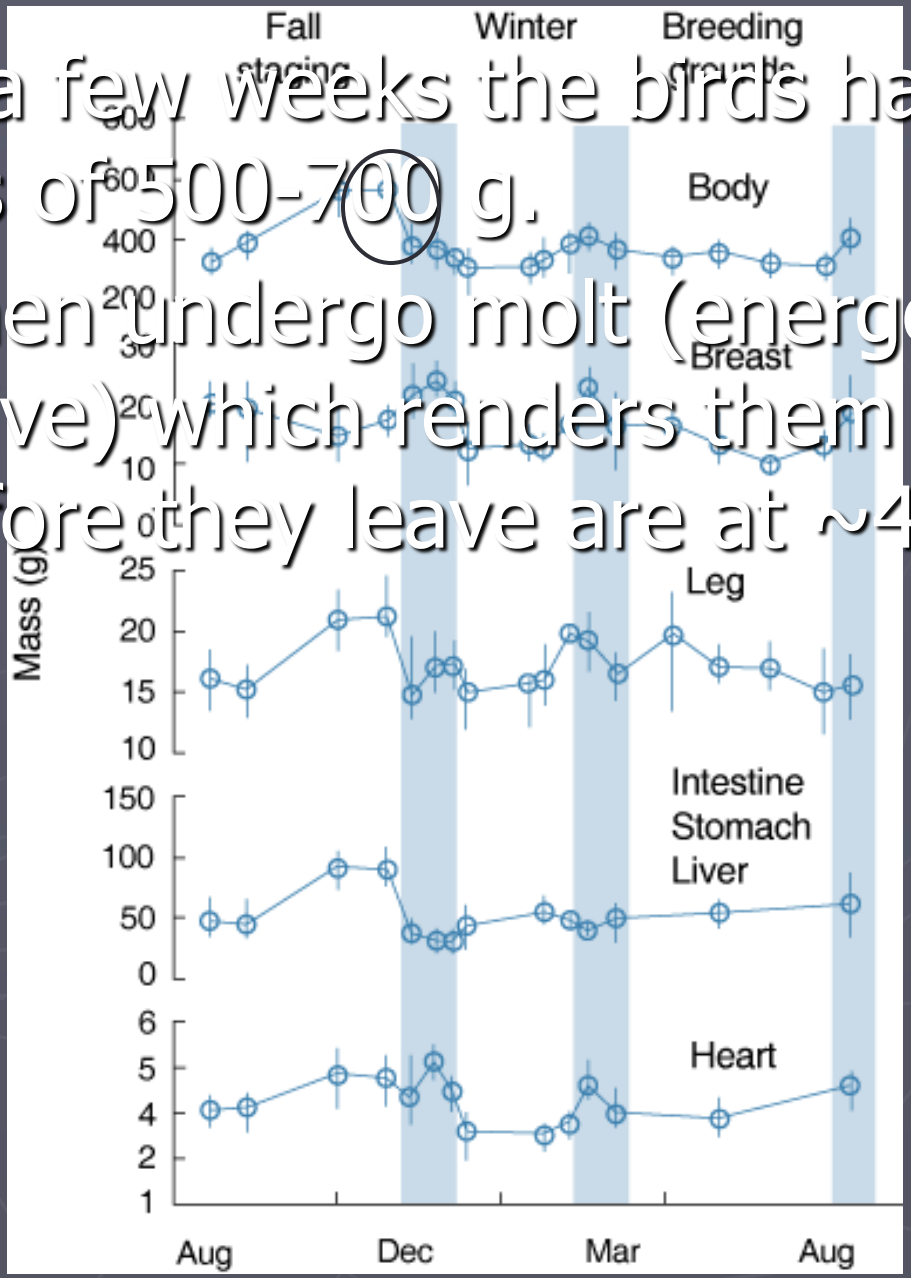
Oldest known NOWA – Delaware Water Gap National Recreation Area

First banded May 1995 as adult
Seen every year except 2007
At least 13 years old!!

- These birds arrive at the Great Salt Lake around late July from their breeding grounds at about 270-350 grams



- Within a few weeks the birds have reached weights of 500-700 g.
- They then undergo molt (energetically expensive) which renders them flightless and before they leave are at ~441g.



- On their winter range in Southwestern US and Mexico mass ~ 330 g.

- Wilson Phalaropes also uses the Great Salt Lake as a staging area. 1/3 of the world's population can be found utilizing the lake as a stopover area (Peaks in July).

- Females arrive first – Why?
- Females arrive mid June at 53g and depart late July – Aug. In the meantime they have almost doubled their mass (~100g) by eating mostly brine flies.

- Arrive at their wintering sites – saline lakes in sw Bolivia and Argentina after a 54 hour nonstop flight.
- Calculations confirm observations - Based on the body mass before departure and the flight speed (80-100 kph),
  - Phalaropes are capable of direct flight from Mono Lake in California to n. Ecuador or n Bolivia before reserves are depleted.

B. Reserve Use Strategies

We can generally identify 2 different strategies for reserve use during migration.

These are best illustrated by Waterfowl, particularly geese.

1. Maintain reserves enroute
   a) Lesser Snow Geese, Ross' Geese, Cackling (B. hutchinsii) and Interior Canada Geese (B. c. interior).

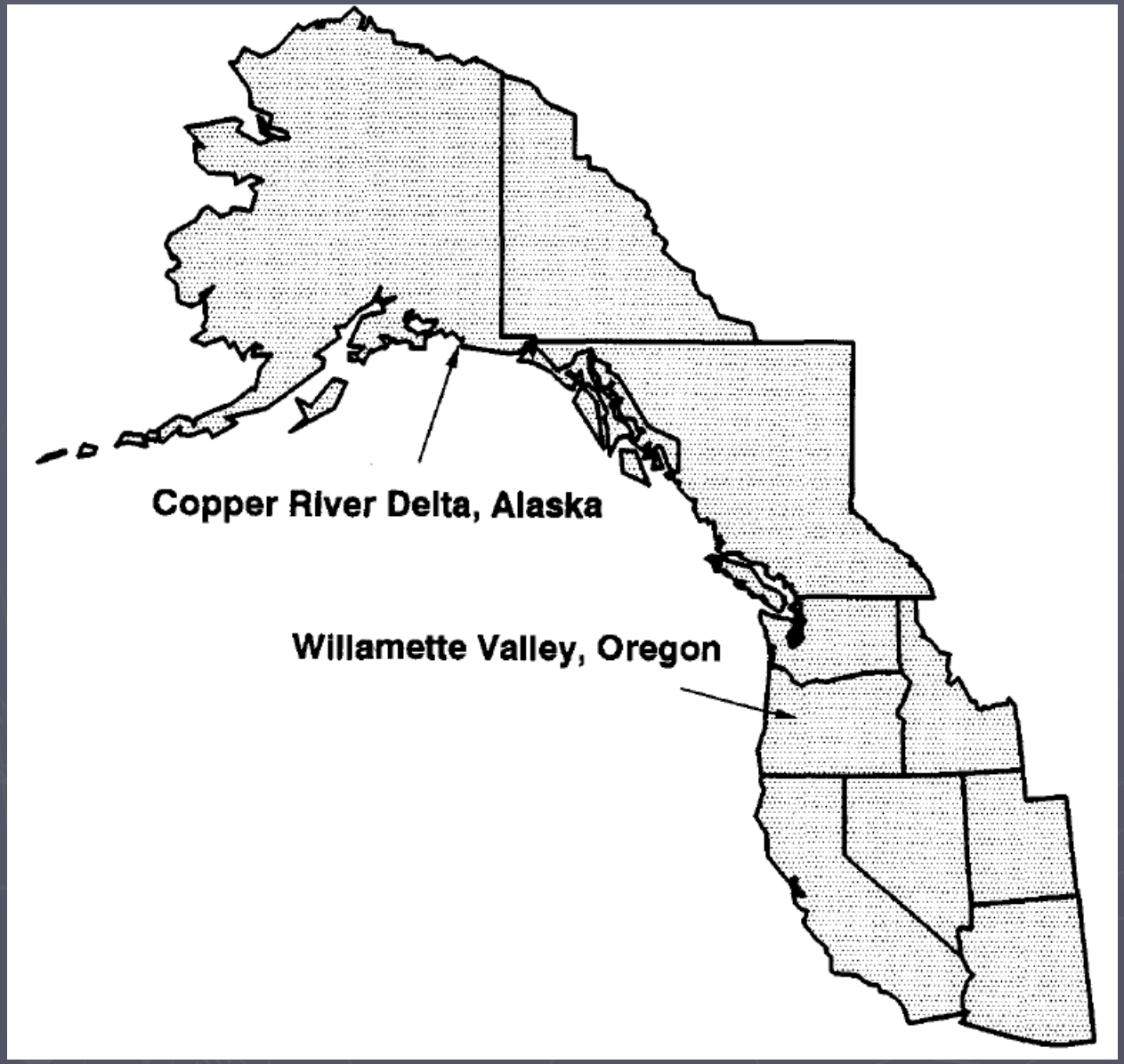
These species all experience a wght gain during spring migration and arrive on the nesting grounds at near peak condition.

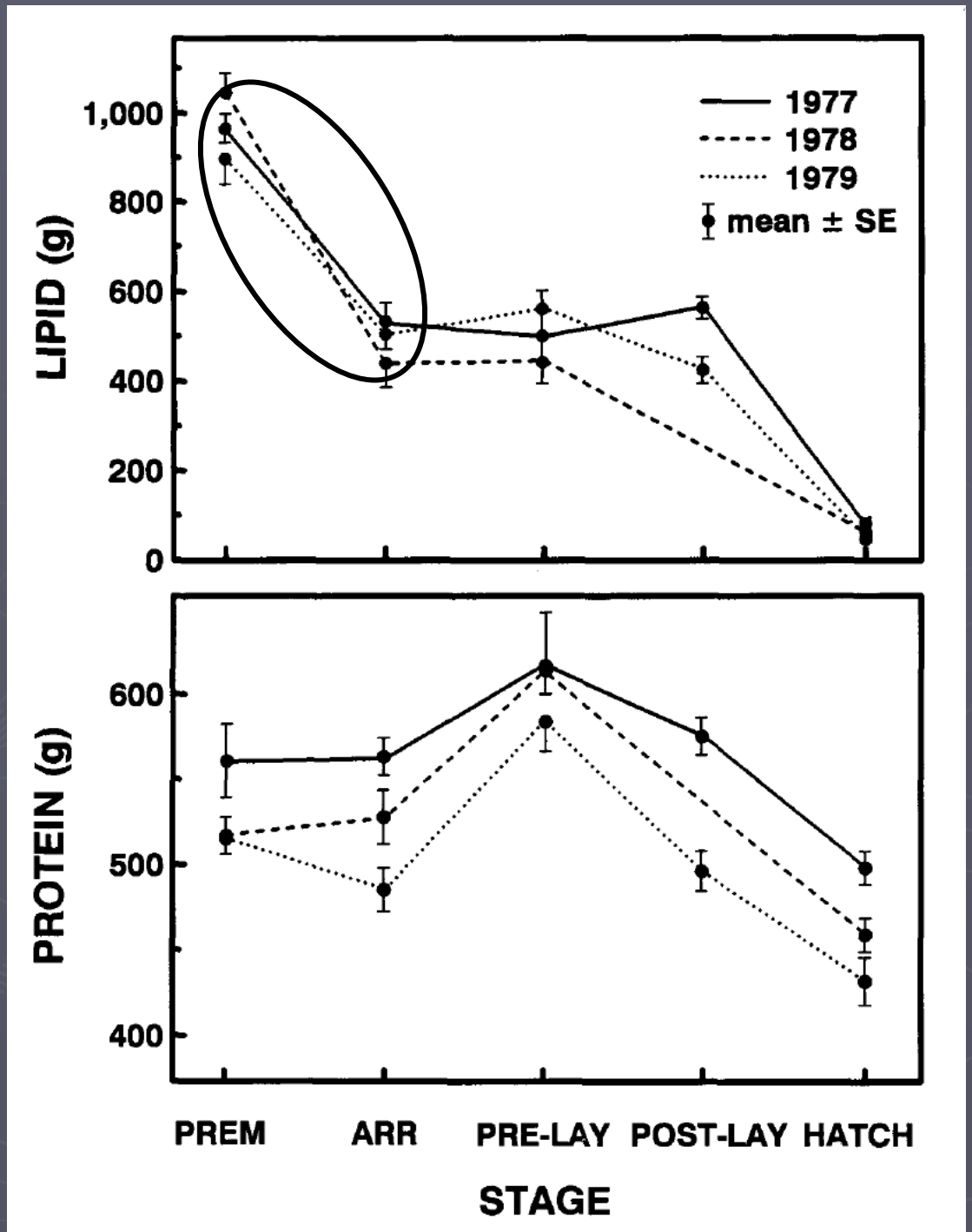
2. Utilize reserves enroute

Employed by Greater Snow Geese and Dusky Canada Geese (B. c. occidentalis).

- *Bromley and Jarvis 1993. Condor 95:193-210*

- Migration route ~ 2600 km long, lies largely along coastal Washington, British Columbia and southeastern Alaska.
- Able to migrate rather quickly from wintering grounds in Oregon ~ 11 days.
- few staging areas and food quality is lower than for interior birds.


Copper River Delta, Alaska
Willamette Valley, Oregon

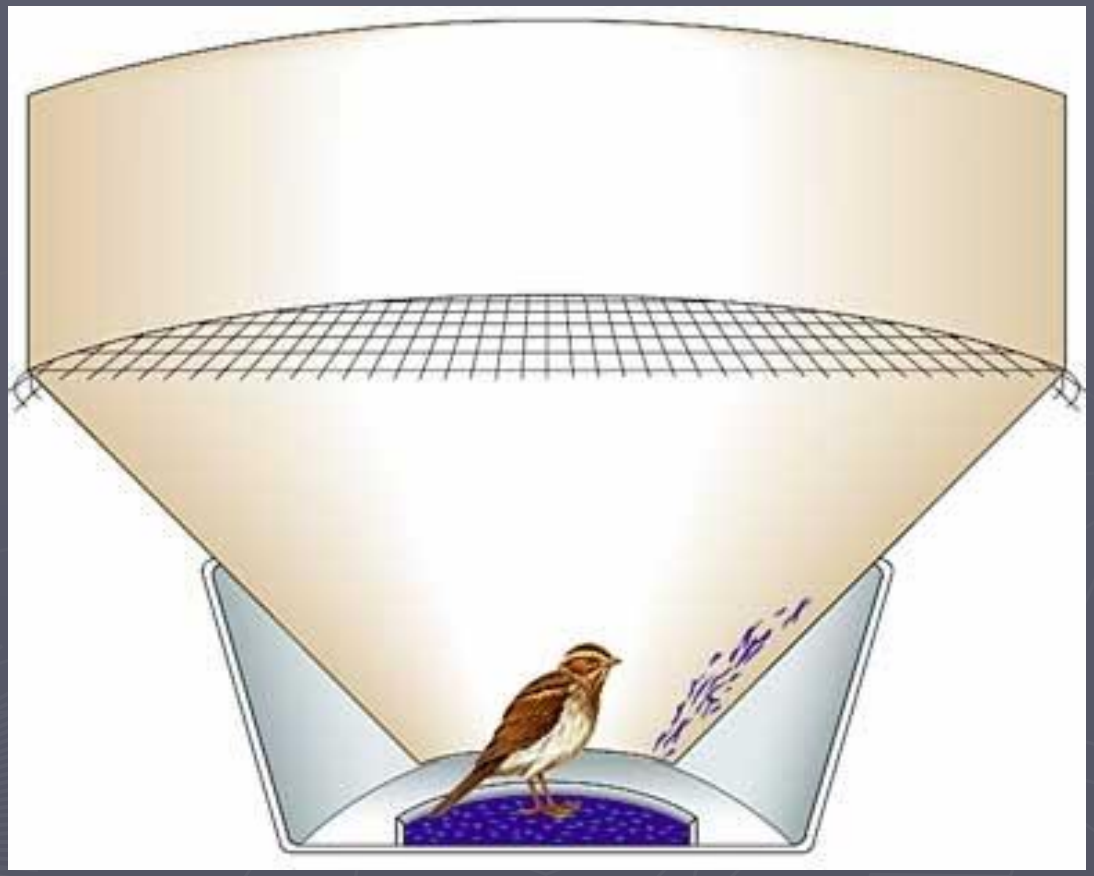

1977
1978
1979
mean ± SE
LIPID (g)
1,000
800
600
400
200
0
PROTEIN (g)
600
500
400
PREM
ARR
PRE-LAY
POST-LAY
HATCH
STAGE

Differences in behavior can be related to fat use while flying.

- Thrushes, warblers and sparrows loose 1.2% of their wght on average per hour but long distance migrants (Blackpoll Warbler) however only loose 0.06% of body mass per hour.

C. Zugunruhe

- Migratory restlessness – nightly unrest because it occurs during the dark period of the day.
- Captive birds demonstrate a daily rhythm
  - Bird sleeps (15min – 2 hrs) then awakens and hops around in cage with increasing vigor until shortly after midnight.



- activity closely parallels the nocturnal activity of free flying migrants.
- Change not due to an increase in total activity but rather shift to nighttime activity.
- Regulated by pineal gland??
- warm weather will enhance the activity but cold weather will suppress it.

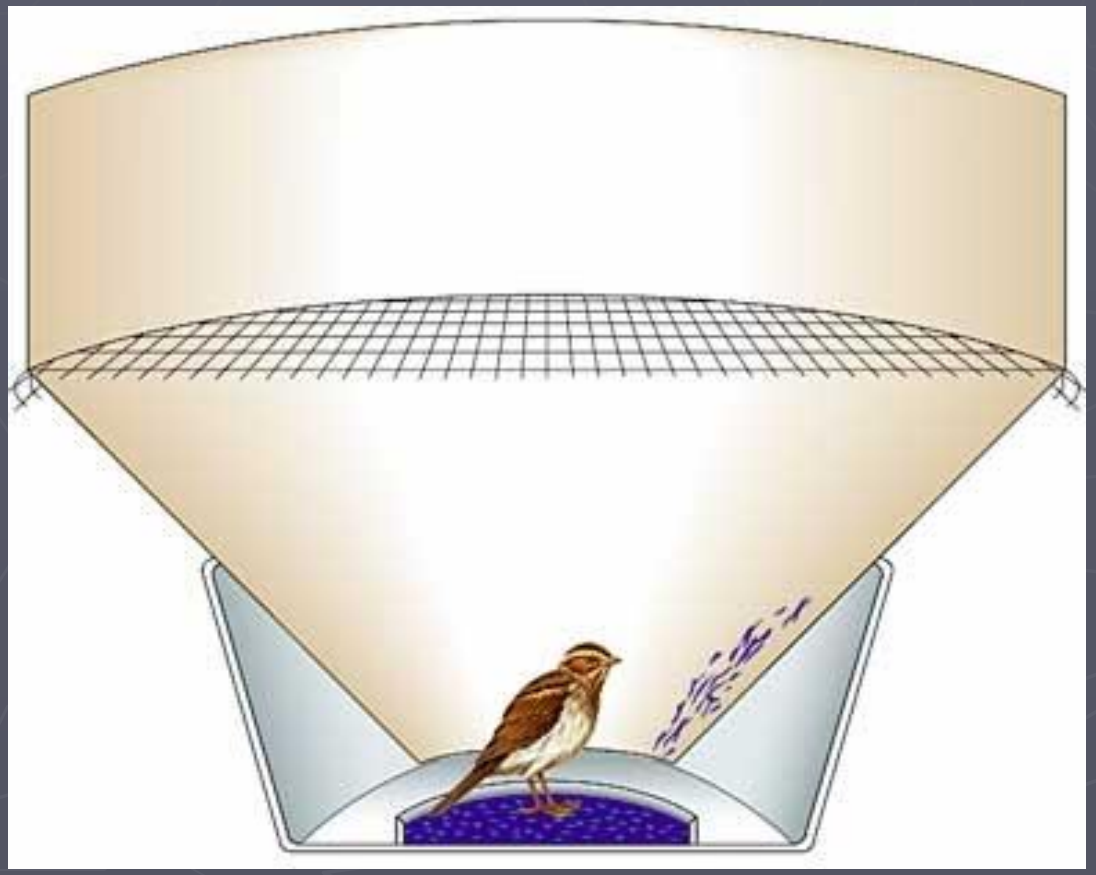
Blackcaps

- winter in Africa;
- birds were taken from different breeding populations –
  - Canary Islands, southern France, southern Germany, southern Finland.
- magnitude and duration

correlated with the length

of their migratory journeys

- A special feature of Zugunruhe is the compass orientation of restlessness.



White-crowned Sparrows

- kept in circular cages in California – S. orientation at night during fall migration and N. orientation during spring migration period.
- determined by activity sensitive perches located around the cage.

- Control of Zugunruhe based on endogenous rhythm in birds

- Willow Warblers flown to wintering grounds in Congo
- Zugunruhe persisted despite arrival on wintering grounds

Helm and Gwinner (2006) recorded Zugunruhe in African Stonechats (doesn't migrate, diverged from northern migrants at least 1 million years ago).

low-level Zugunruhe may be common in all birds, could underlie recent rapid changes in movement and range patterns attributed to global change and other human interventions.

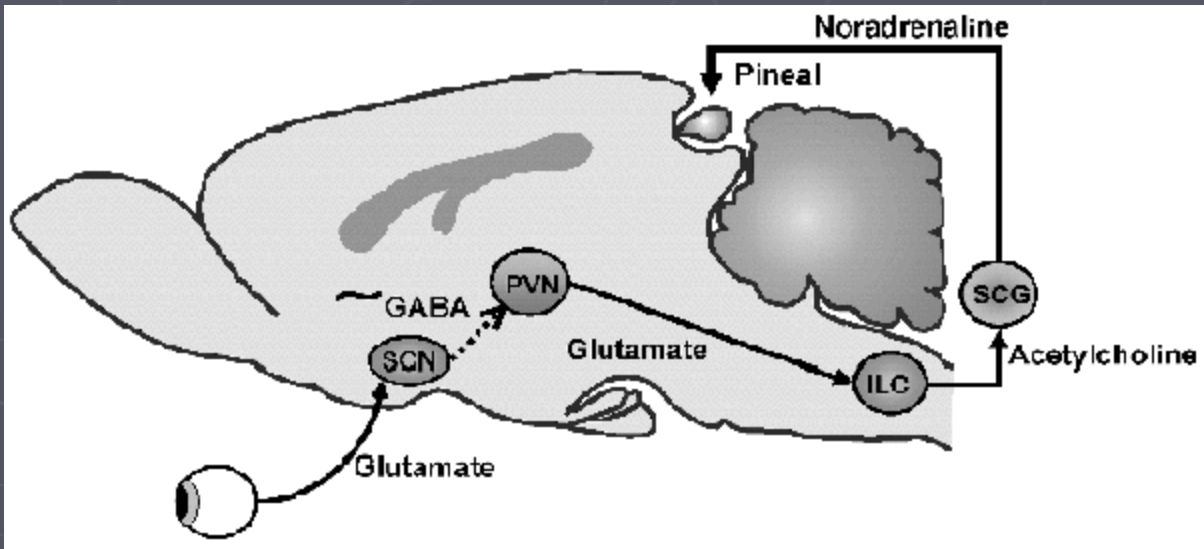
Results suggest Zugunruhe based on endogenous control independent of proximate environmental stimuli

II. Endogenous Control

- Both fat deposition and Zugunruhe under endogenous control
- Appears there is a neuroendrocrinological mechanism

- Hypothesized Mechanisms:

Pineal gland controls daily flow of Corticosterone and prolactin



These hormones influence

- gonad development
- fat deposition
- Zugunruhe
- compass orientation

Once primed, bird is easily induced to migrate by external stimulation such as favorable weather

Sex hormones not involved in behavior

III. Exogenous Stimulation

A. Photoperiod

Long days stimulate both fat deposition and Zugunruhe

December – increase day length leads to development of premigratory state

B. Temperature

Has modifying effect

Cold – direct energy into thermoregulation, less available for premigratory preparation

Warm – accelerates premigratory state