Avian Ecology:
Life History, Breeding Seasons, & Territories

Life History Theory –

Why do some birds lay 1-2 eggs whereas others 12+?

Why do some species begin reproducing at < 1 year whereas others not until 10+ ?

I. Introduction

Life History Theory – Framework for understanding how physiological traits and behaviors are under the control of evolution

<u>Traits –</u>

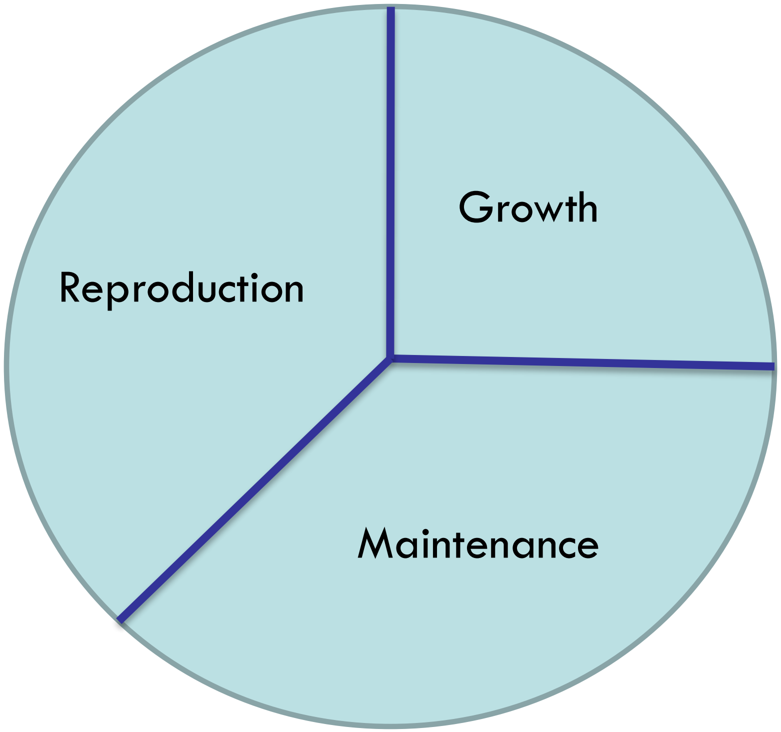
Survival

Clutch Size

Incubation period length

Nestling period length

Total Lifetime Energy Available



$$TE = G + M + R_{c+f}$$

Key concept –
Trade-offs exist between life history traits

- Black-capped Chickadee
  - Reproduction – 15 fledglings/year
  - Survival - < 50% probability surviving to next year

- Royal Albatross
    - Reproduction – 1 young/2 years
    - Survival - > 95% probability surviving to next year

Several Generalities of Avian Survival Rates

- Larger bird species tend to have higher survival relative to smaller species

Species	Annual Adult Survival (%)	Average Weight oz (g)	
Blue Tit	30	0.4	(11)*
Barn Swallow	37	0.7	(19)
Song Sparrow	30	0.8	(21)
European Starling	47	2.9	(80) female
		3.0	(85) male
American Robin	52	2.8	(77)
Blue Jay	55	3.1	(87)
California Quail	50	6.1	(170) female
		6.3	(176) male
Sooty Shearwater	91	10.3	(287)
Northern Fulmar	94	17	(479) female
		21.8	(609) male
American Coot	40	20	(560) female
		26	(724) male
Black-crowned Night-Heron	70	31.5	(883)
Herring Gull	70	37.3	(1,044) female
		43.8	(1,226) male
Mallard	52	38.7	(1,082)
White Stork	79	107–125	(3,000–3,500)*
Canada Goose (*canadensis* race)	84	118	(3,314) female
		136	(3,814) male
Yellow-eyed Penguin	90	185	(5,200)*
Tundra Swan	92**	221	(6,200) female
		254	(7,100) male
Royal Albatross	97	296	(8,300)*

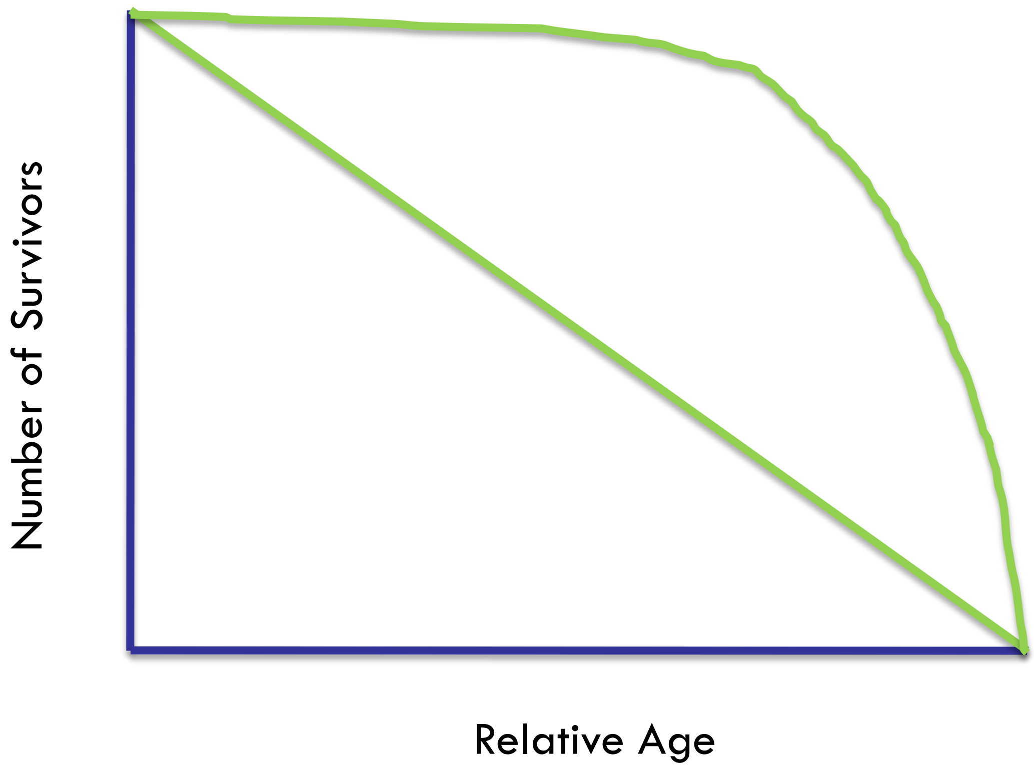
*Weight and survival data from Brooke and Birkhead (1991)
**Survival data from Limpert and Earnst (1994).

• Immature birds have lower rates than mature birds
(1st yr Gulls ~ 30% vs. 2nd + ~ 80%)

• Birds in tropics tend to have higher rates than relatives at higher latitudes
(~ 80% vs. ~ 50%)

• Birds have higher survival rates than mammals of similar size

Survivorship Curves – allows us to compare species

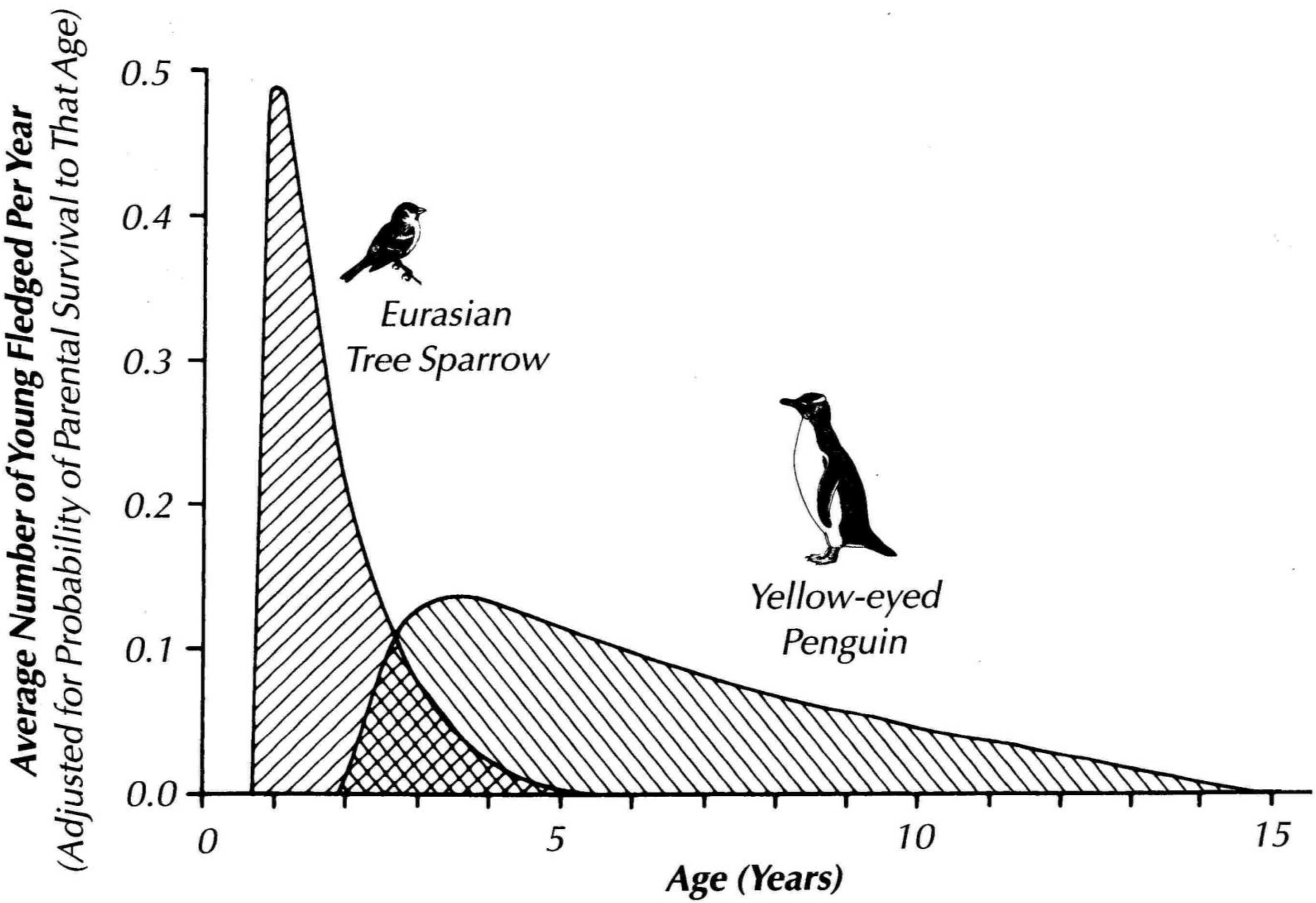


Birds experience a constant rate of mortality throughout adult life.

Variation in annual survival rates between different species helps us understand differences in reproductive strategies

• Species with low prospects for future reproduction (e.g. low annual survival rates) will expend more energy into current effort (larger clutches, more breeding attempts etc.).

• Species with high prospects will expend less energy into current effort.


Average Number of Young Fledged Per Year
(Adjusted for Probability of Parental Survival to That Age)
0.5
0.4
0.3
0.2
0.1
0.0
Eurasian Tree Sparrow
Yellow-eyed Penguin
0
5
10
15
Age (Years)

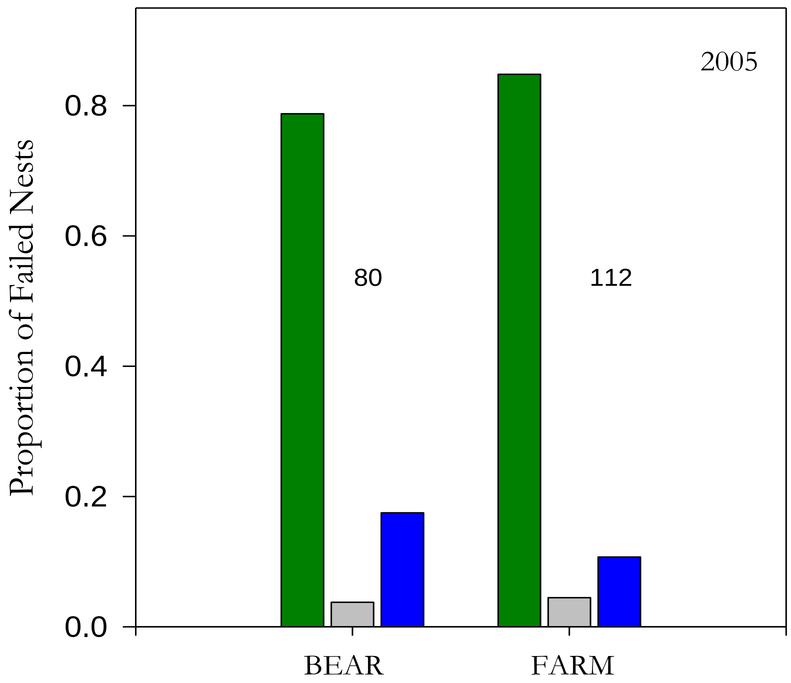
Reproductive strategies also depend on survival prospects of eggs & young.

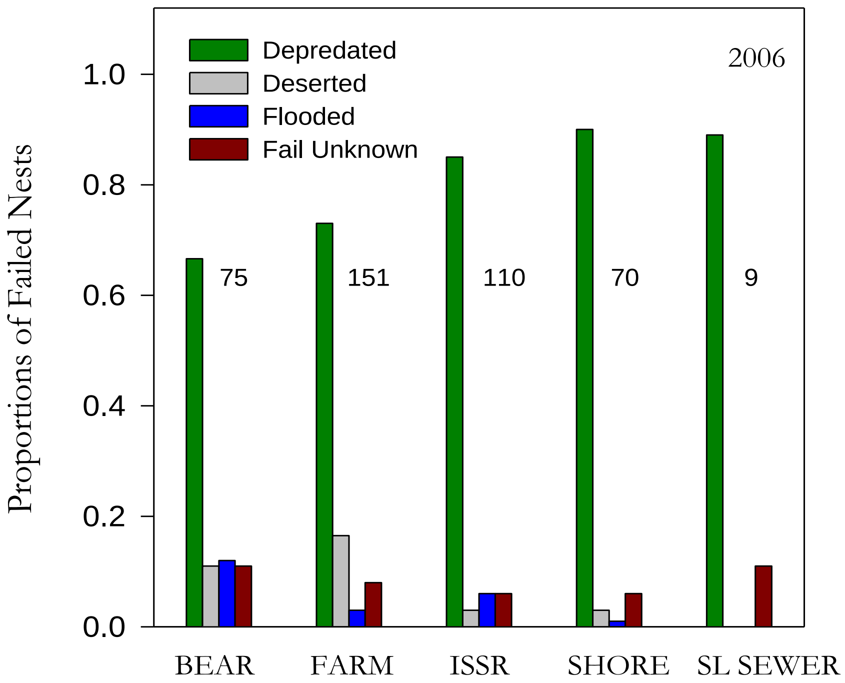
If probability of producing a successful nest is low, what strategy would natural selection favor?

Don't put all your eggs in one basket!

Survival of eggs and young

Most important source of egg mortality is nest predation.





Bear River Migratory Bird Refuge
O – Line Dike
June 9, 2007
3:19 am

Bear River Migratory Bird Refuge
O – Line Dike
June 24, 2007
4:09 am

Bear River Migratory Bird Refuge
Whistler Canal
May 24, 2007
9:34 am

Species	% Nests Lost to Predation	Location	Reference
Yellow-billed Cuckoo	39%	Arkansas	(Martin 1993a)
Eastern Phoebe	49%	Southern Indiana	(Weeks 1979)
	71%	Central Appalachians	(Hill and Gates 1988)
Greater Pewee	42%	Southeastern Arizona	(Chace and Tweit 1999)
Acadian Flycatcher	39%	Arkansas	(Martin 1993a)
Red-eyed Vireo	49%	Arkansas	(Martin 1993a)
Warbling Vireo	38%	Arizona	(Martin 1993a)
Carolina Wren	64%	Northwestern Alabama	(Haggerty and Morton 1995)
American Robin	39%	Pacific NW of N. America	(Sallabanks and James 1999)
	54%	Arizona	(Martin 1993a)
Wood Thrush	40%	Arkansas	(Martin 1993a)
Hermit Thrush	83%	Arizona	(Martin 1993a)
American Redstart	nearly 52%	New Hampshire	(Sherry and Holmes 1992)
Black-and-white Warbler	26%	Arkansas	(Martin 1993a)
Hooded Warbler	47%	Arkansas	(Martin 1993a)
	44%	Pennsylvania	(Evans Ogden and Stutchbury 1
	30%	Ohio	(Evans Ogden and Stutchbury 1
	36%	Ontario, Canada	(Evans Ogden and Stutchbury 1
Ovenbird	24%	Michigan	(Hann 1937)
	29%	Arkansas	(Martin 1993a)
	70%*	Central Illinois	(Robinson 1992)
Worm-eating Warbler	21%	Arkansas	(Martin 1993a)
Orange-crowned Warbler	33%	Arizona	(Martin 1993a)
Virginia's Warbler	31%	Arizona	(Martin 1993a)
Red-faced Warbler	40%	Arizona	(Martin 1993a)
MacGillivray's Warbler	49%	Arizona	(Martin 1993a)
Yellow-rumped Warbler	38%	Arizona	(Martin 1993a)
Western Tanager	45%	West-Central Idaho	(Hovis et al. 1997)
	30%	Northeastern New Mexico	(Goguen and Mathews 1998)
	46%	Arizona	(Martin 1993a)
Scarlet Tanager	69–78%**	Illinois	(Brawn and Robinson 1996)
Green-tailed Towhee	61%	Arizona	(Martin 1993a)
White-throated Sparrow	35%	Adirondack Park, New York	(Tuttle 1993)
	45%	Algonquin Park, Canada	(Falls and Kopachena 1994)
Dark-eyed Junco	31%	Arizona	(Martin 1993a)
Indigo Bunting	75%	Indiana	(Carey and Nolan 1979)
	43%	Arkansas	(Martin 1993a)
Black-headed Grosbeak	23%	Arizona	(Martin 1993a)

Breeding Seasons

Breeding Seasons

I. Factors affecting breeding seasons

- Most intriguing feature is the periodicity of reproduction

- Why are Mountain Bluebirds paired and ready to breed in late March and early April every year?

What factors affect the breeding season of a particular species in a particular place at a particular time?

A. Hypotheses
    1. Food availability
    2. Habitat
    3. Temperature
    4. Photoperiod

B. Types of Answers
Proximate vs. Ultimate

Notice that the central question can be answered at two different levels;
At a proximate and at an ultimate level

Proximate Level – explains the how and in what way aspect of the question, describes the mechanistic and physiological aspects.

Ultimate Level – involves an evolutionary explanation and involves an argument about adaptation/survival value in connection with the study of breeding periodicity notion of proximate and ultimate factors was defined

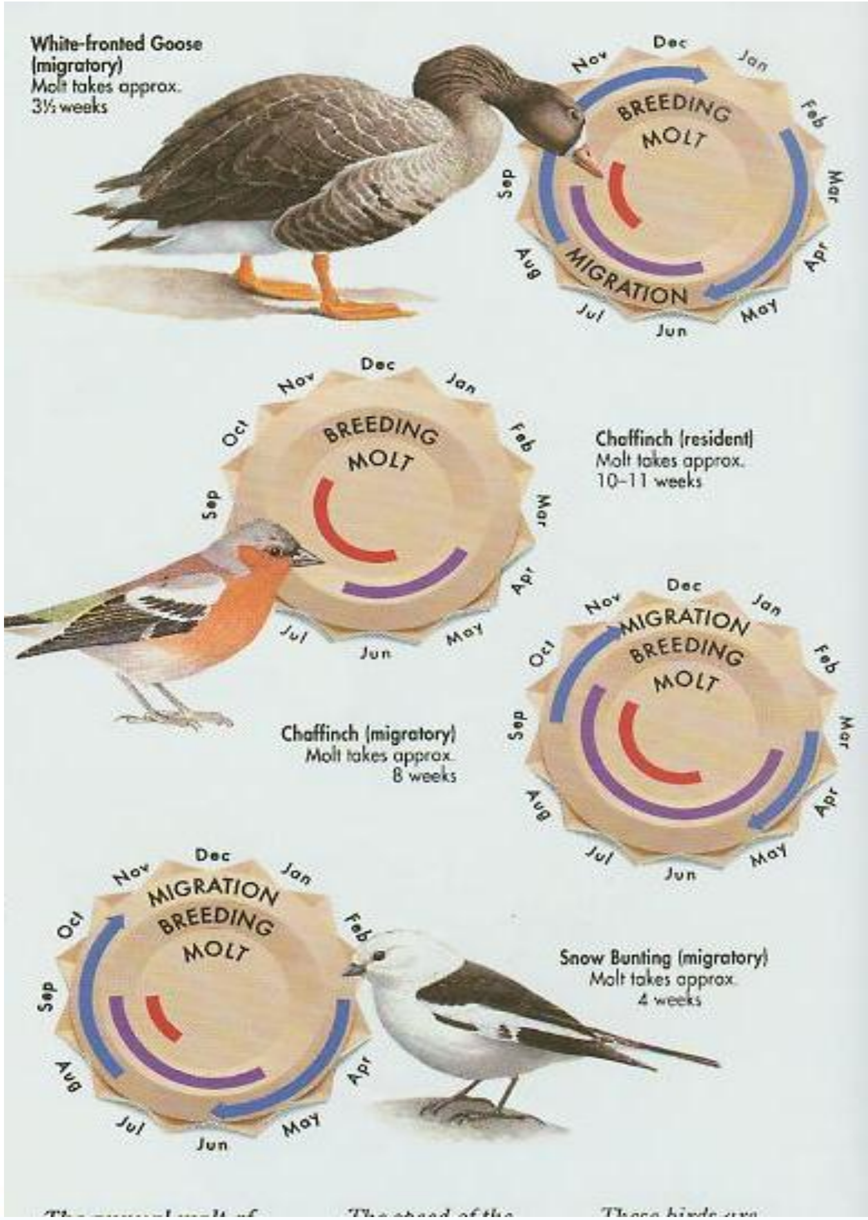
need to differentiate between factors involved in a phenotypes evolution and factors involved in its physiological expression

Ultimate factors affect the timing of reproduction and proximate environmental factors get birds to the optimal time.

II. Annual Cycle

A. Annual Energy Budget and the Annual Cycle

There is an annual energy budget that partitions out the energy demanding events in a birds life with a certain degree of equity.


White-fronted Goose
(migratory)
Molt takes approx.
3½ weeks
BREEDING
MOLT
MIGRATION
Chaffinch (resident)
Molt takes approx.
10–11 weeks
Chaffinch (migratory)
Molt takes approx.
8 weeks
Snow Bunting (migratory)
Molt takes approx.
4 weeks
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov

- Winter Thermoregulation – 90-100kJ/day
- Prebasic Molt 90kJ/day
- Vernal Migration, including premigratory fat deposition or movement to breeding habitat if not a migratory species 100kJ/day
- Reproduction 100kJ/day
  - Gonad development
  - Territory establishment
  - Courtship and copulation
  - Nest building , egg laying
  - Incubation
  - Brooding
  - Post-fledgling care
- Prealternate Molt 90kJ/day
- Migration including premigratory fat deposition, or movement to winter territory if not migratory 100kJ/day

III. Ultimate factors

What are the ultimate factors that function as selective forces in the evolution of breeding periodicity?

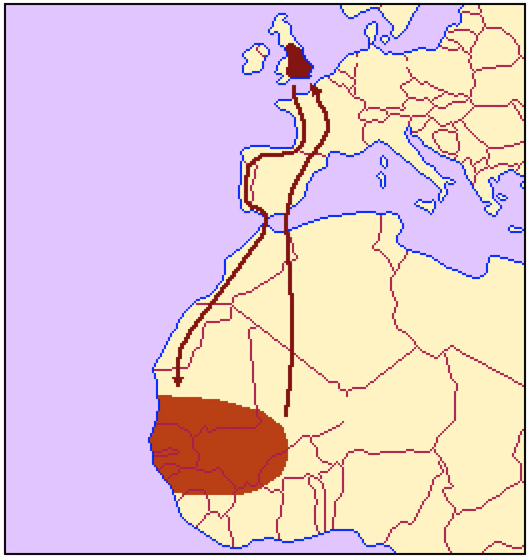
A. Factors on the breeding range.

1. Yellow Wagtail (*Motacilla flava*)

All subspecies winter together in Africa under the same environmental conditions, Period of molt, fat deposition, and gonad development is correlated with latitude of subspecies breeding grounds.

Furthest migrants left last!

Show a differential response that is correlated to the latitude of their breeding range suggesting that it seems to be determined by the latitude hence climate of the breeding area.



What determines the timing of breeding?

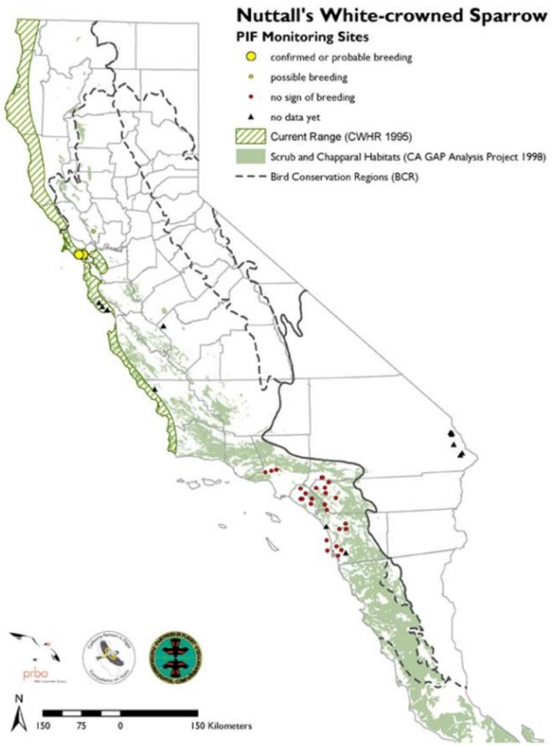
Must be factors on the breeding grounds!

Why?

Because all were exposed to the same conditions on the wintering grounds

2. The case of *Zonotrichia leucophyrs*

Subspecies *pugetensis and nutallii* both winter in San Francisco Bay area



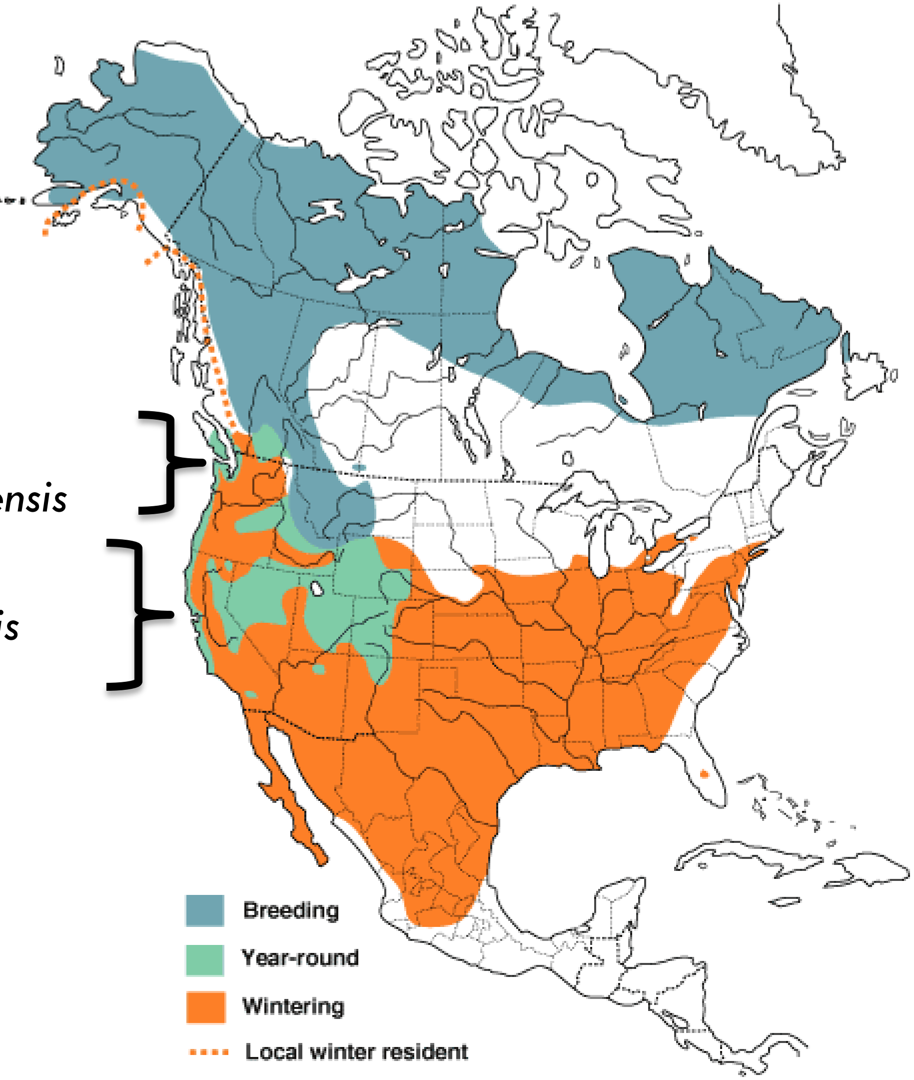
nuttallii, the resident subspecies begins nesting in March

pugetensis goes through prebasic molt, puts on fat doesn't migrate until April – long after *nuttallii* is breeding!!

Breeding
Z.l. pugetensis

Winter
Z.l. pugetensis
Z.l. nuttallii

Breeding
Z.l. nuttallii



nuttallii responds earlier to same winter environment than *pugetensis*

Timing of reproductive development correlated with seasonal suitability of latitude.

B. Environmental Factors

Hypothesized – timing of breeding season evolved so that breeding occurs under environmental conditions that are most suitable for survival of young

- Food availability
- Nest site availability – sedge wrens
- Water levels (riverine ducks in Australia)
- Minimal rates of nest predation

(Clay-colored Robin)

IV.Proximate Control

Cannot wait until food availability or nest sites are optimal before commence reproduction.

Begin before optimal time!

Must be set of environmental factors that affect development of reproductive state

A. Endogenous

Are they endogenous rather than exogenous?

Willow Warbler

(12L/12D)

a. molt expressed in absence of natural environmental cues

b. periodicity of molt affected (drifts out of phase)

c. cycle can be maintained but not sufficient

Input from environment provides Zeitgeber (time giver)

B. Exogenous

Proximate environmental factors affect development of reproductive state.

Factor must reliably predict the advent of the optimum for ultimate factor involved!

1. Photoperiod

Photoperiod is reliable factor.

a. used by majority of temperate species

b. less valuable for tropical species

2. Rainfall

regularity of alternate wet and dry periods provides an alternate predictor – effect may be direct most likely indirect

C. Need for predictability

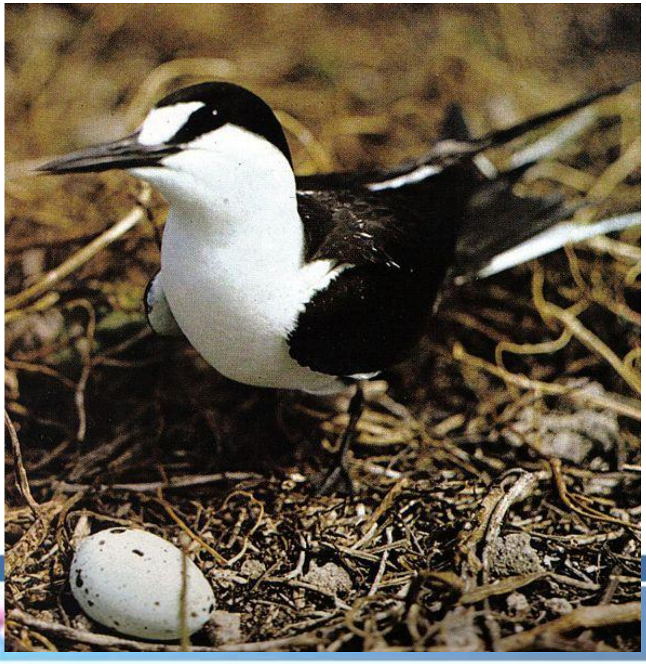
Species differ in needs for predictive information provided by proximate environmental factors

1. minimal need due to constancy of environment

ultimate factor present throughout most of year, hence prediction unnecessary

a. Sooty Terns

Ascension Island Populations Breed every 9.7 months



b. Rufous-collared Sparrow

Birds breed every 6months, associated with 2 rainy seasons

2. minimal need because environment is unpredictable

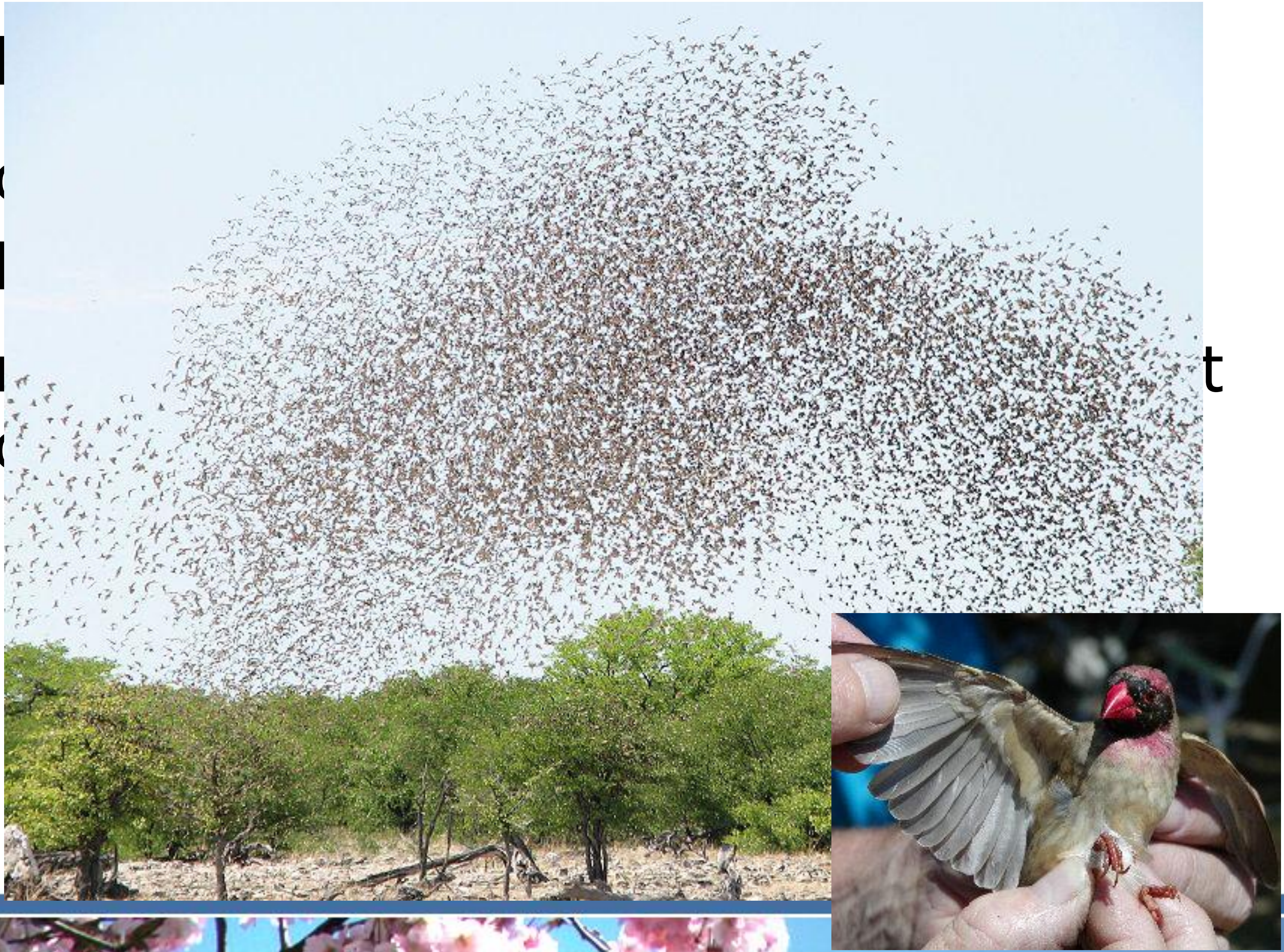
Characteristic of arid regions

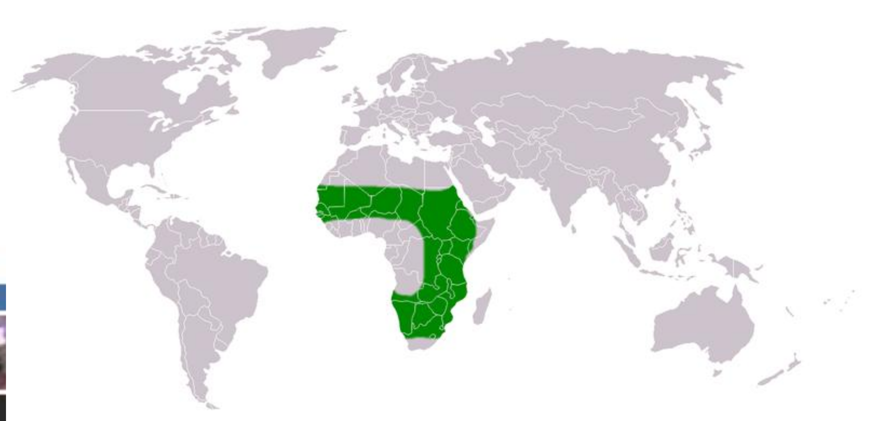
a. Zebra Finches of Australia

breed following irregular rains no matter what time of year pairs seen copulating within few hours of rainfall

build nest and lays eggs within 1 week!

- adults maintain tonic levels of FSH, LH
- gonads remain at constant size throughout year (not producing gametes)
- upon ingesting water, FSH increases – meiosis completed
- if experimentally dehydrated – gonads shrink





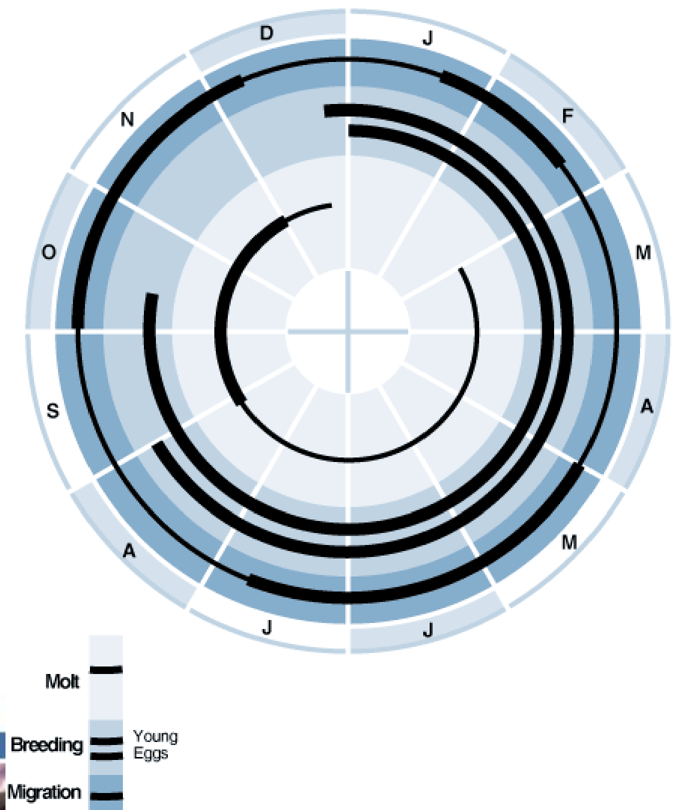
Males use grass for nest building

Provides tactile sensation that affects hypothalamus increasing release of FSH

Red Crossbills – reproduction timed to availability of conifer crops

Roam in large nomadic flocks

When find food they breed no matter what season.



3. Strong dependence

temperate species use daylength

obligatory response is modified by other environmental factors

accelerators & inhibitors

a. Testis size in mild winters 2x larger than in winters with below normal temps

b. White Crowned Sparrow – cool stormy spring delays onset of breeding

LH and Testosterone levels maintained longer than in fair spring

c. habitat condition may also function to accelerate or inhibit

lack of nesting cover and poor food availability can cause sexually mature birds to delay reproduction

Male Dickcissels removed from territories and kept under natural photoperiod went into gonadal regression and molted prematurely

Breeding Territories

Breeding Territories

During breeding season nearly all birds defend some type of territory

Size and function varies widely

- Nest only
- Area which includes food, nest sites, roost sites etc.

A territory is a defended area.

Type A (mating, nesting, & feeding territory)

An area within which all activities occur (such as courtship, mating, nesting, & foraging).

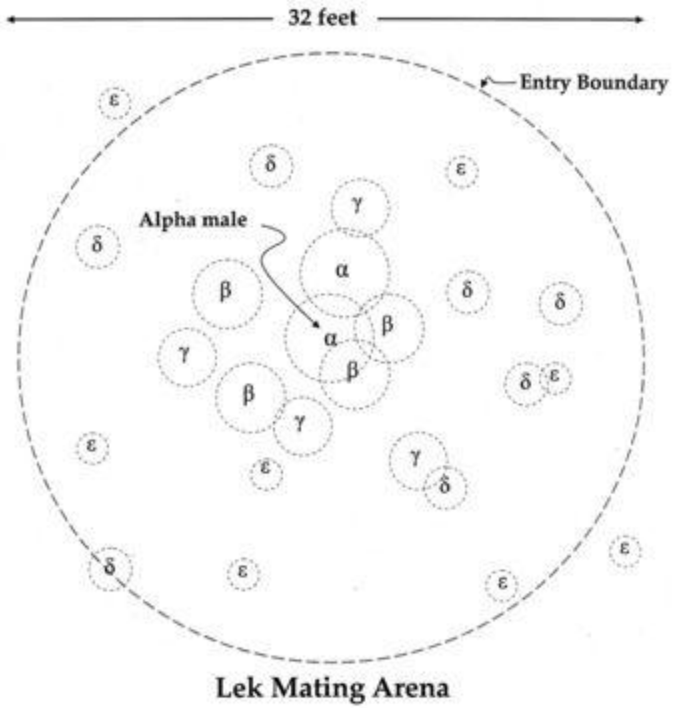
also called an 'all-purpose territory'
the type of territory defended by many songbirds

Type B, or mating & nesting territory
An area within which all breeding activities occur, but most foraging occurs elsewhere.
the type of territory defended by male Red-winged Blackbirds, Yellow-headed Blackbirds

Type C, or nesting territory
A nest plus a small area around it.
the type of territory defended by colonial waterbirds

Type D, or pairing & mating territory

the type of territory defended by males in lekking species



Type E, or roosting territory

Type F, or winter territory

Winter territories typically include foraging areas & roost sites.

May be equivalent (in terms of location), or nearly so, to the Type A territory, or may be, for a migratory species, on the wintering grounds

Functions of Territories

- Evade predators more easily
- Locate / defend food

Functions of Territories

- Reduces chance of interference by others in population
    - nest material
    - destruction of conspecific eggs/young
    - egg dumping / extra-pair copulations

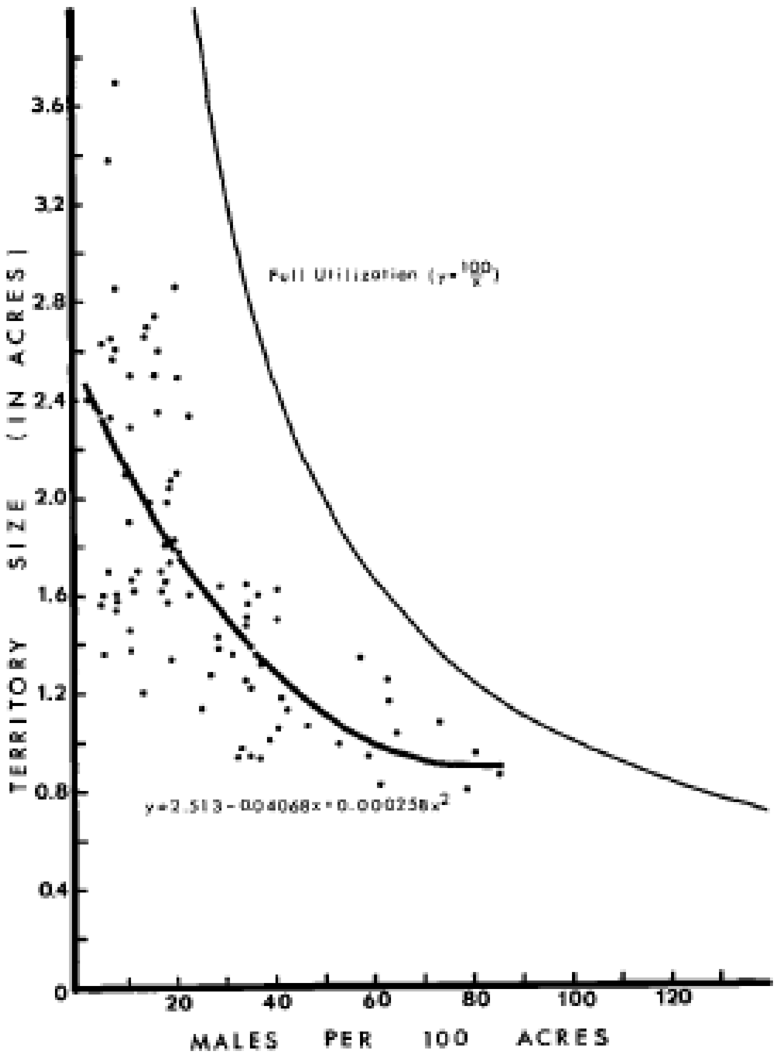


Figure 5. Territory size as a function of male density.

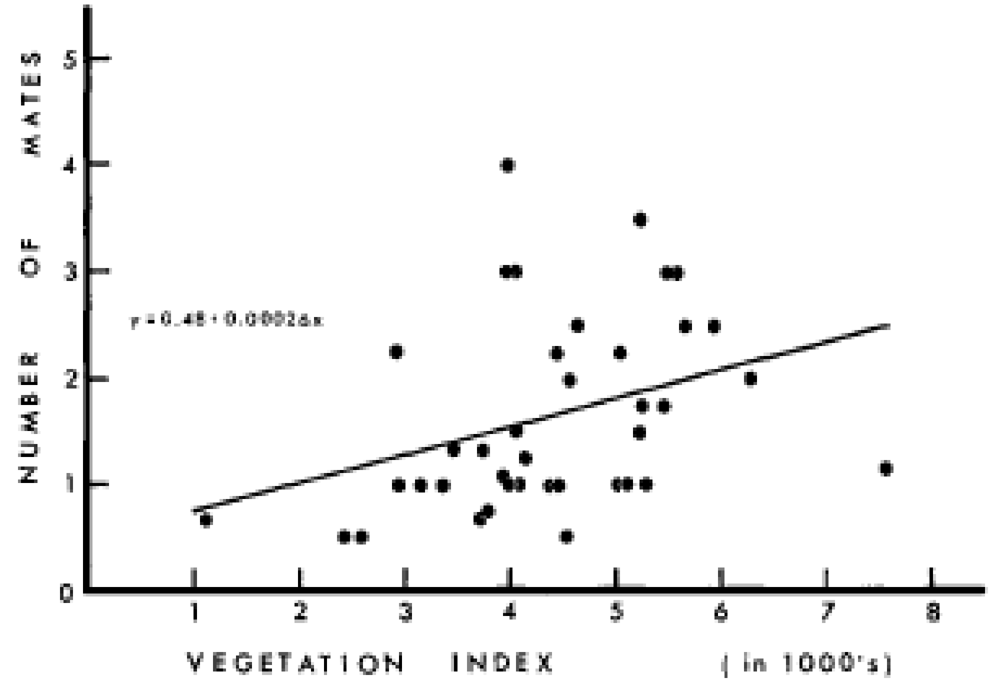


Figure 7. Number of mates of individual males as a function of the vegetation index of their territories.

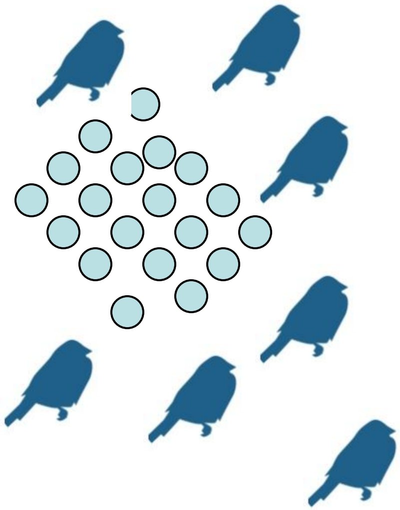
Why don’t all species defend territories?

A territory is advantageous as long as resources do not become too clumped or too unpredictable.

Territories are a type of interference competition and hence is correlated with abundant resources

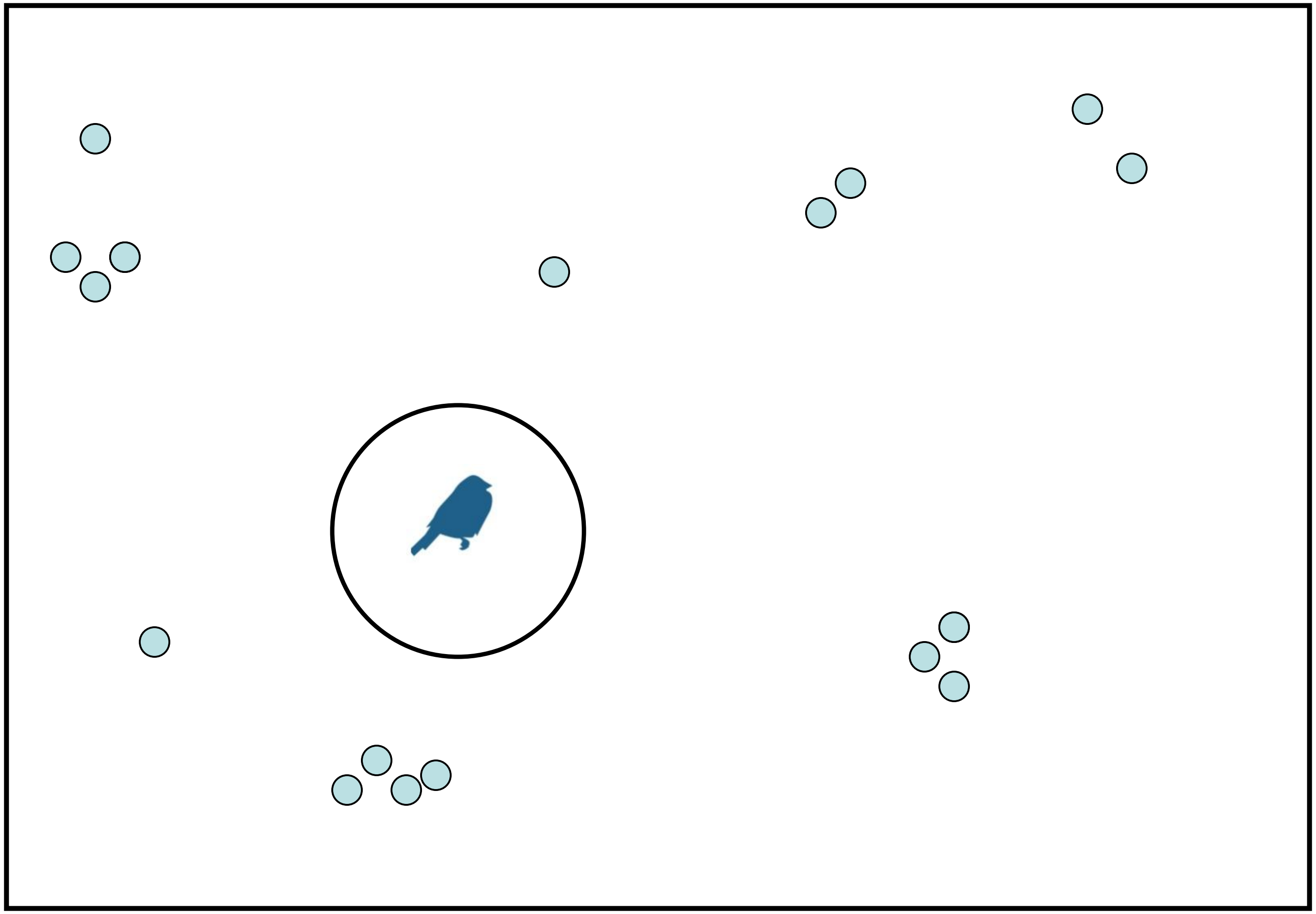
1. Resources are aggregated
highly aggregated spatially,

the competition for that one best spot would be intense and no single male would probably be able to successfully defend that area and still mate.



2. Resources unpredictable

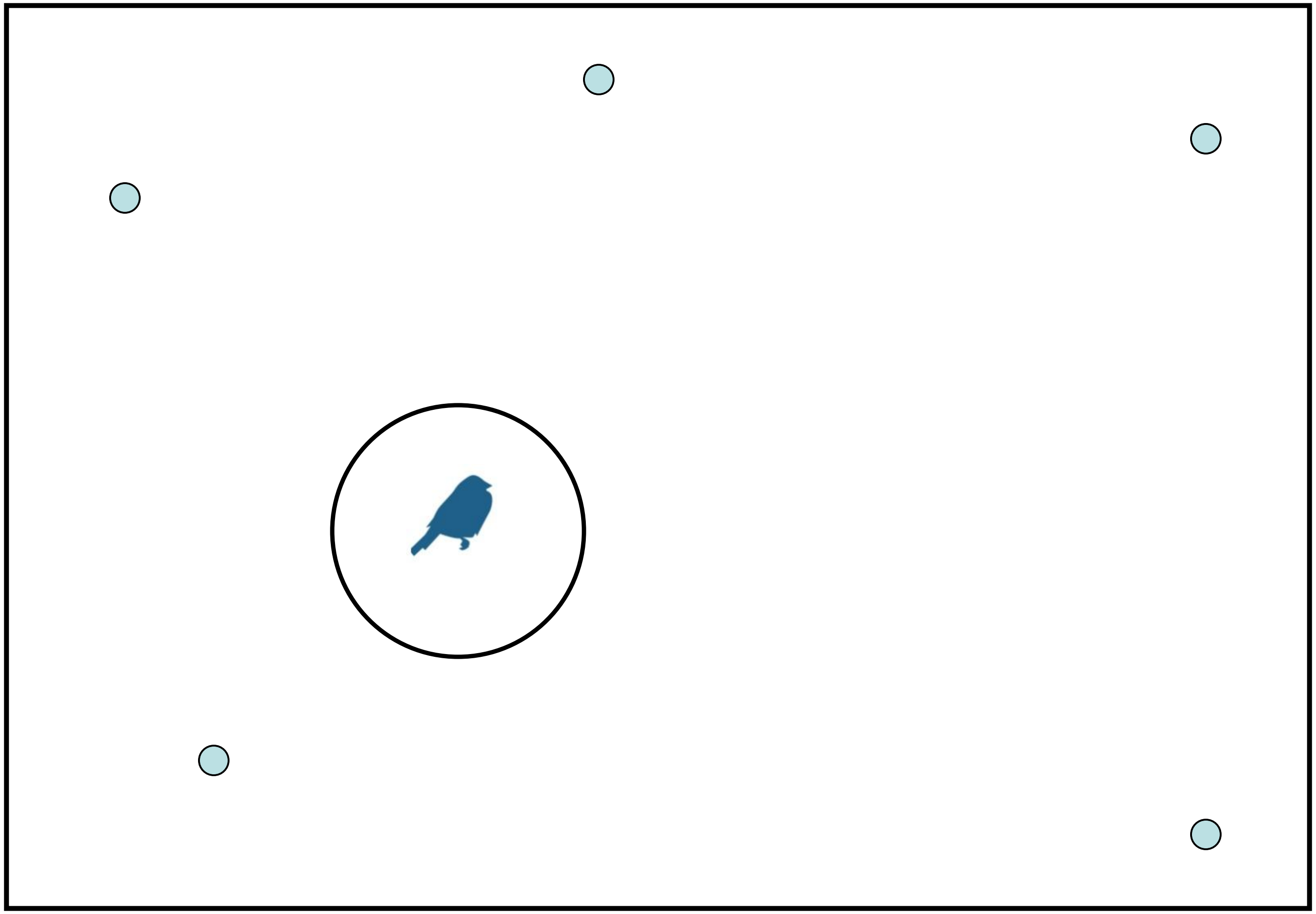
Similarly if the available resources for nesting are temporally unpredictable it is not productive to maintain a territory in the hopes that somehow resources will develop within the territory boundary.



3. Resources Widely Dispersed

Cost in both time and energy

May also be so widely dispersed that it takes too much time and energy to defend it – e.g. prey populations for many raptors



Thus, territoriality depends on the interaction of resource distribution and the cost of resource defense.