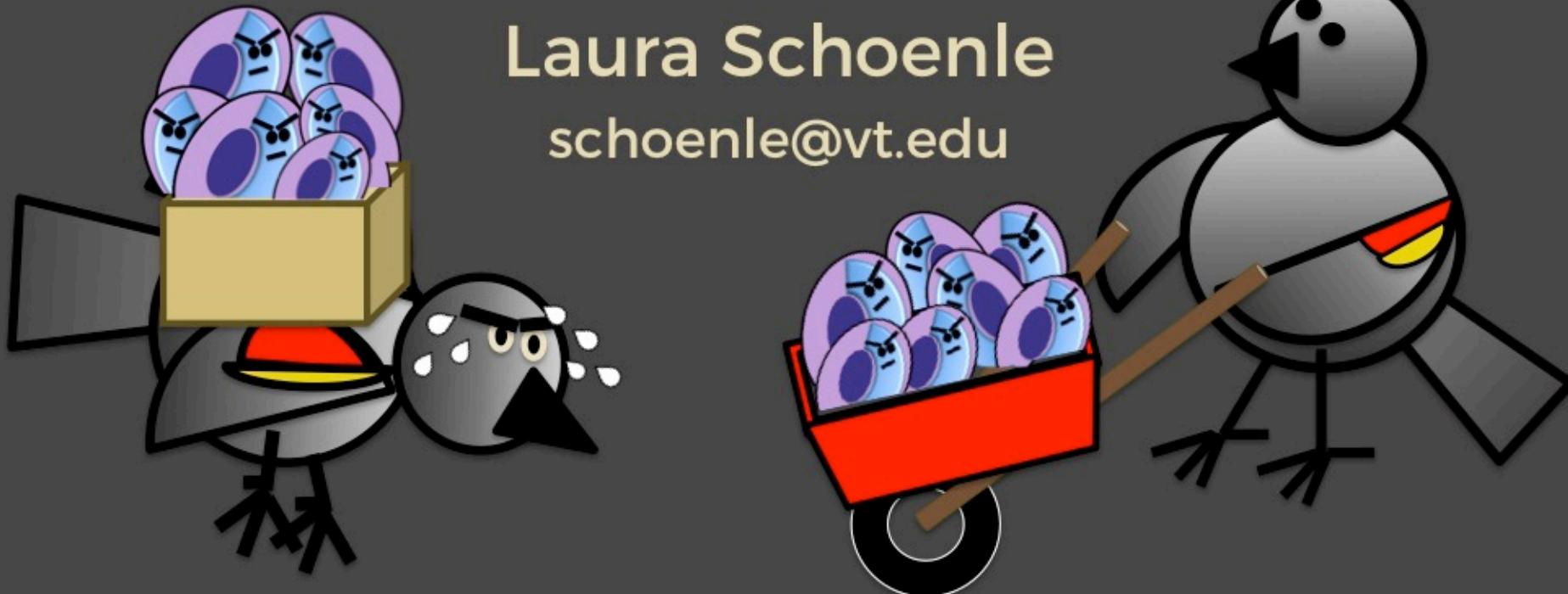


SURVIVING OR THRIVING WITH MALARIA?

THE ROLE OF STRESS HORMONES IN MEDIATING
RESISTANCE AND TOLERANCE

Laura Schoenle
schoenle@vt.edu



man flu (*mæn flu*): An illness that causes the male of the species to be helpless and sicker than any other family member. In females; a *cold*.

Sex differences in hormone concentrations can change rates of virus replication

The screenshot shows a news article from TIME magazine. At the top, there's a red header bar with the TIME logo and navigation links for 'LATEST', 'MAGAZINE', 'VIDEOS', and a search icon. Below the header, the article is categorized under 'HEALTH MEDICINE'. The main title is 'It Turns Out 'Man Flu' Might Actually Be Real'. The author is Alice Park (@aliceparkny), and the date is Jan. 15, 2016. To the right of the author info are social media sharing icons for email, Facebook, Twitter, Pinterest, and LinkedIn. On the left side of the article, there's a sidebar for the 'moto 360' smartwatch, featuring a circular image of the watch face and some text about it being a 'sidekick'.

It Turns Out 'Man Flu' Might Actually Be Real

Alice Park @aliceparkny | Jan. 15, 2016

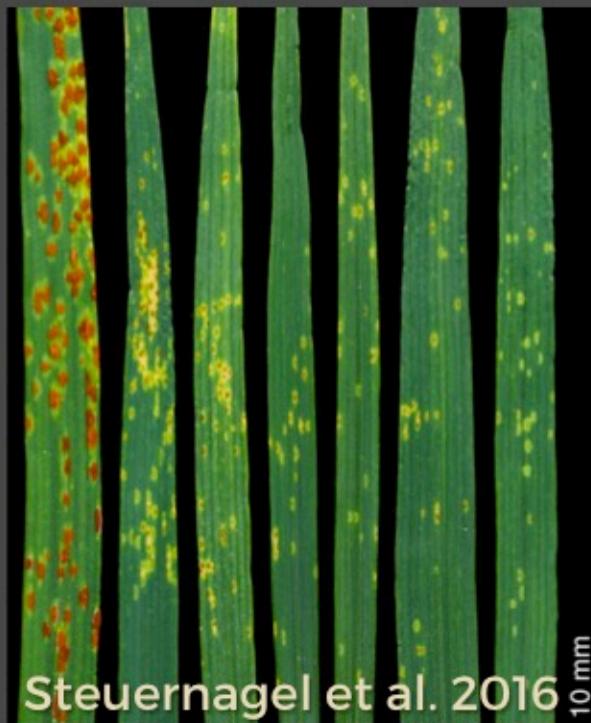
moto 360

Meet your new sidekick.

A study hints at why women may be less likely to get infected with the flu virus than men. But here's what men — and women — need to know

(Peretz et al. 2015)

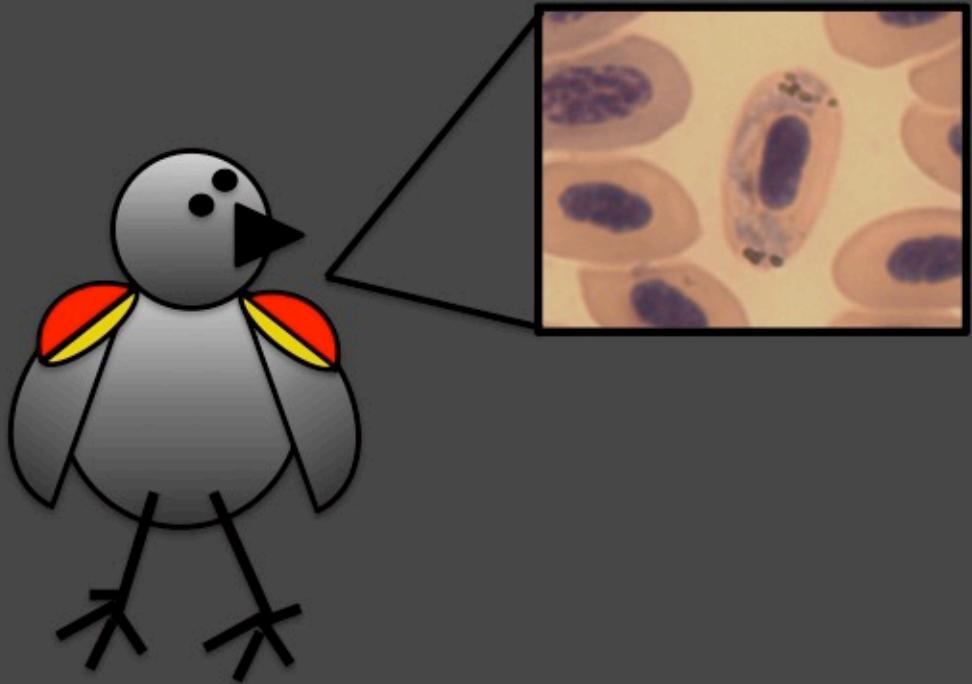
VARIATION IN RESPONSE TO INFECTION



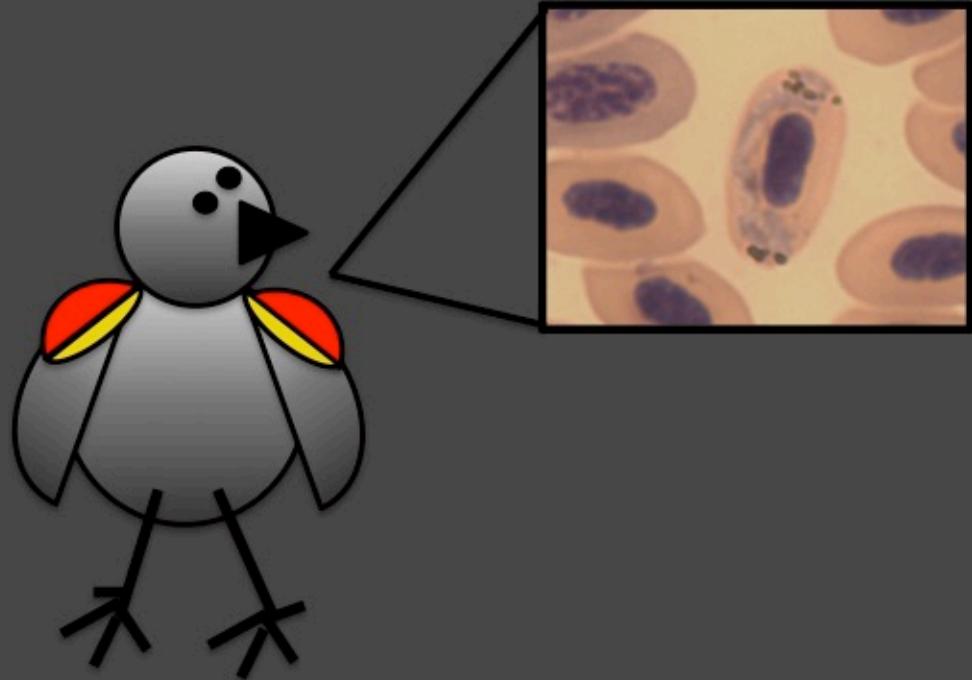
VARIATION IN RESPONSE TO INFECTION



WHY?

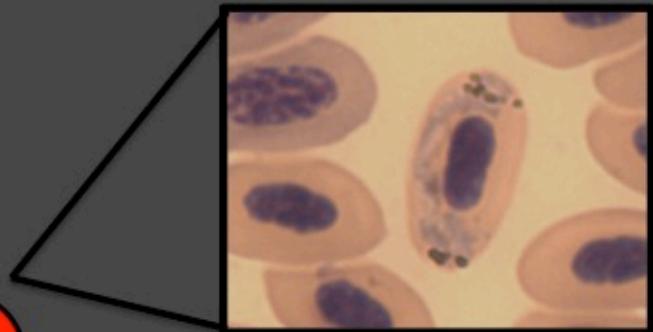
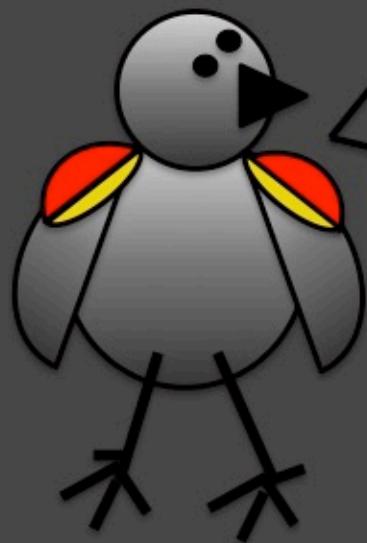


RESISTANCE



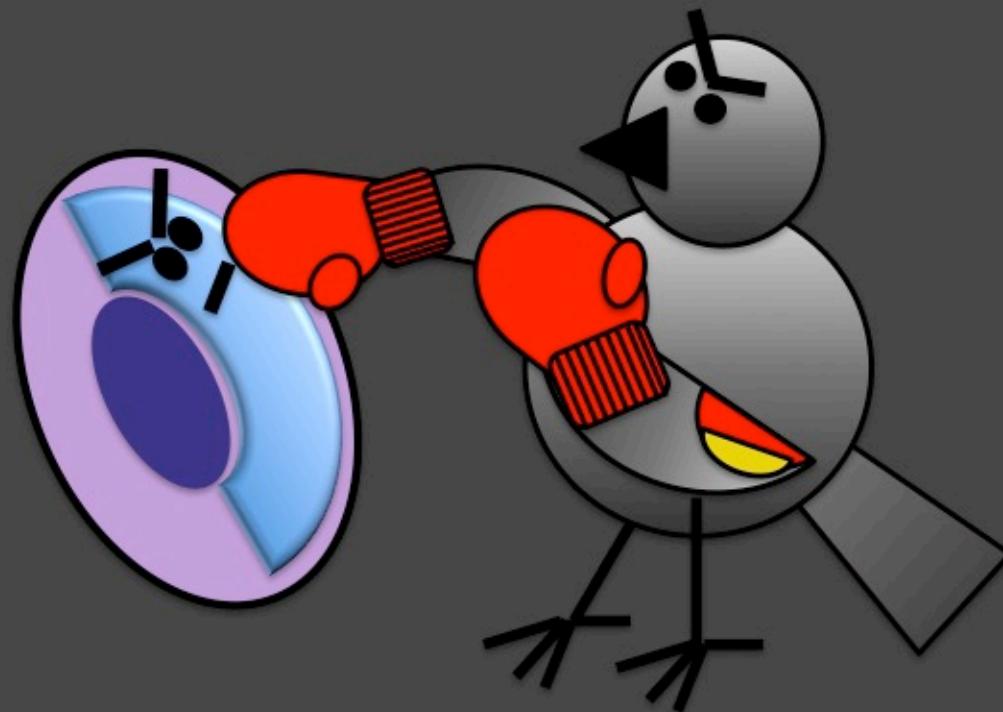
RESISTANCE

TOLERANCE



PARASITE RESISTANCE

resistance = removing parasites



PARASITE RESISTANCE

resistance = removing parasites

more resistant individuals will have
fewer parasites or increased clearance

PARASITE TOLERANCE

tolerance = minimize the damage per parasite

more tolerant individuals will have fewer costs for a given parasite burden



PARASITE TOLERANCE

tolerance = minimize the damage per parasite

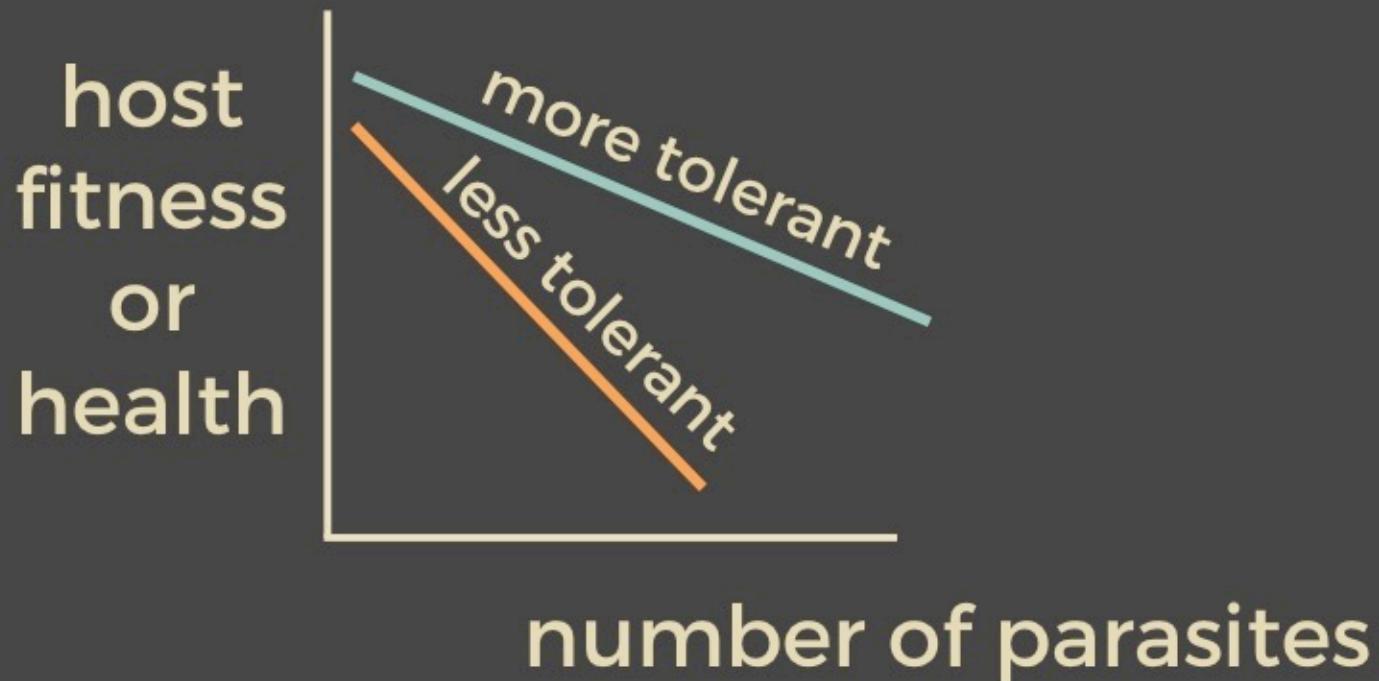
host
fitness
or
health



number of parasites

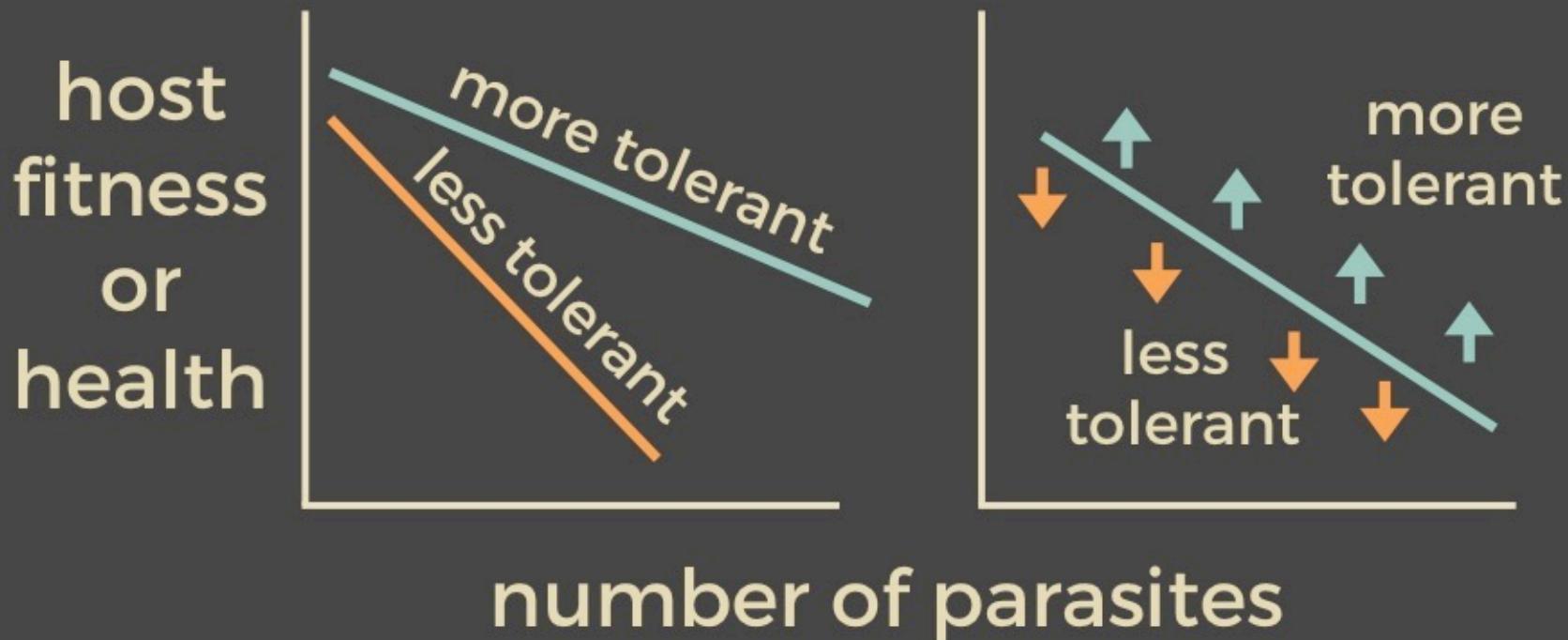
PARASITE TOLERANCE

tolerance = minimize the damage per parasite



PARASITE TOLERANCE

tolerance = minimize the damage per parasite



RESISTANCE



TOLERANCE



**immune
response**

**tissue
repair**

RESISTANCE



TOLERANCE



**immune
response**

**tissue
repair**

RESISTANCE



TOLERANCE



**immune
response**

**tissue
repair**

RESISTANCE



TOLERANCE



GLUCOCORTICOID “STRESS” HORMONES: A POTENTIAL MECHANISM

GLUCOCORTICOID HORMONES (CORT)



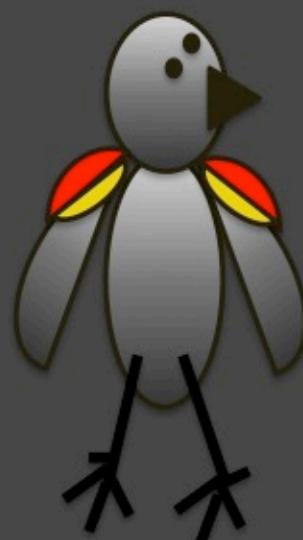
GLUCOCORTICOID LEVELS RESPOND TO:

short, unpredictable events

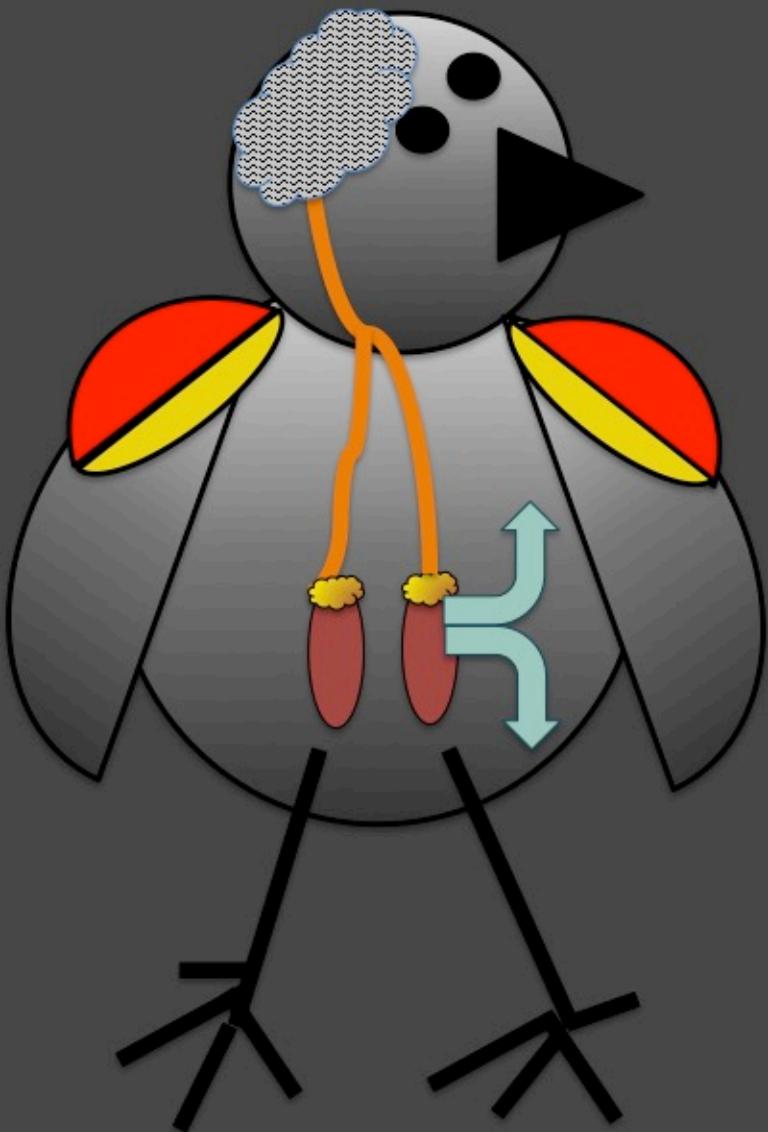


GLUCOCORTICOID LEVELS RESPOND TO:

long term, predictable, and/or
energetically costly challenges

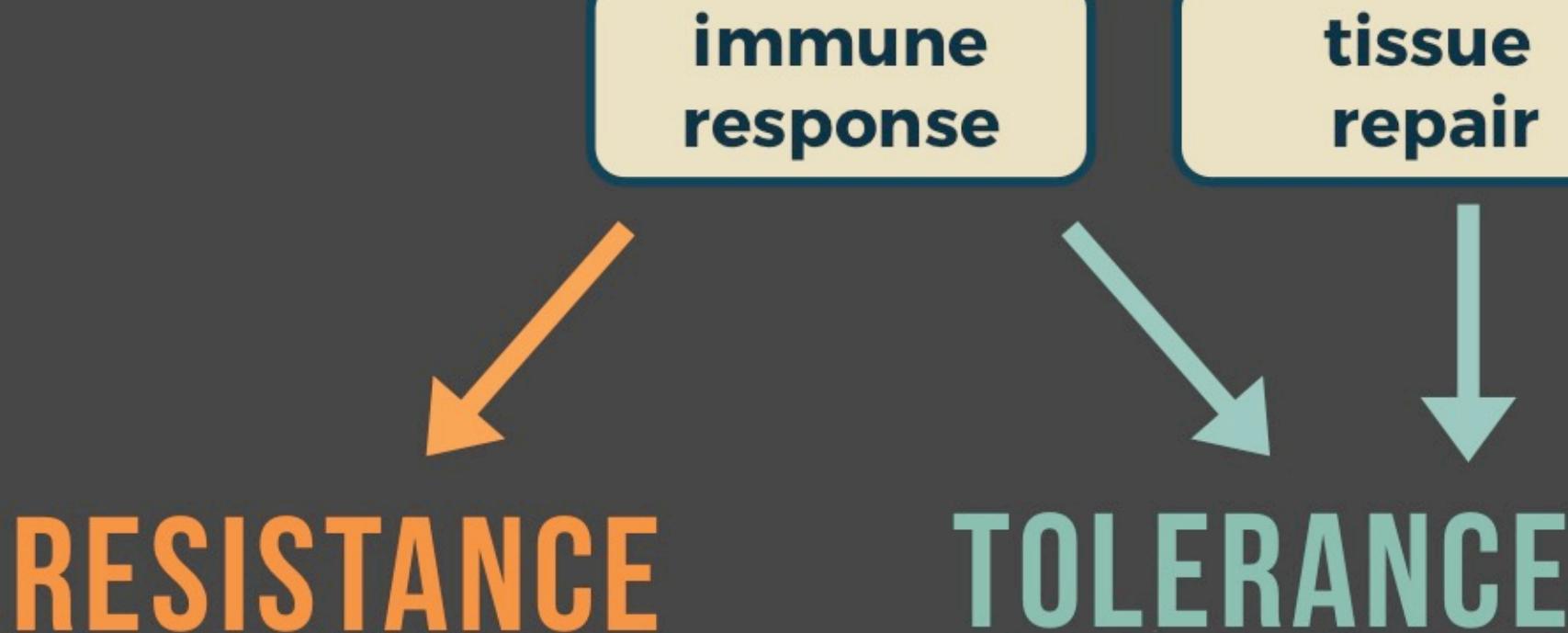


GLUCOCORTICOIDS: SUITE OF EFFECTS



- Energy mobilization
- Reproduction
- Immune function

CORT



DO GLUCOCORTICOIDS MEDIATE RESISTANCE AND/OR TOLERANCE TO MALARIA?

GLUCOCORTICOIDS

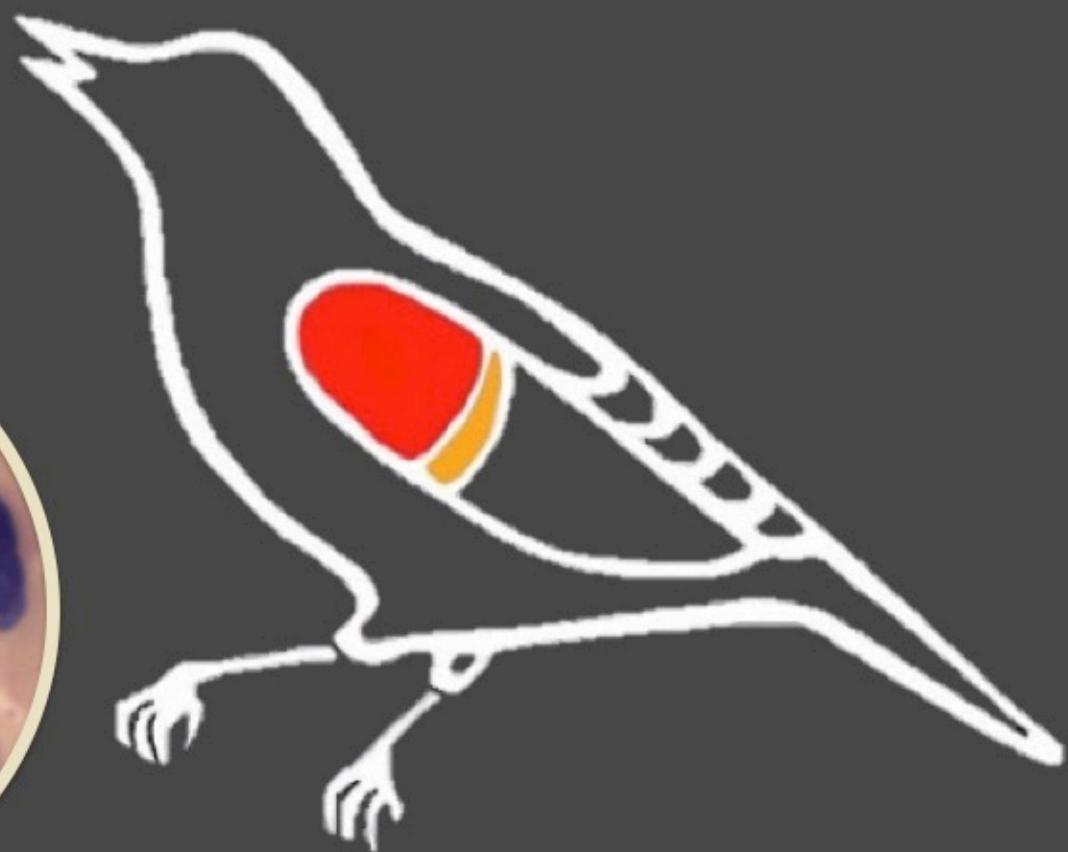
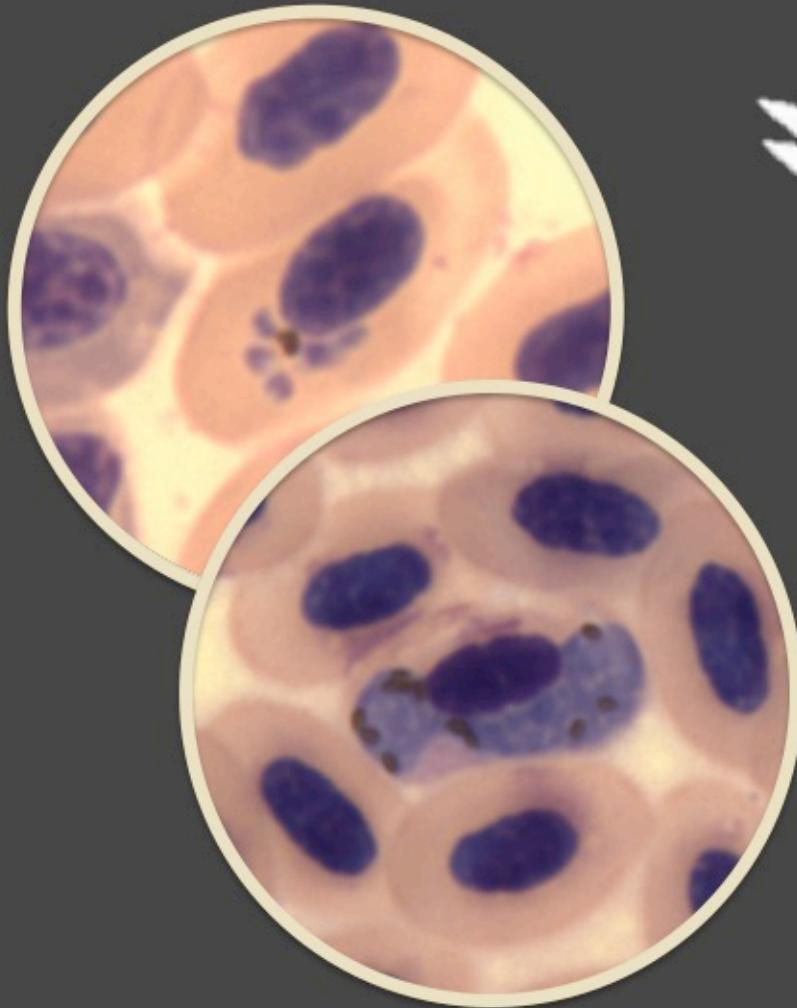


RESISTANCE

TO TOLERANCE



STUDY SYSTEM

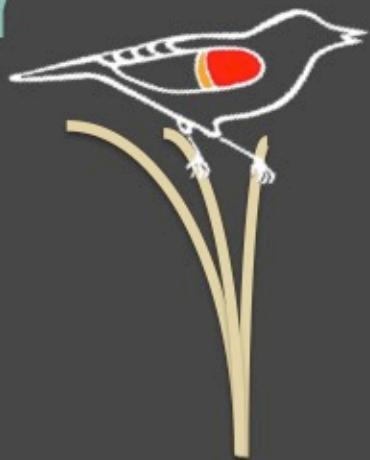




95%

are infected

OBSERVATIONAL FIELD STUDY



CORT



immune
response

tissue
repair

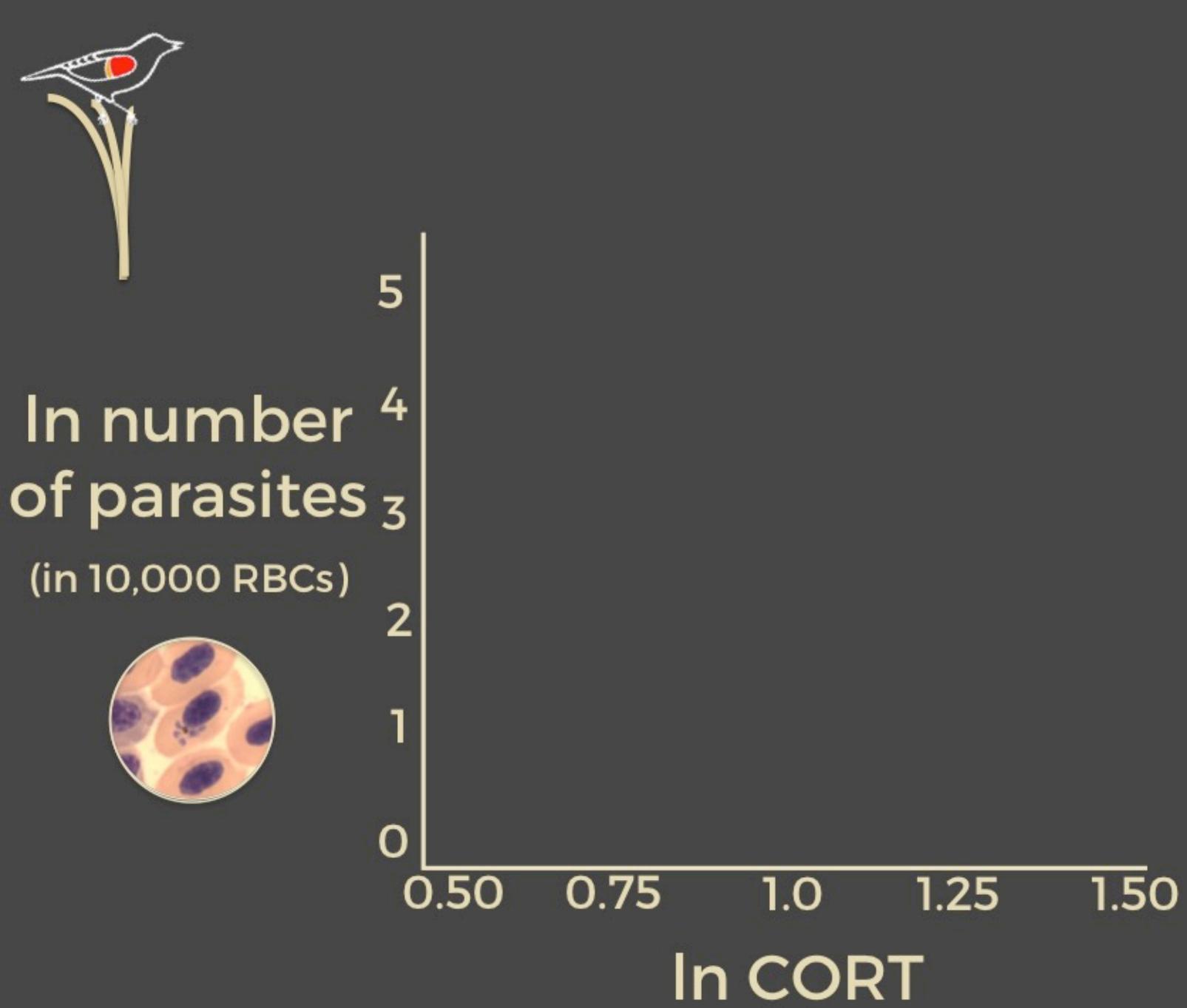


RESISTANCE



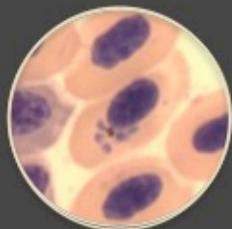
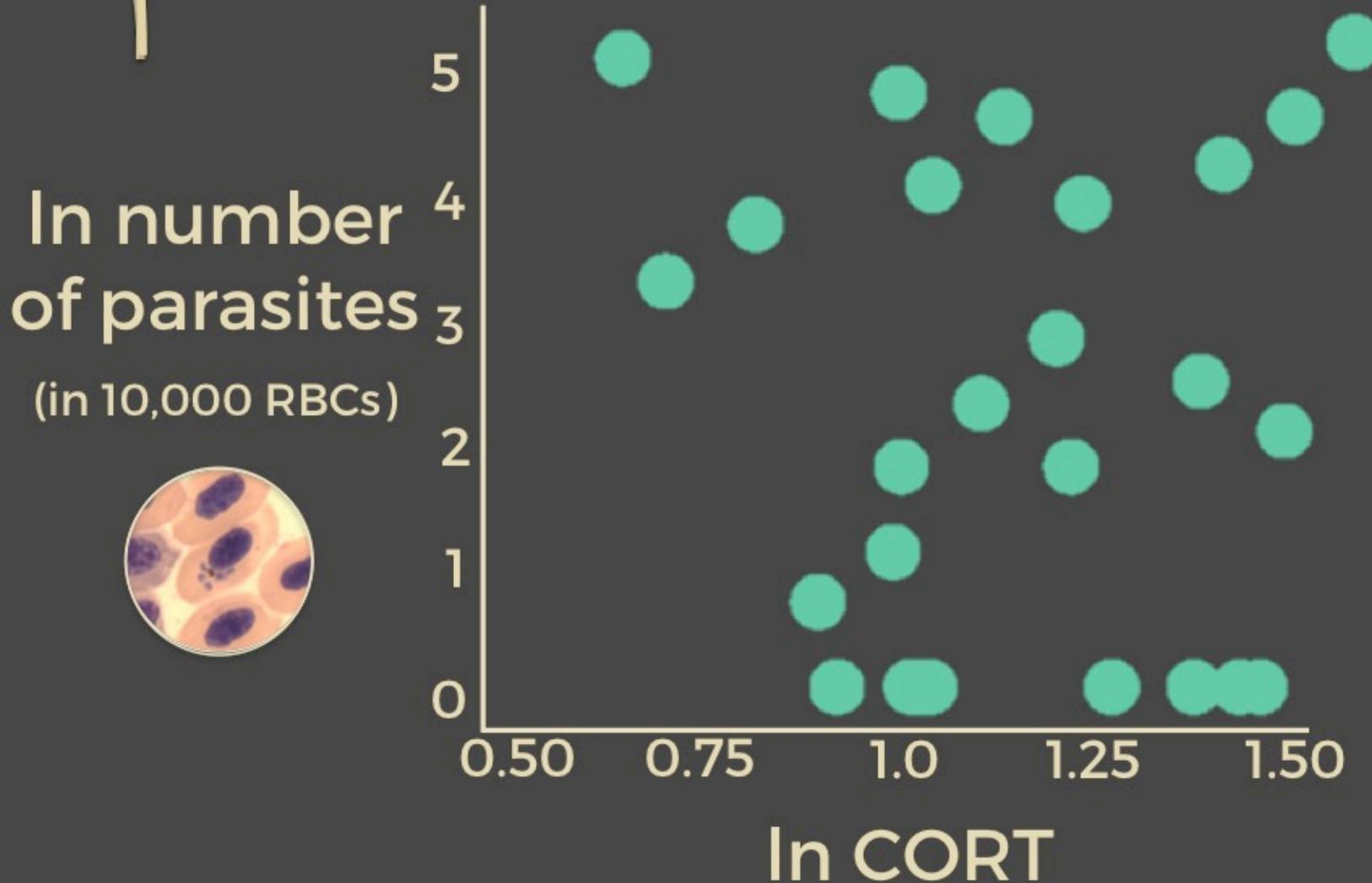
TOLERANCE

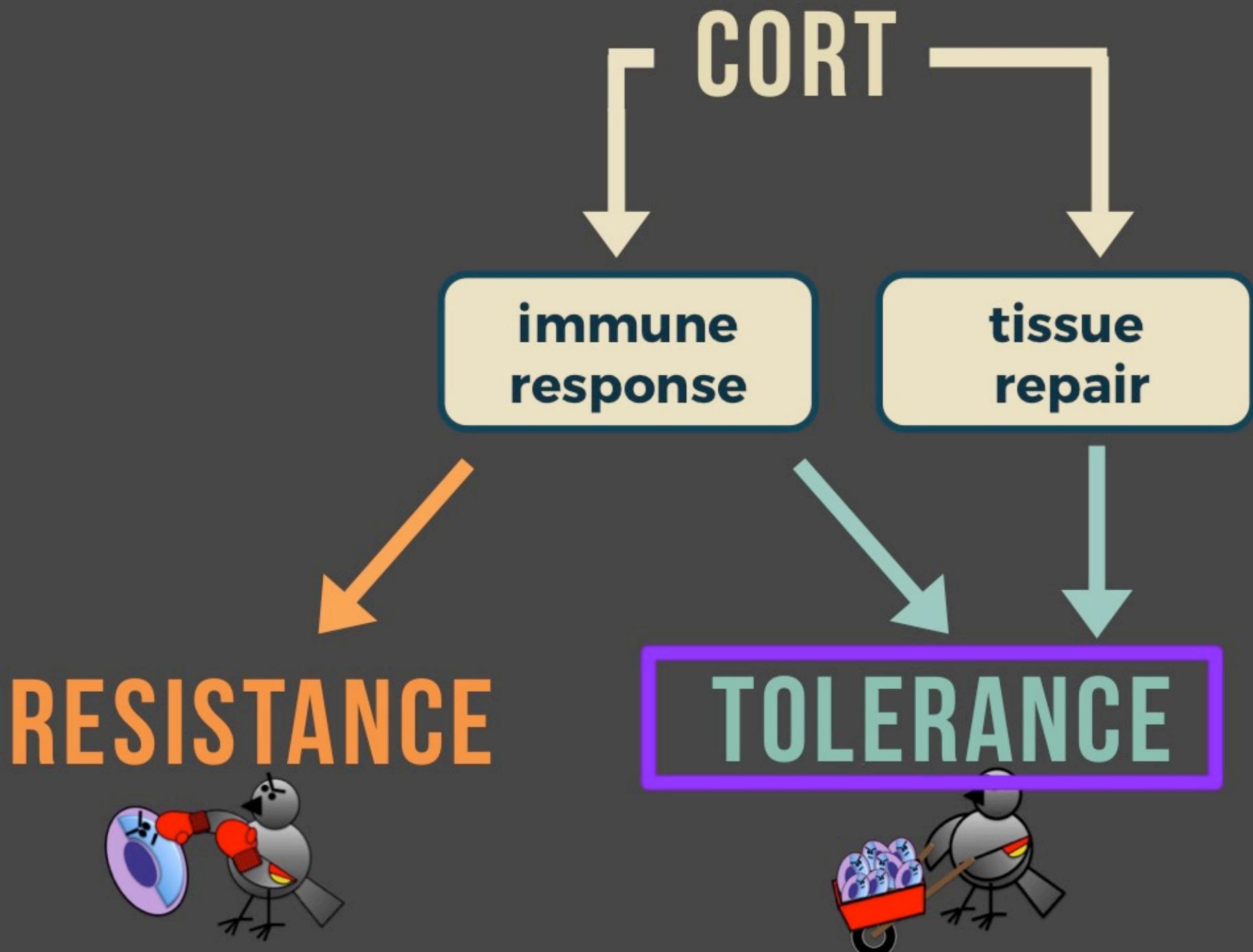




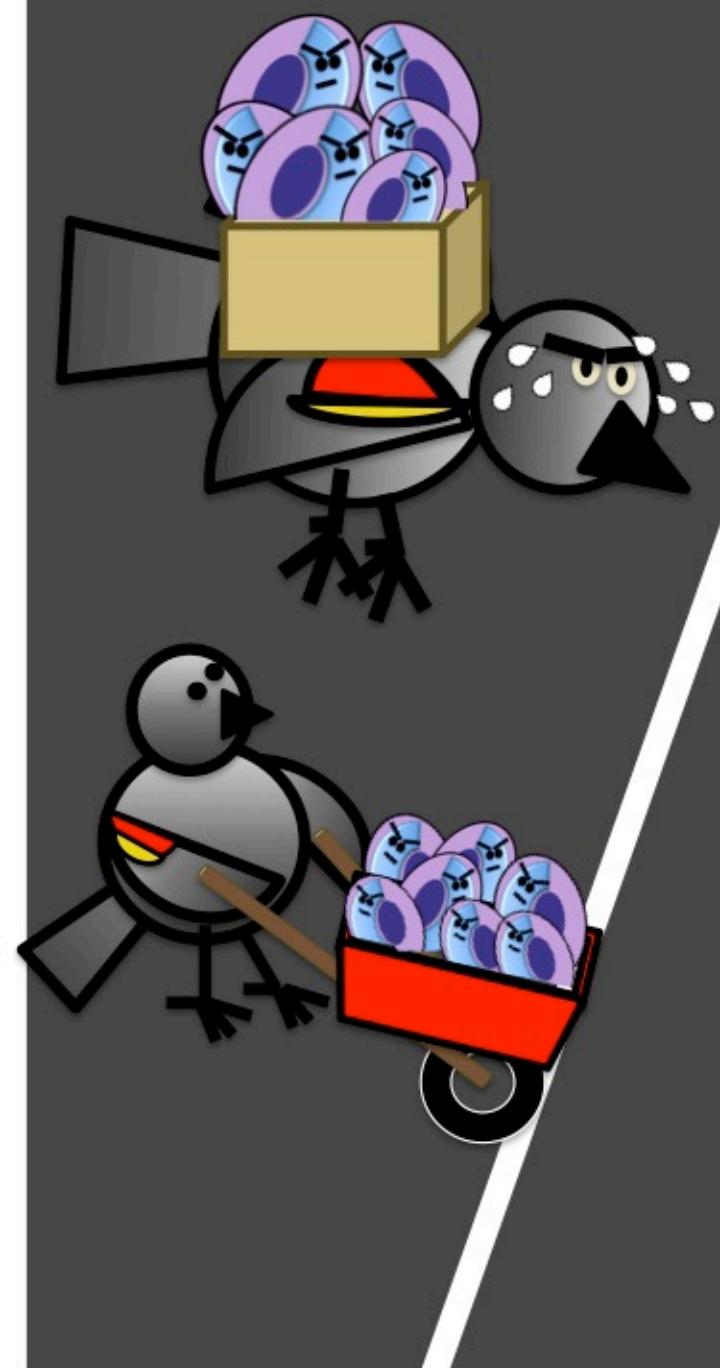


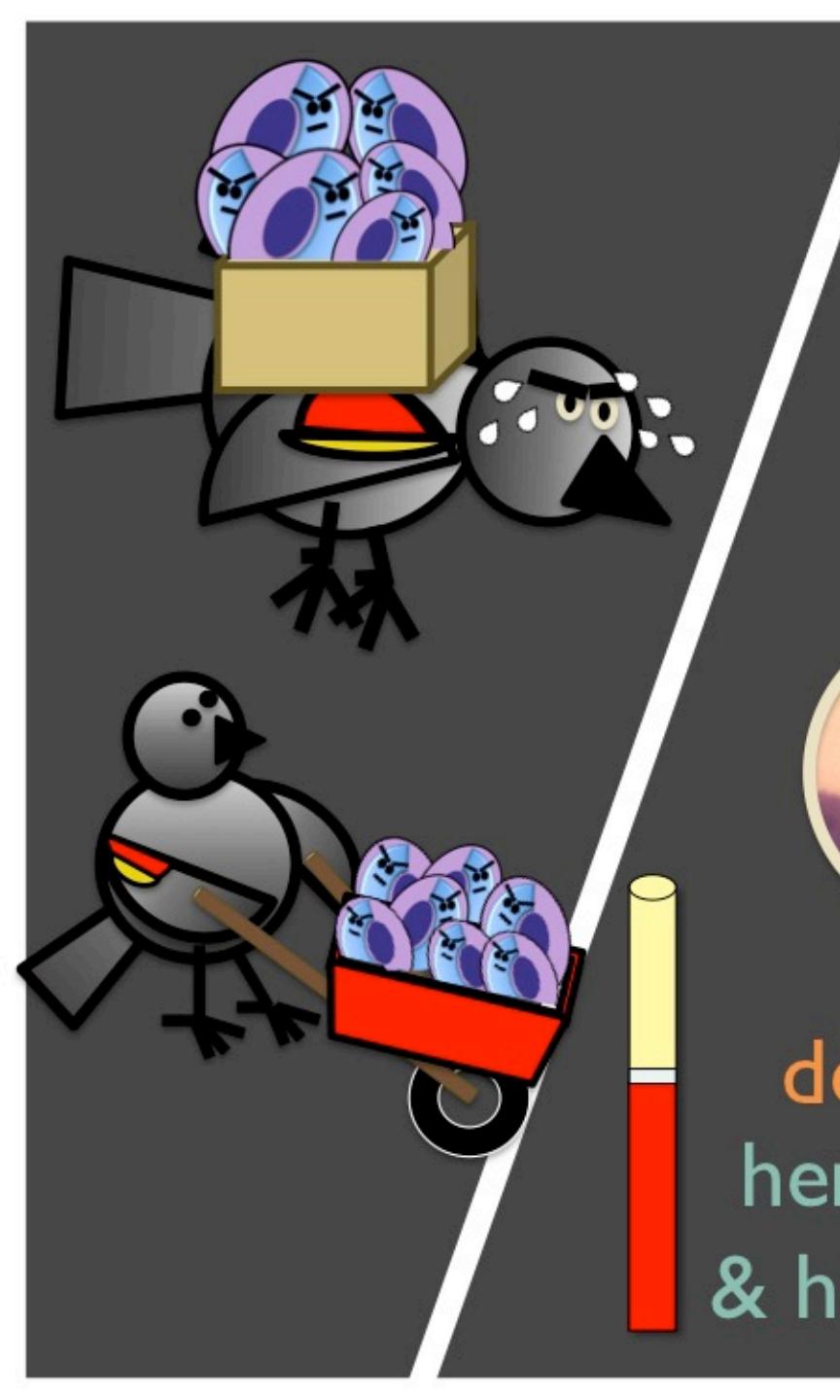
CORT IS NOT RELATED TO INFECTION INTENSITY





COST OF AVIAN MALARIA INFECTION

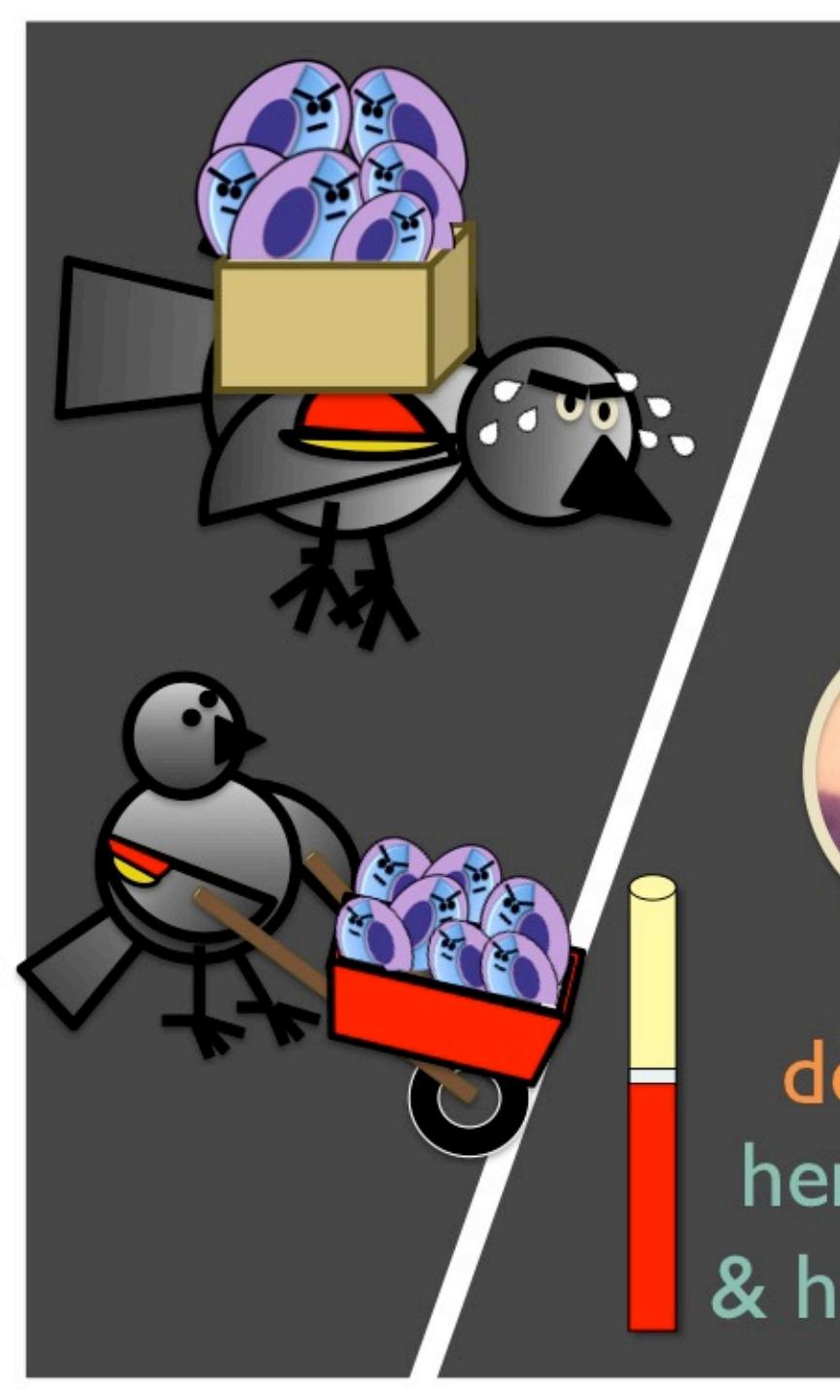




COST OF AVIAN MALARIA INFECTION

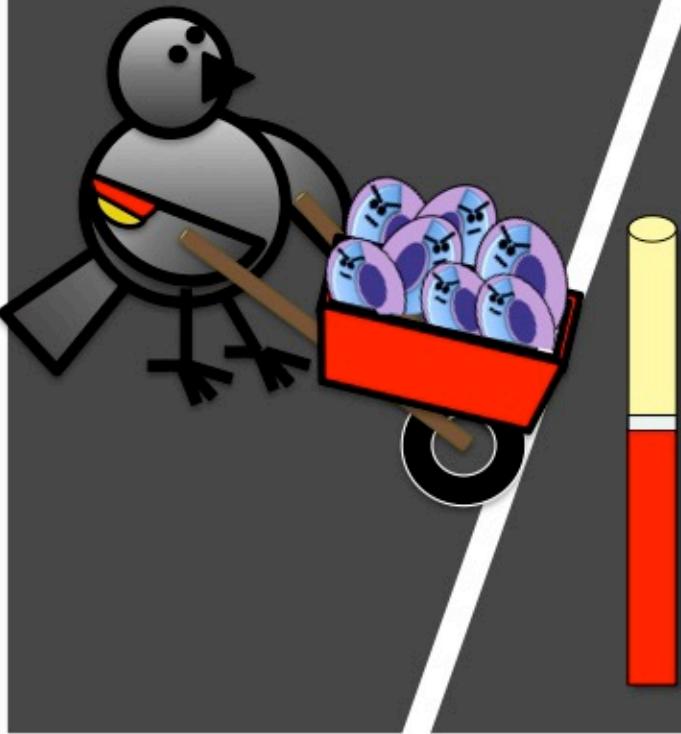


decreases
hemoglobin
& hematocrit





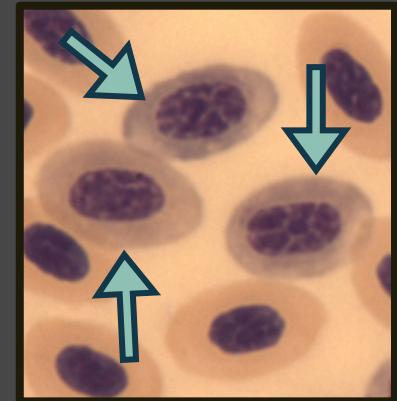
COST OF AVIAN MALARIA INFECTION



increase
RBC production



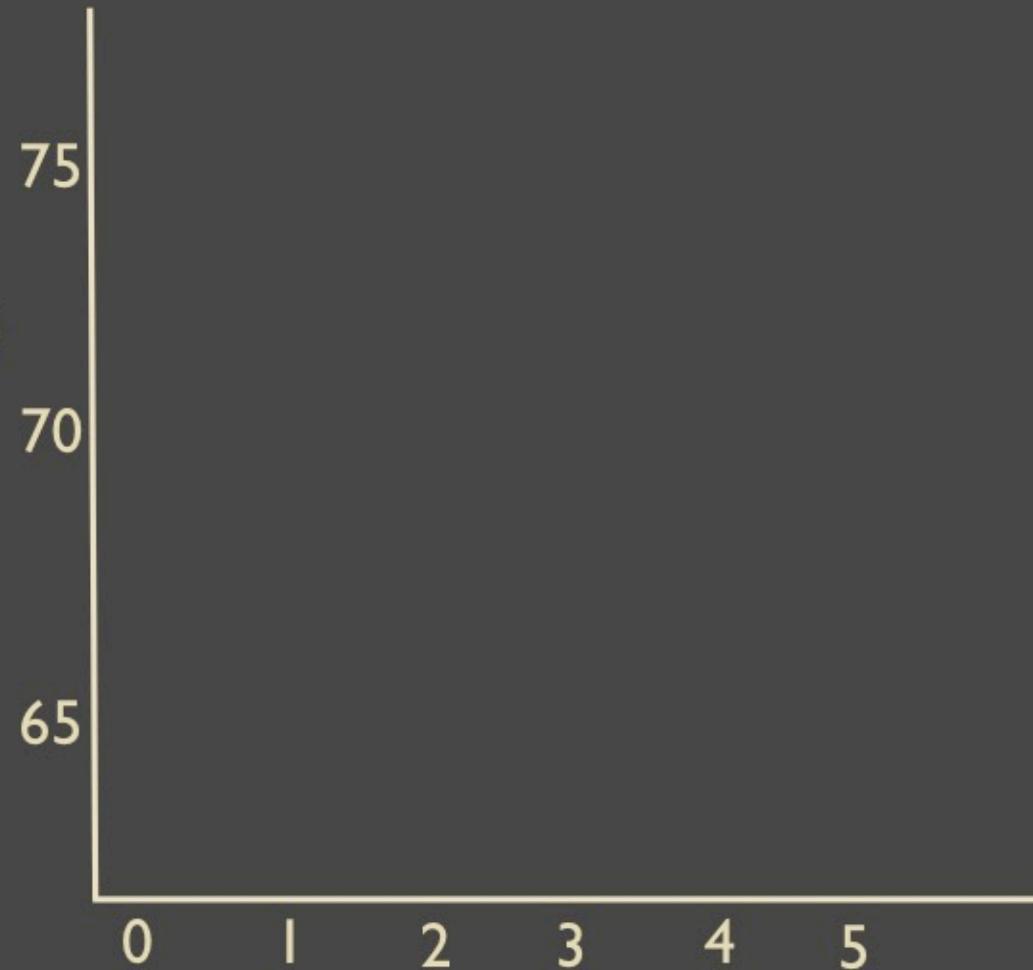
decreases
hemoglobin
& hematocrit





COST OF AVIAN MALARIA INFECTION

scaled mass
index

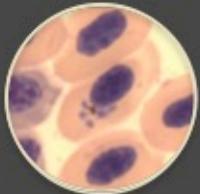
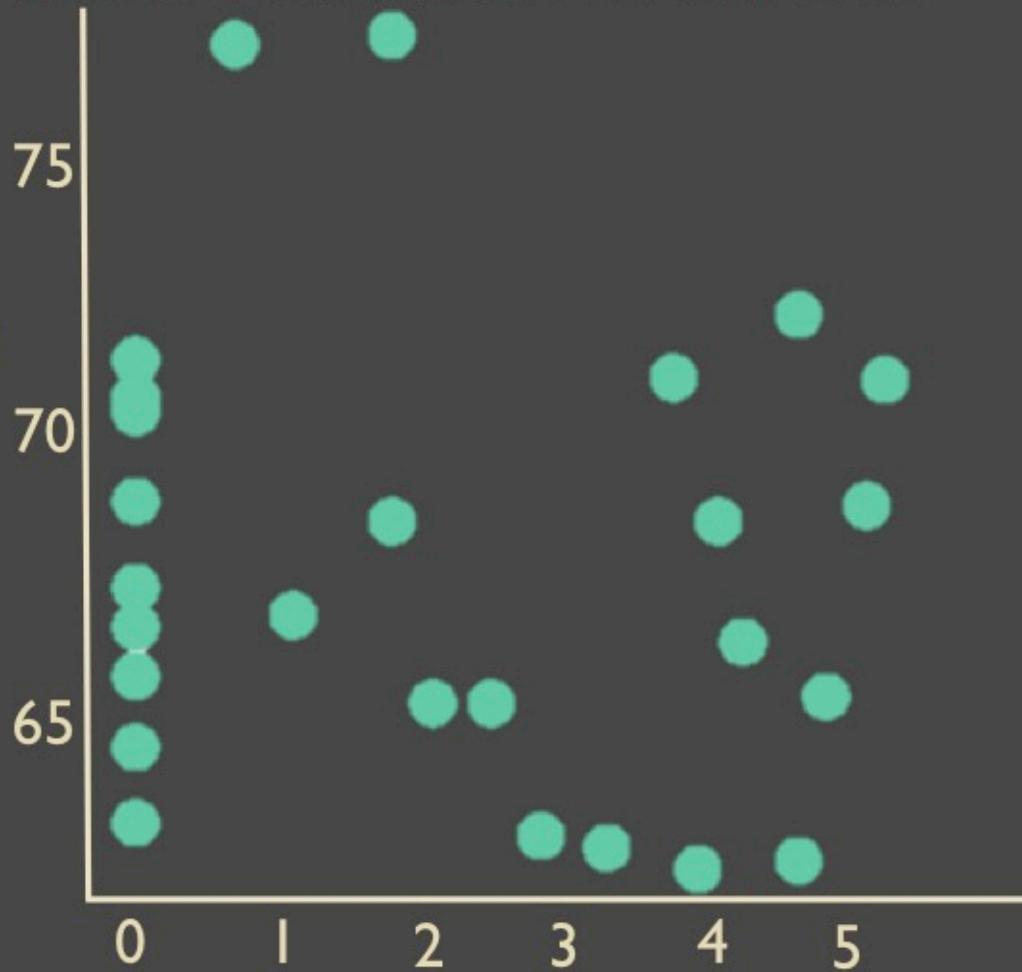


In number of parasites
(# infected/10,000 red blood cells)



MASS DOES NOT CORRELATE WITH PARASITE BURDEN

scaled mass
index

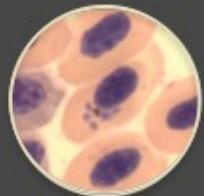
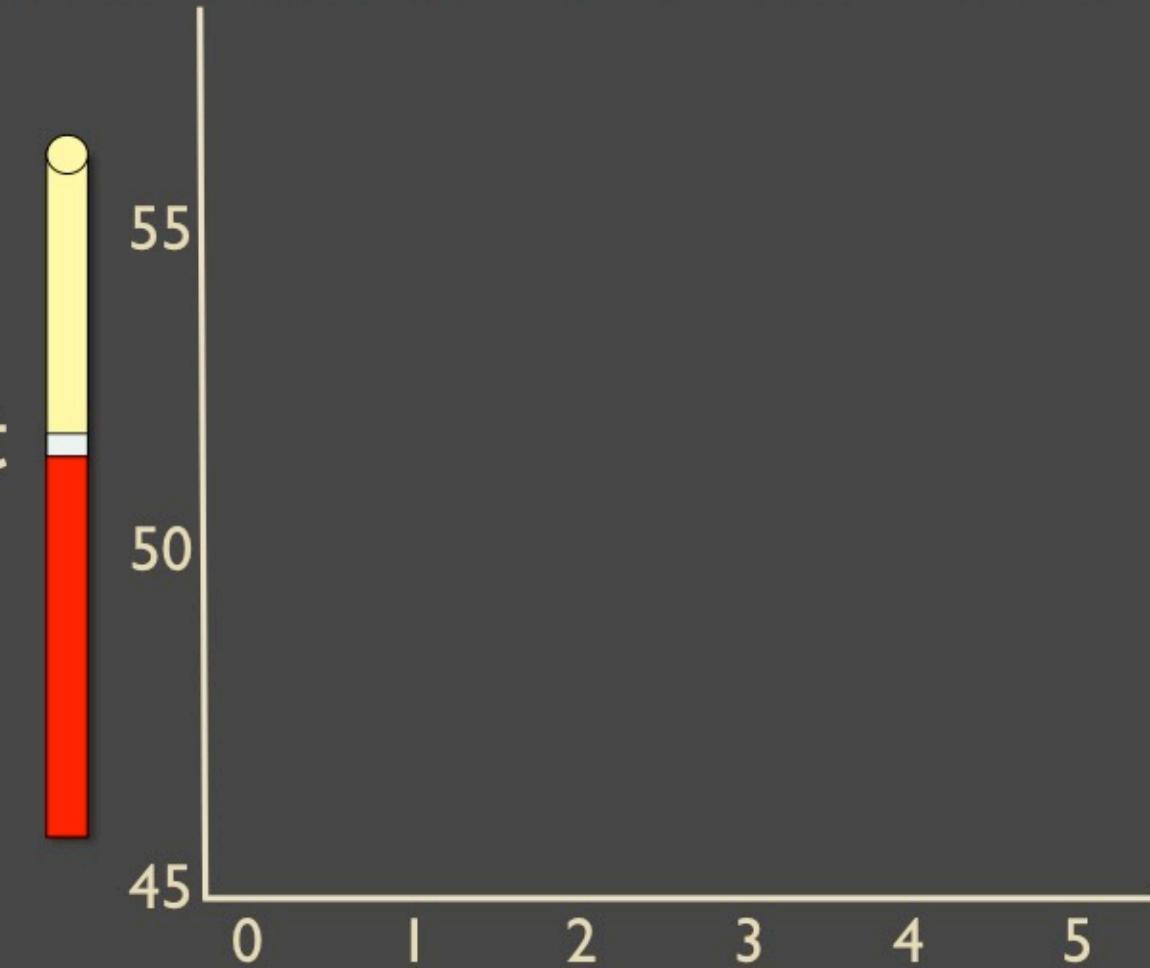


In number of parasites
(# infected/10,000 red blood cells)

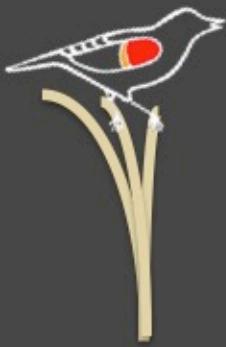


COST OF AVIAN MALARIA INFECTION

hematocrit

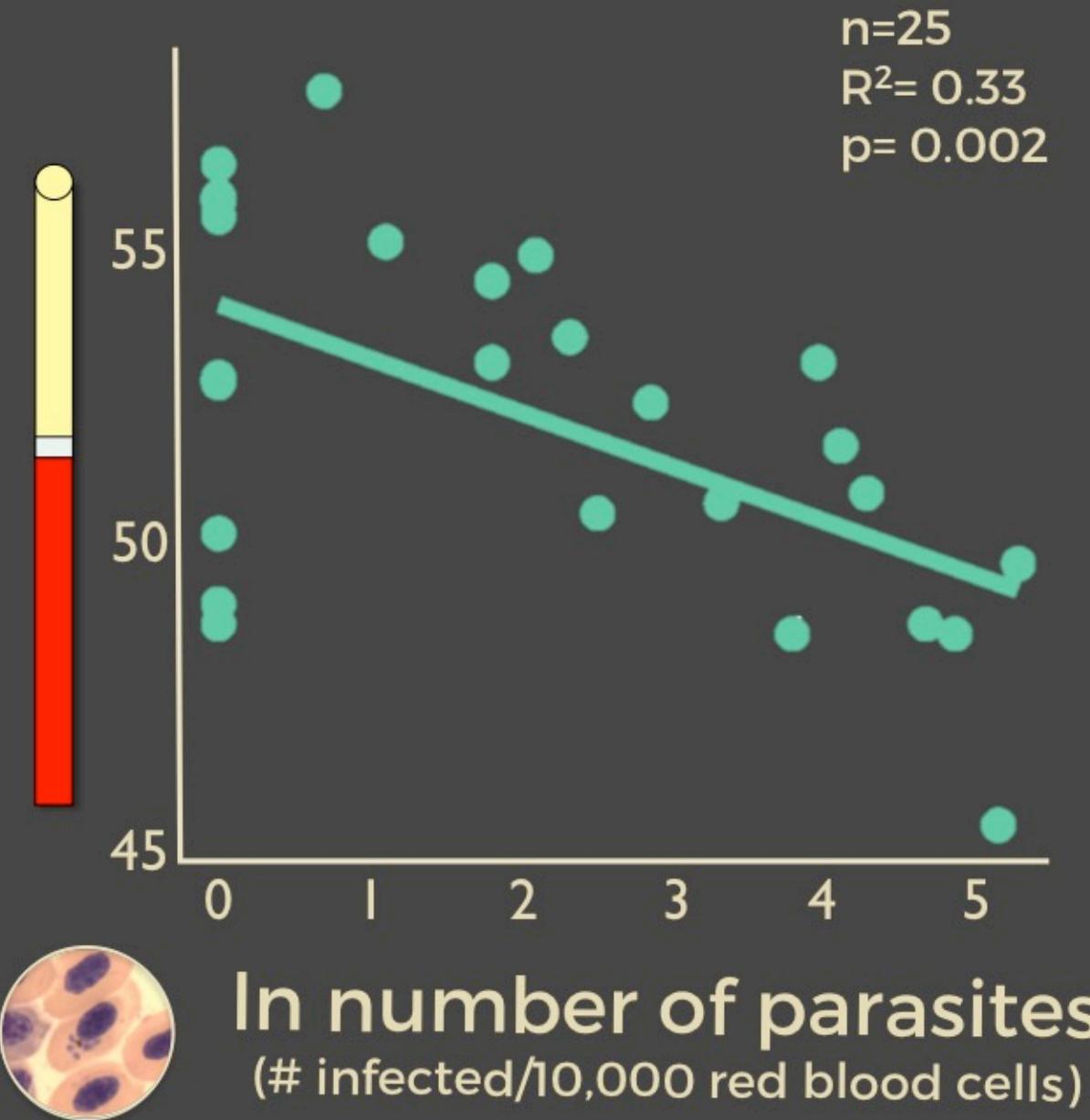


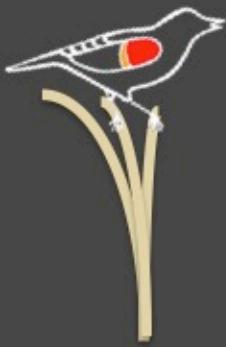
In number of parasites
(# infected/10,000 red blood cells)



MORE PARASITES = LOWER HEMATOCRIT

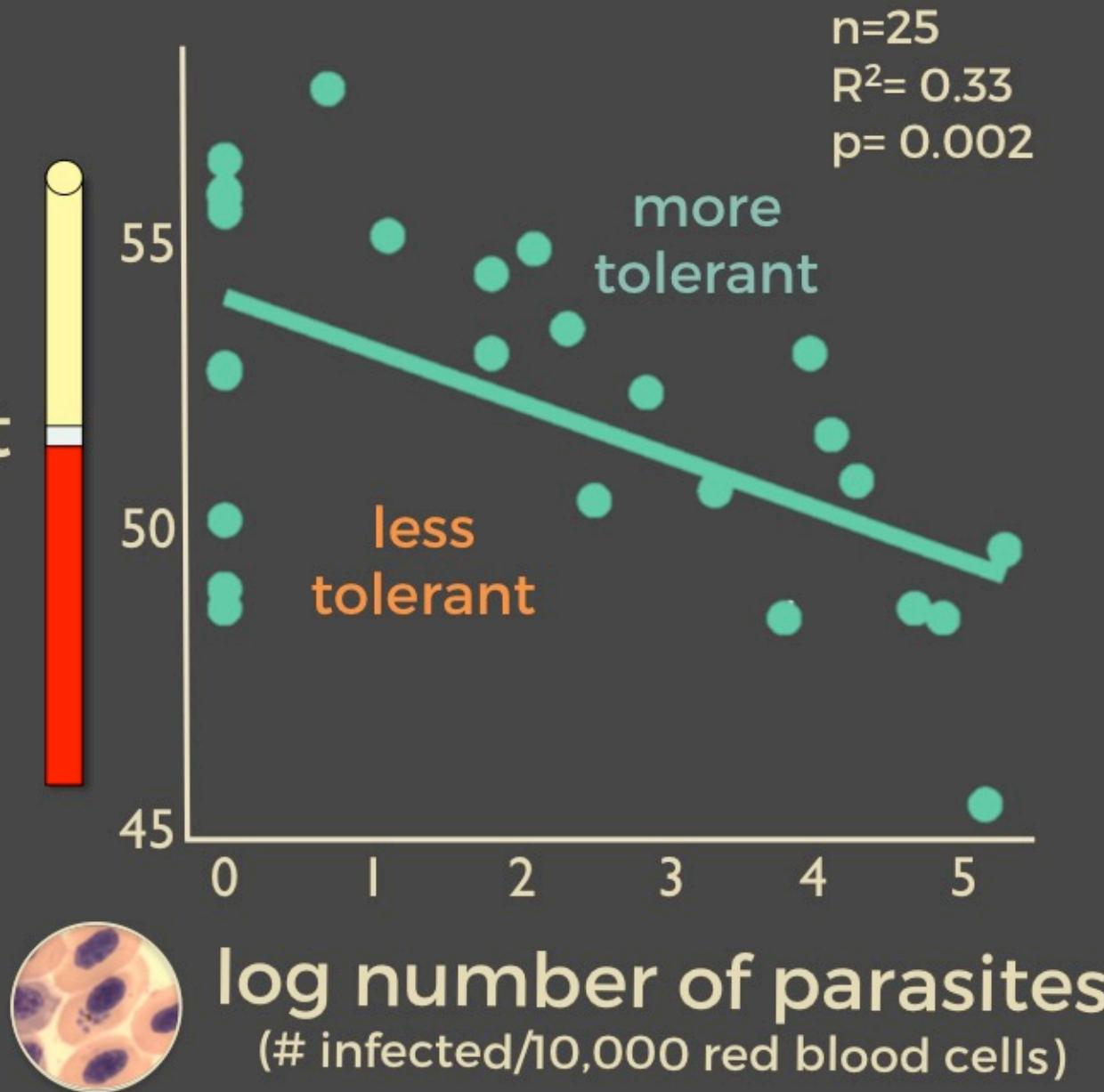
hematocrit





MORE PARASITES = LOWER HEMATOCRIT

hematocrit



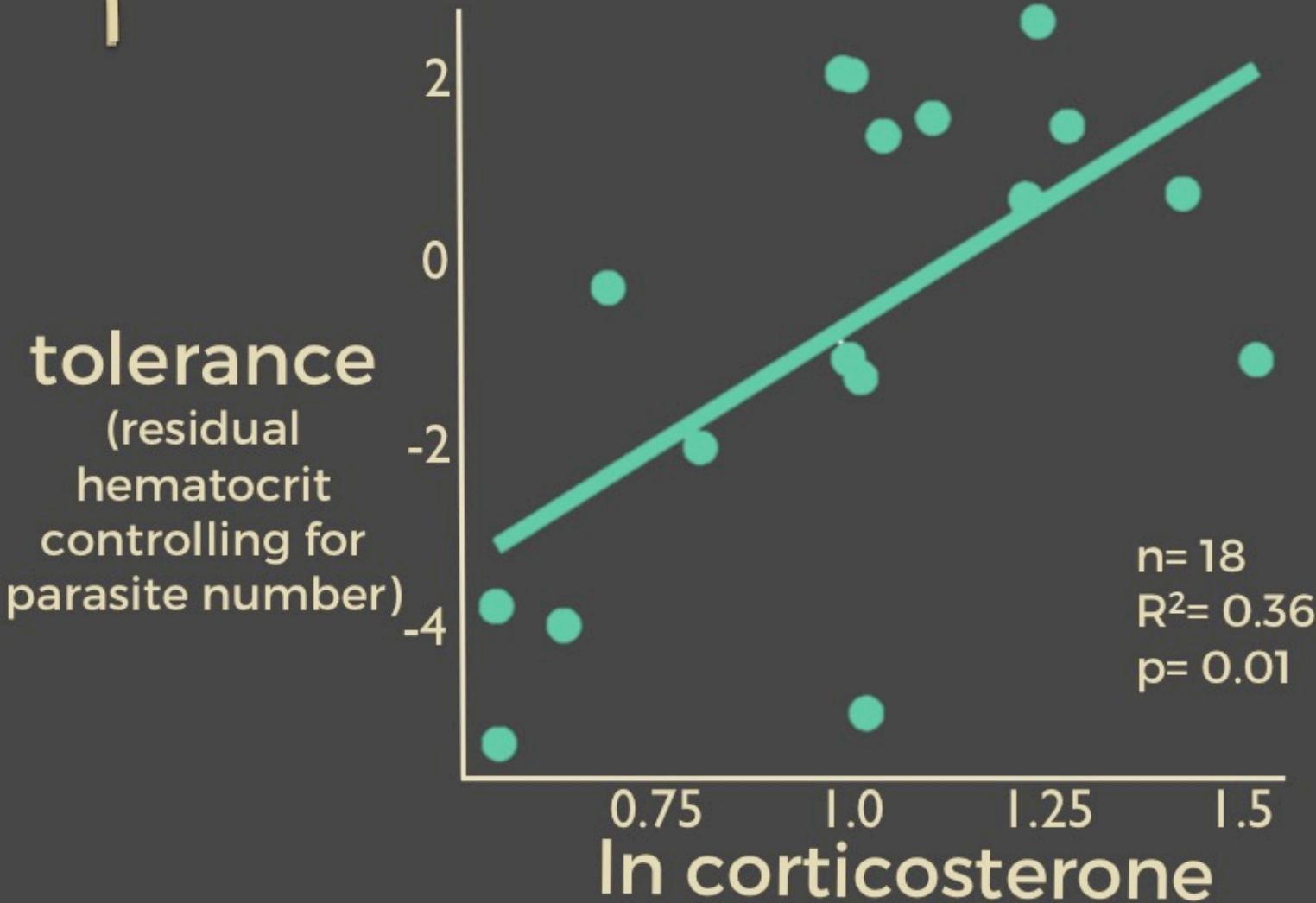


tolerance
(residual
hematocrit
controlling for
parasite number)

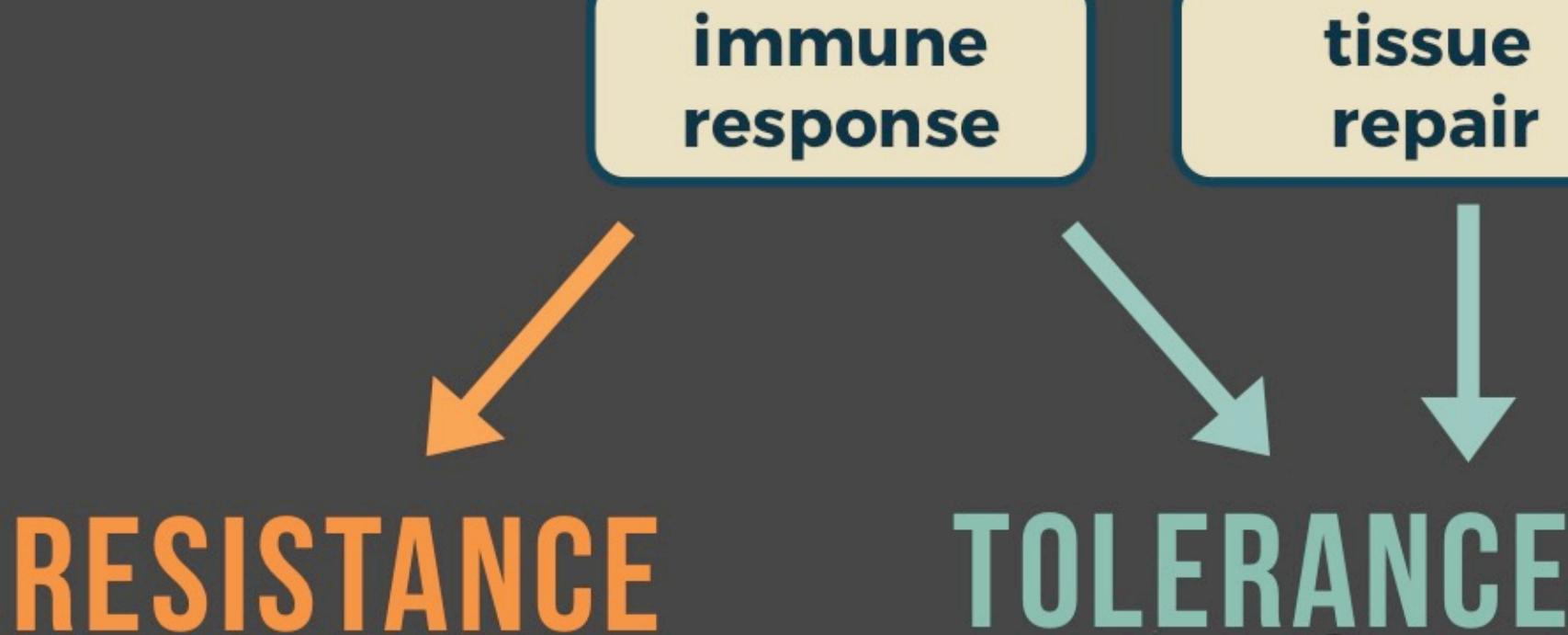




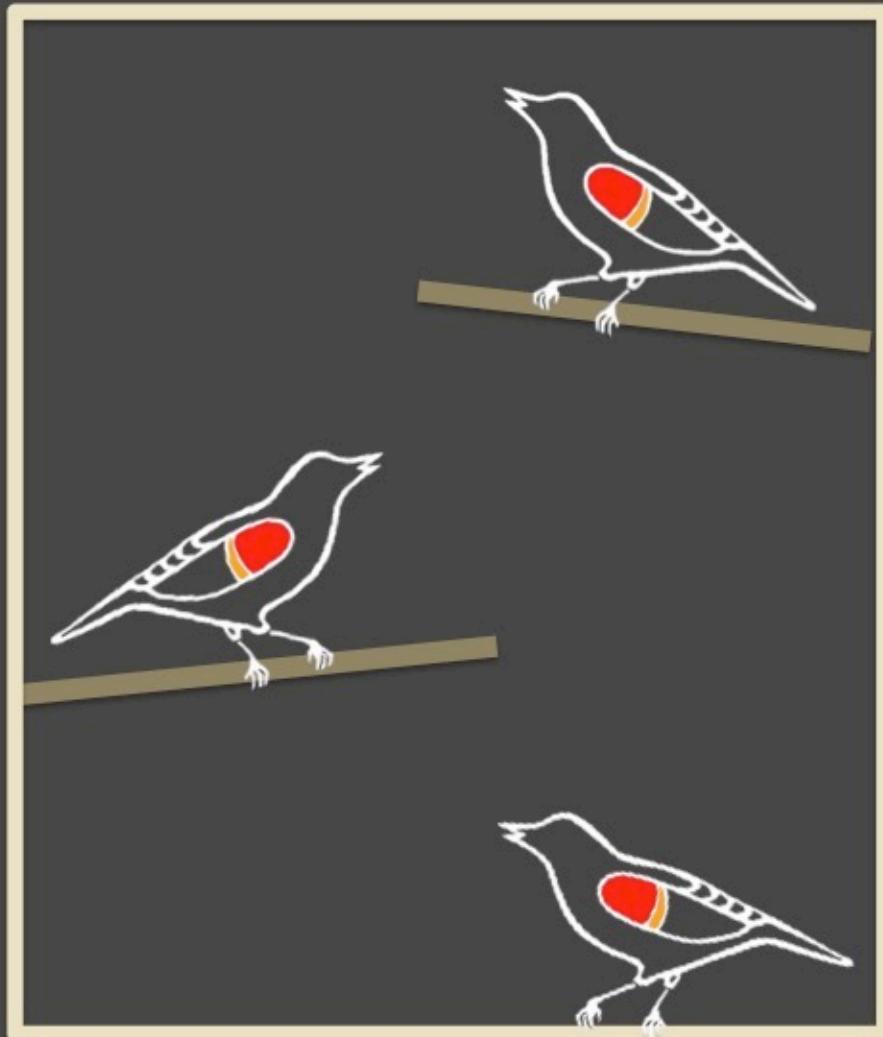
BIRDS WITH HIGHER ENDOGENOUS CORT HAVE HIGHER TOLERANCE TO INFECTION



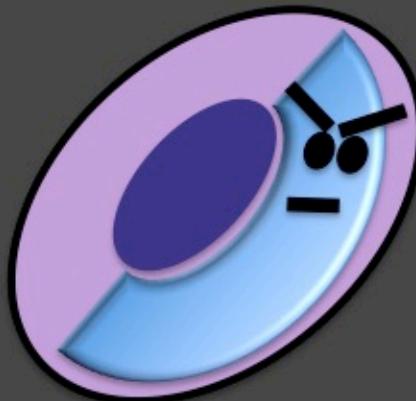
CORT



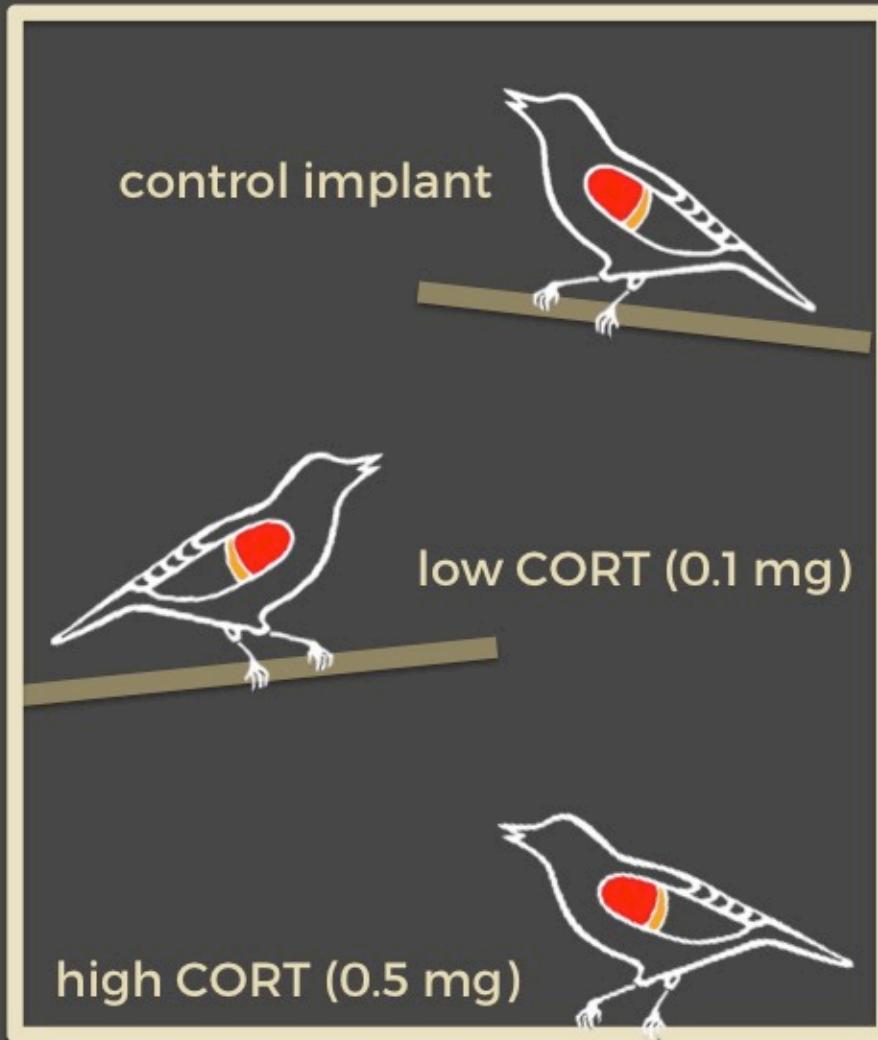
AVIARY EXPERIMENT



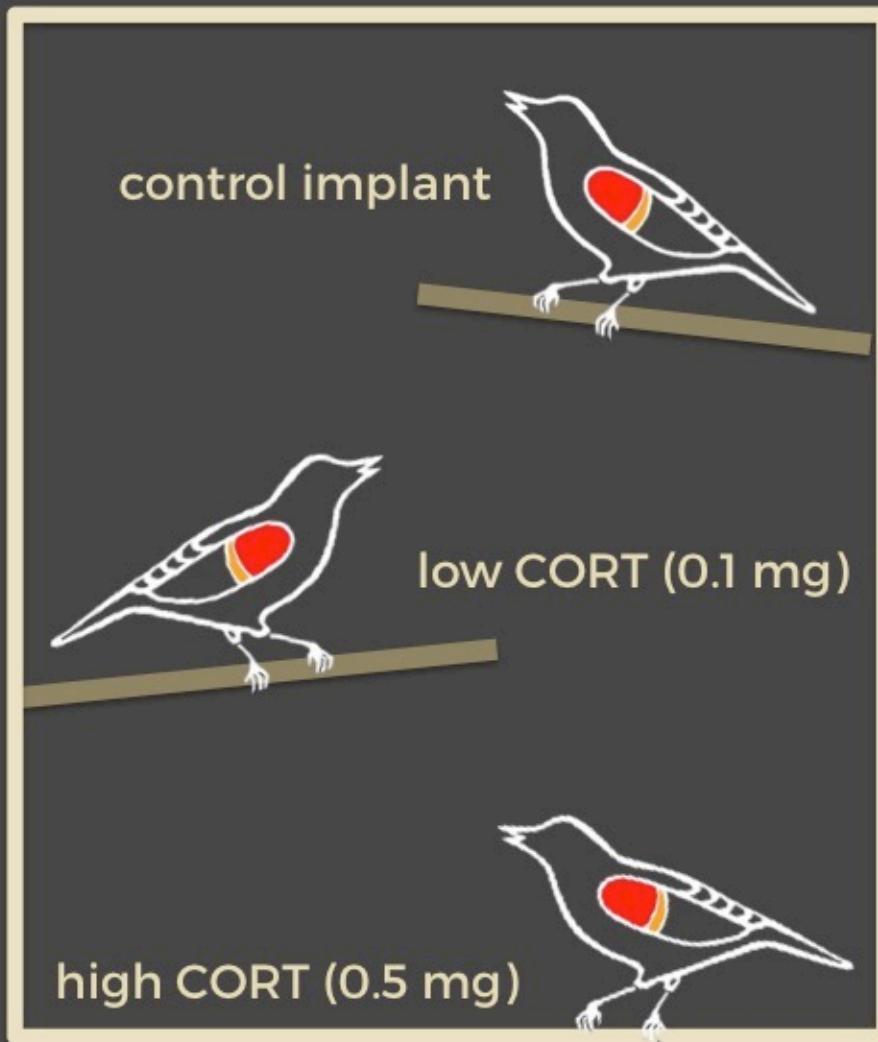
**The birds are naturally infected with malaria



AVIARY EXPERIMENT



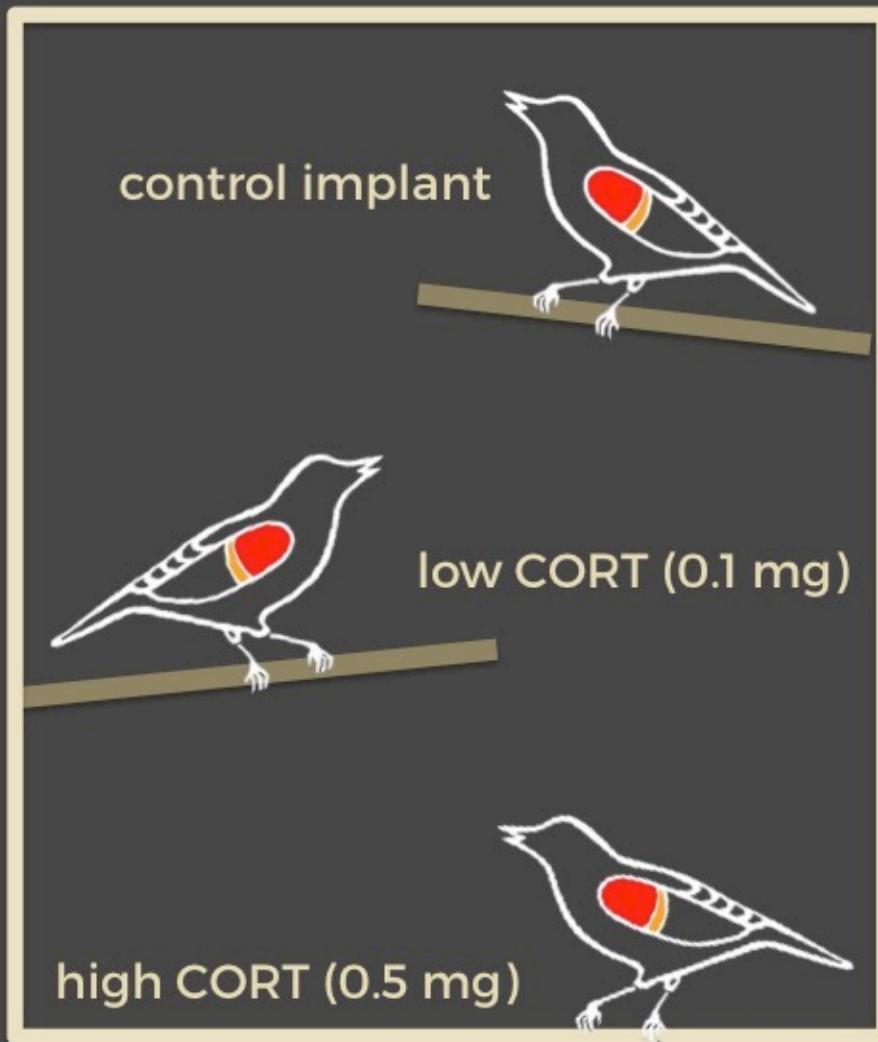
AVIARY EXPERIMENT



Blood Sample & Weigh



AVIARY EXPERIMENT



Blood Sample & Weigh

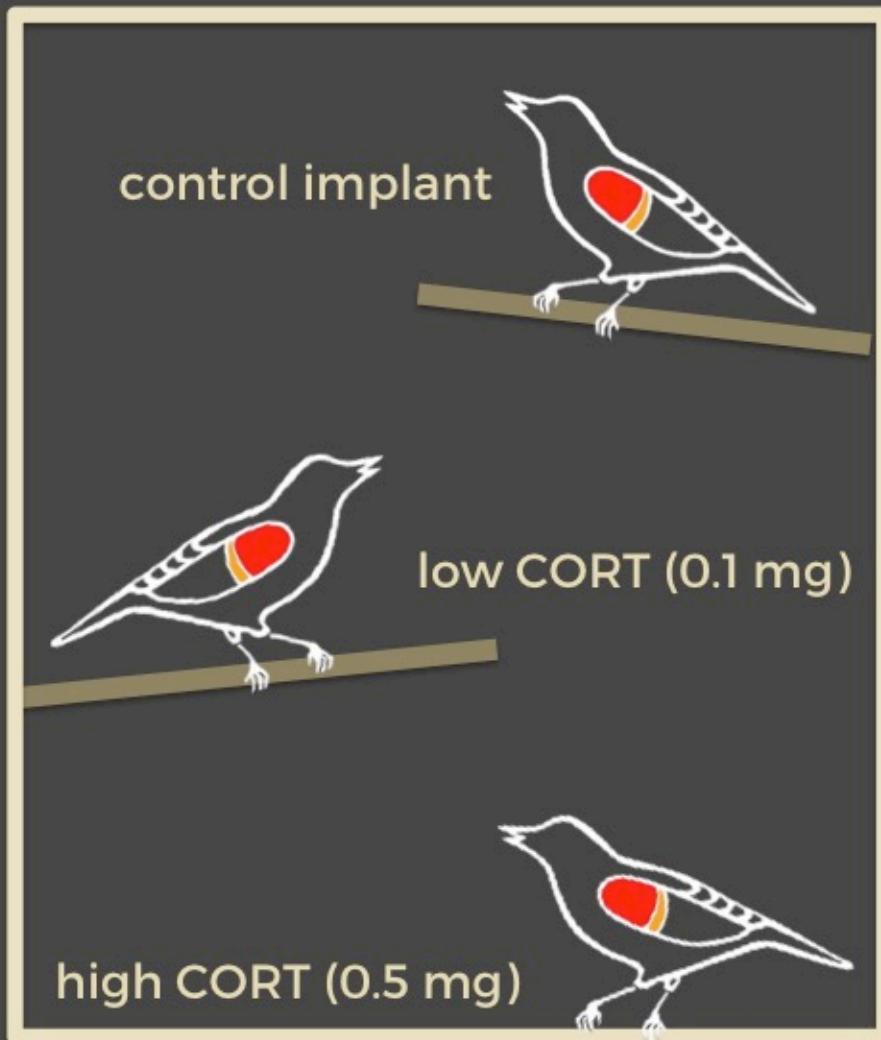


0



Implant

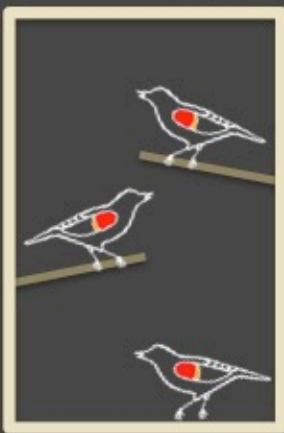
AVIARY EXPERIMENT



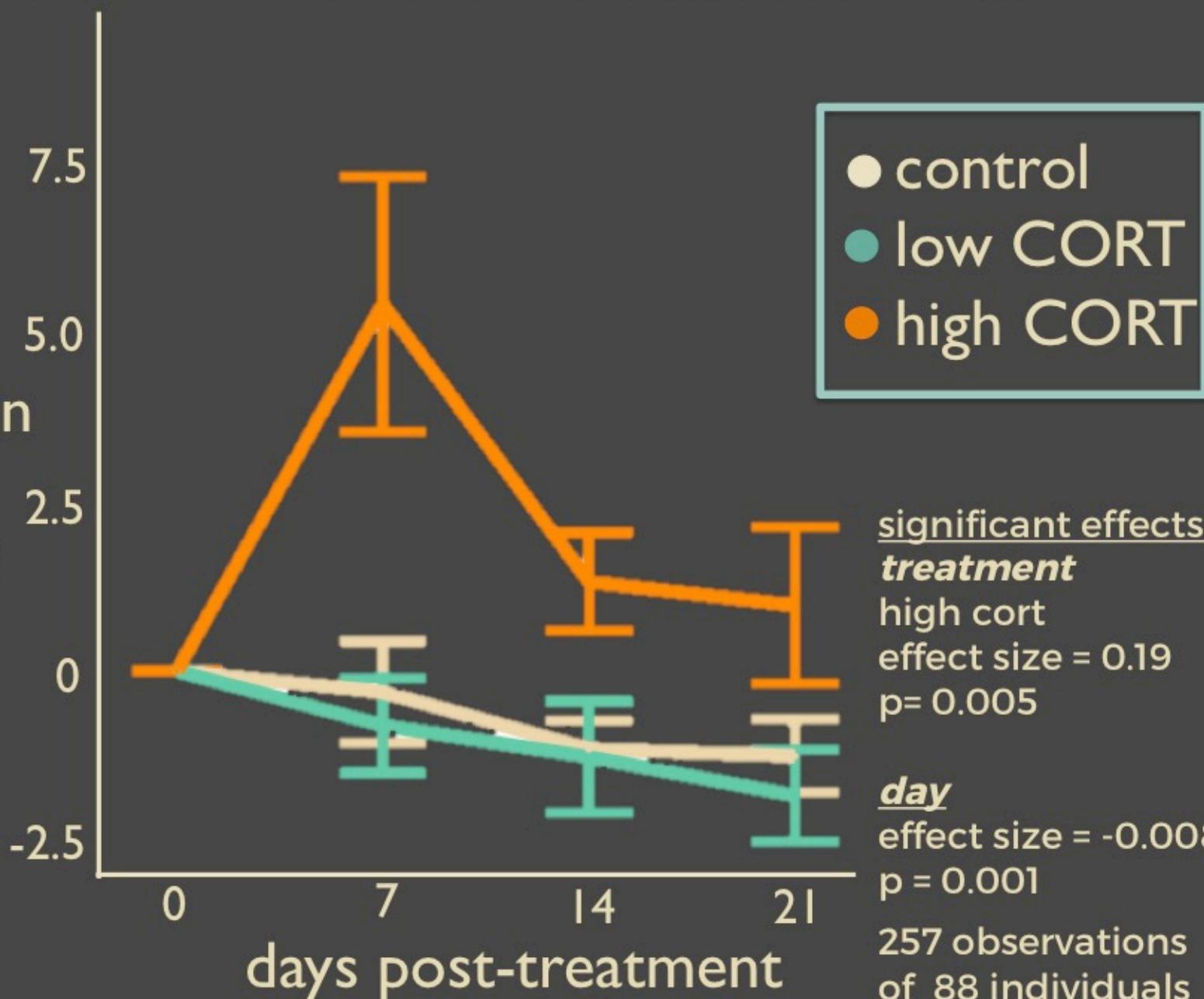
Blood Sample & Weigh



HIGH DOSE IMPLANT INCREASE CORT



change in
CORT
(ng/mL)



CORT



immune
response

tissue
repair

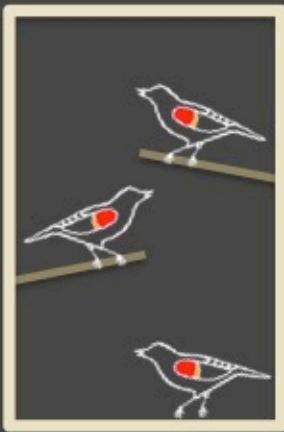


RESISTANCE

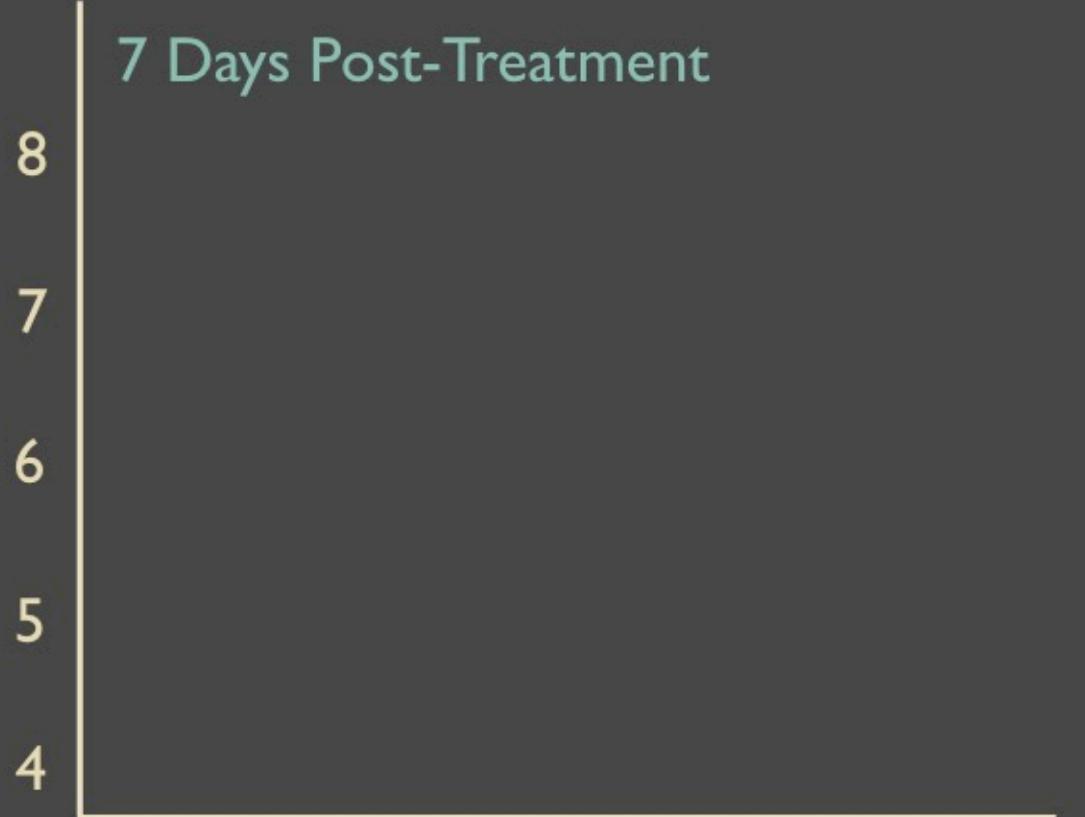


TOLERANCE



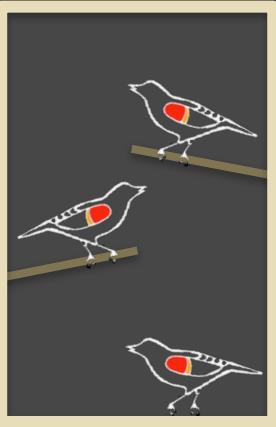


In change in
number of
parasites
(in 10,000 RBCs)

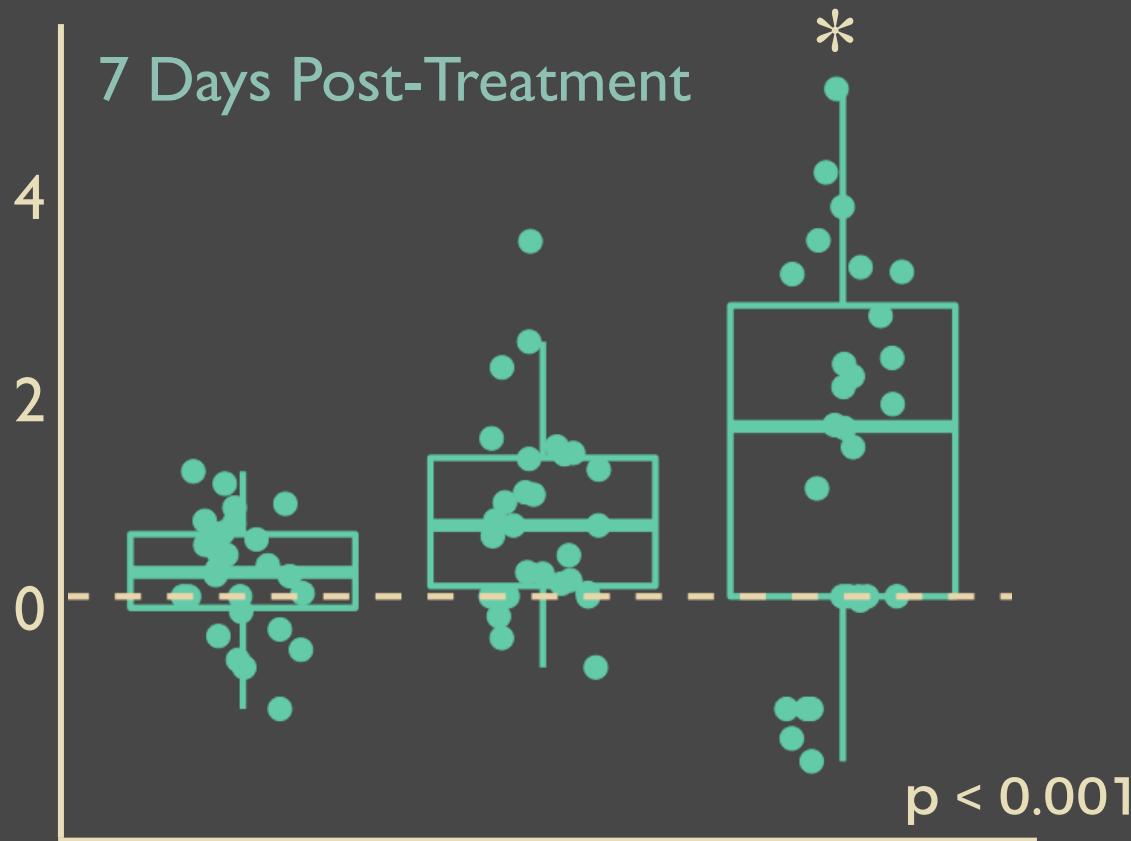
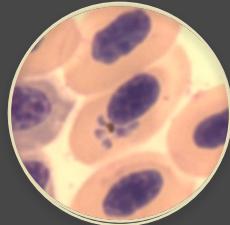


Control Low CORT High CORT
Implant (n=26) (n=28)
(n=25)

HIGH CORT INCREASES INFECTION INTENSITY

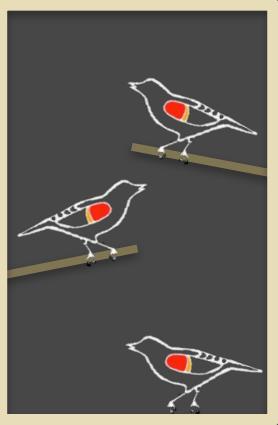


In change in
number of
parasites
(in 10,000 RBCs)

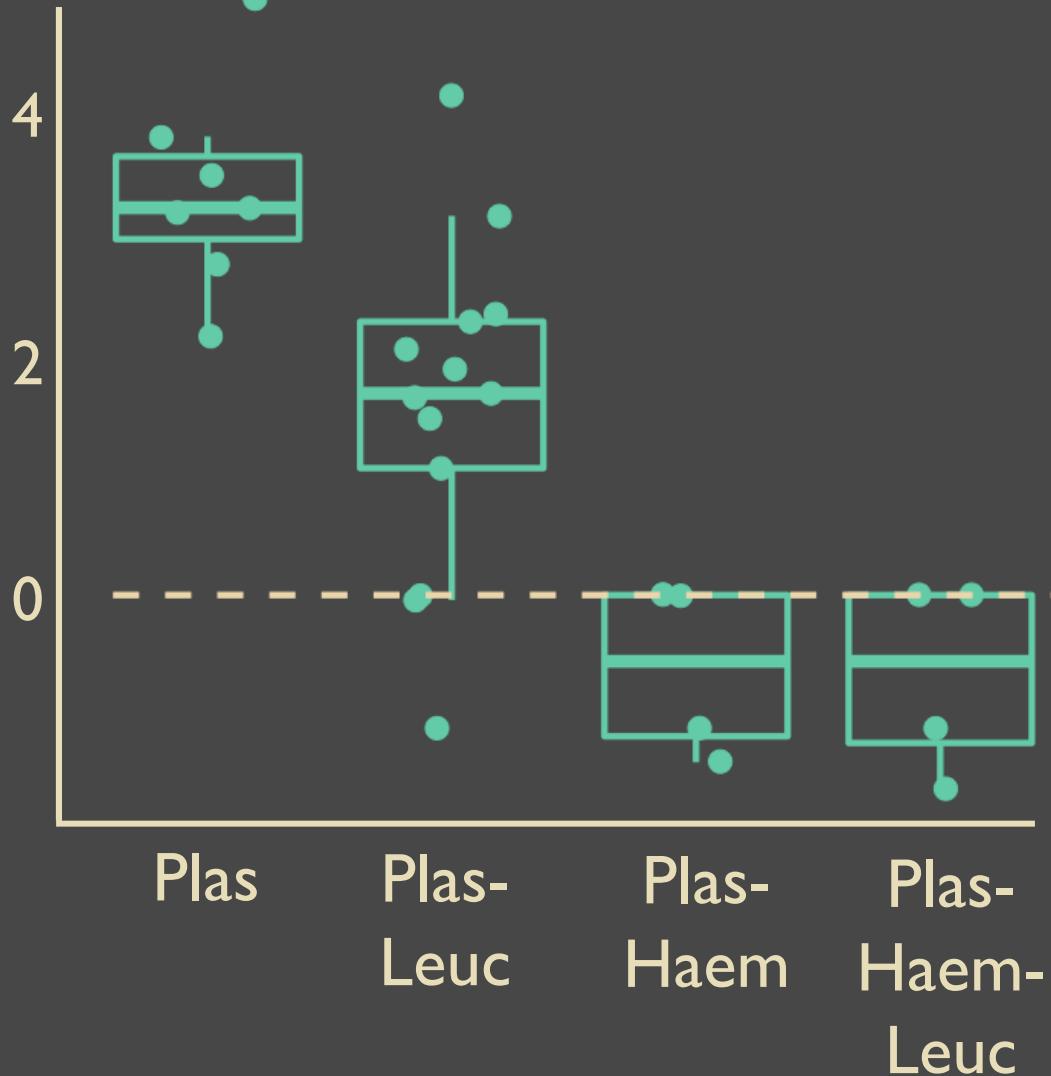
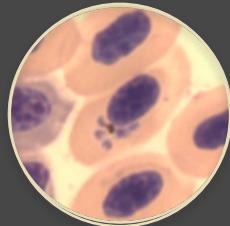


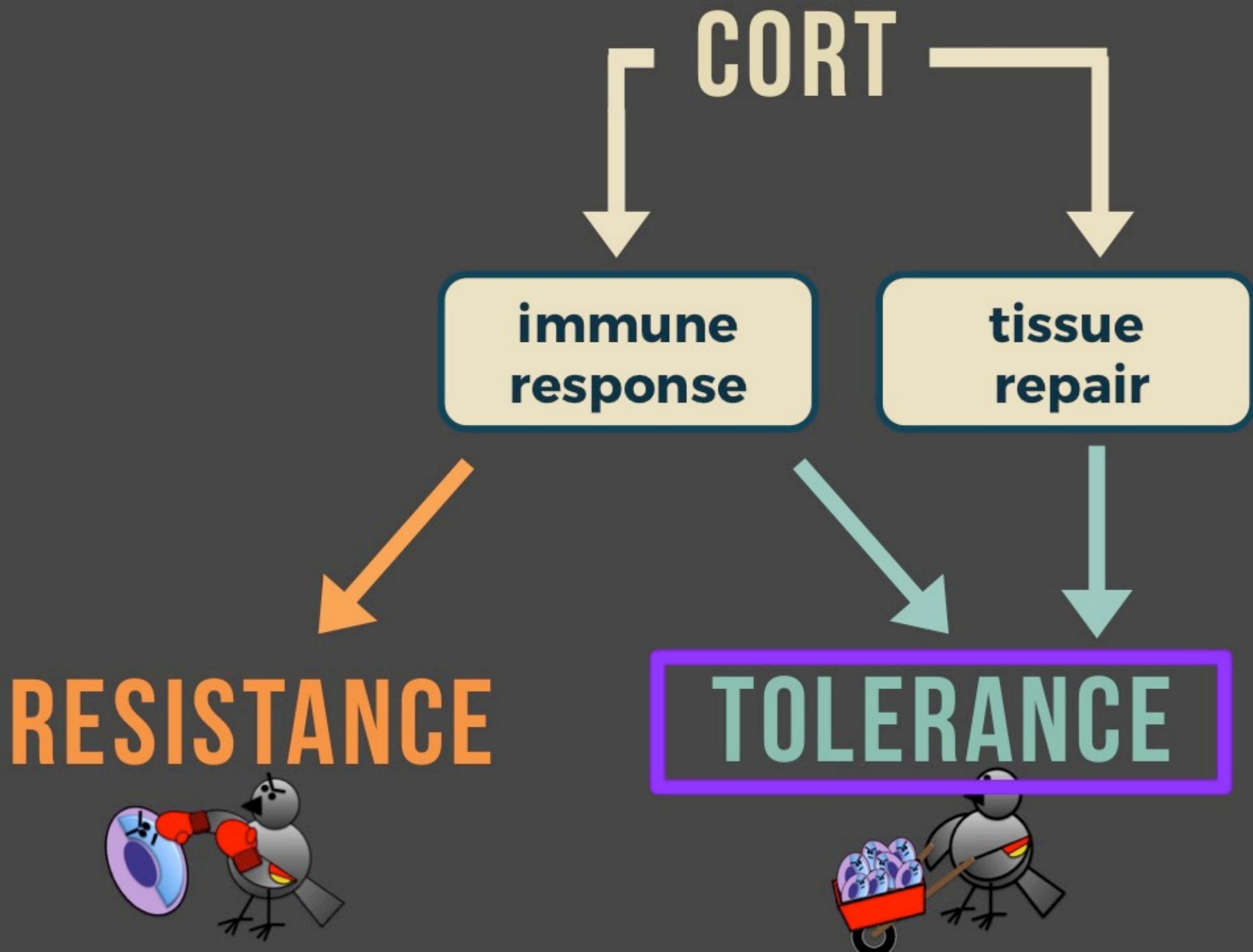
Control Low CORT High CORT
Implant (n=26) (n=28)

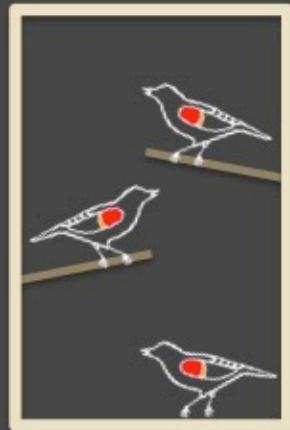
CO-INFECTION PREVENTS CHANGE IN BURDEN



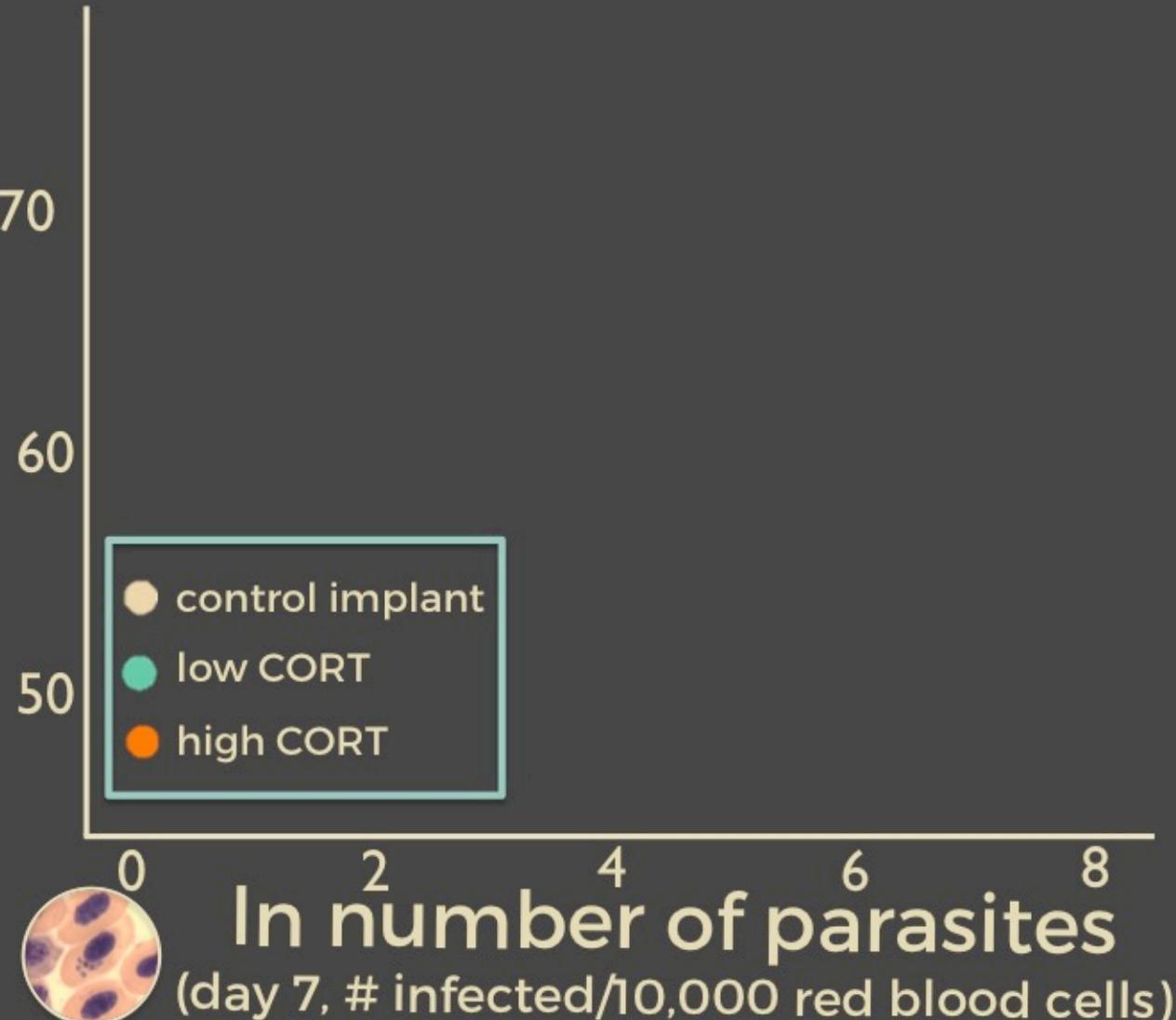
In change in
number of
parasites
(in 10,000 RBCs)

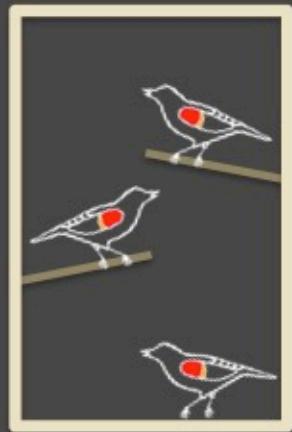




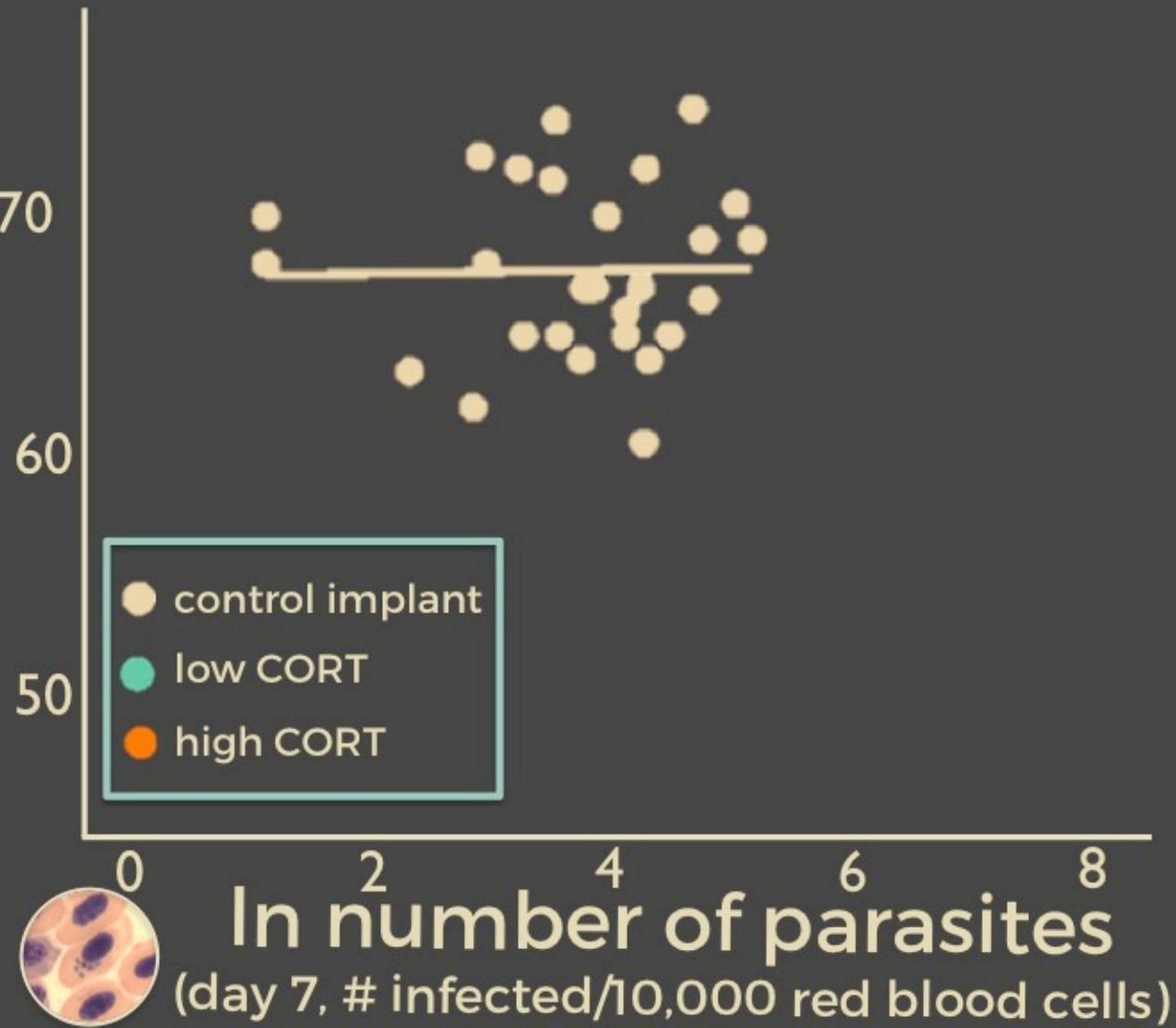


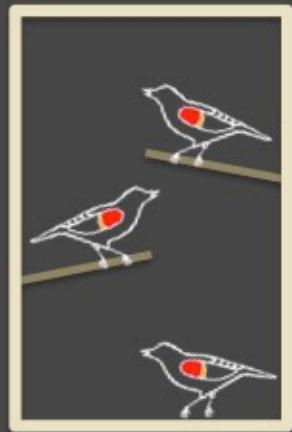
mass
(g)
day 7



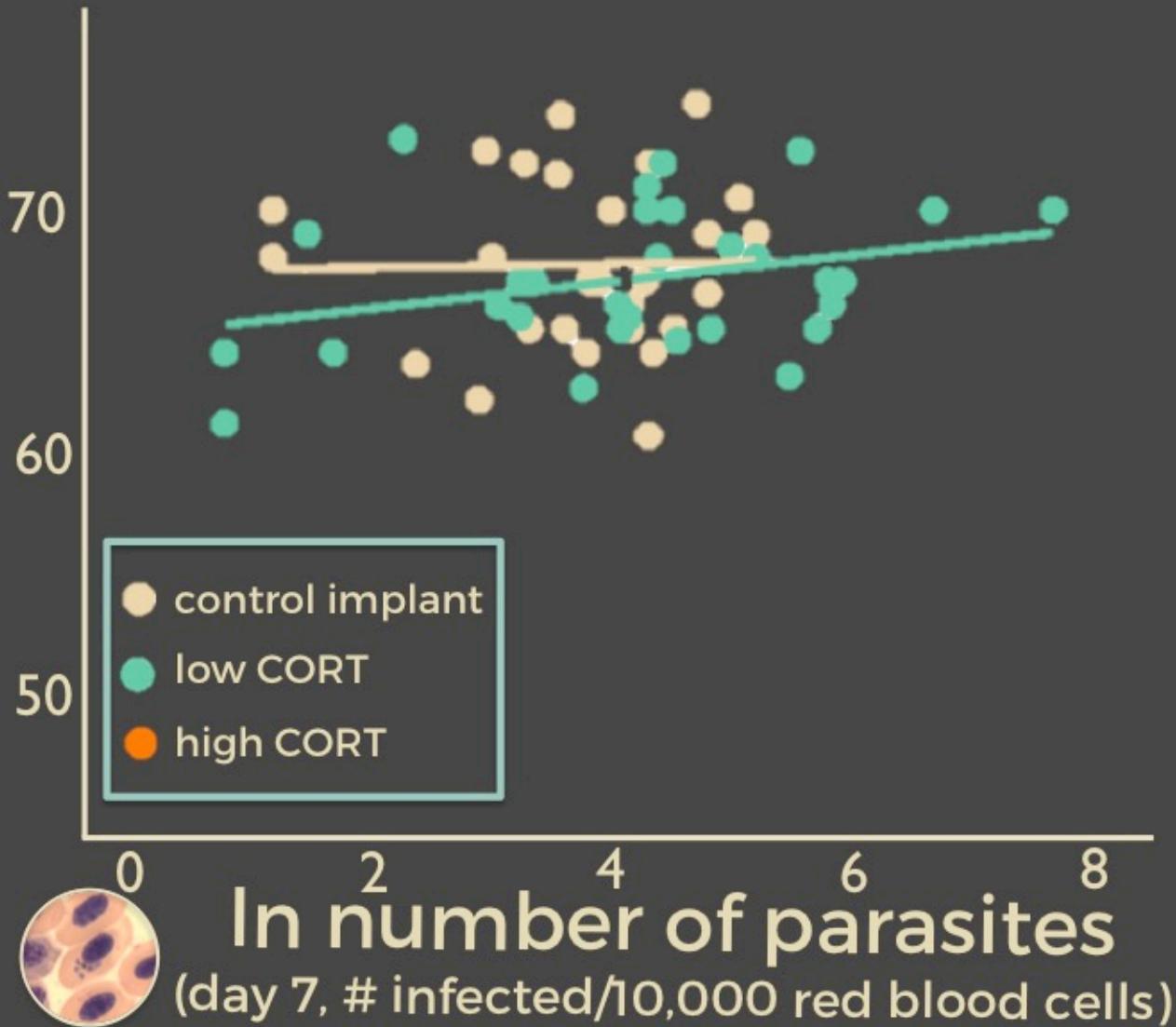


mass
(g)
day 7

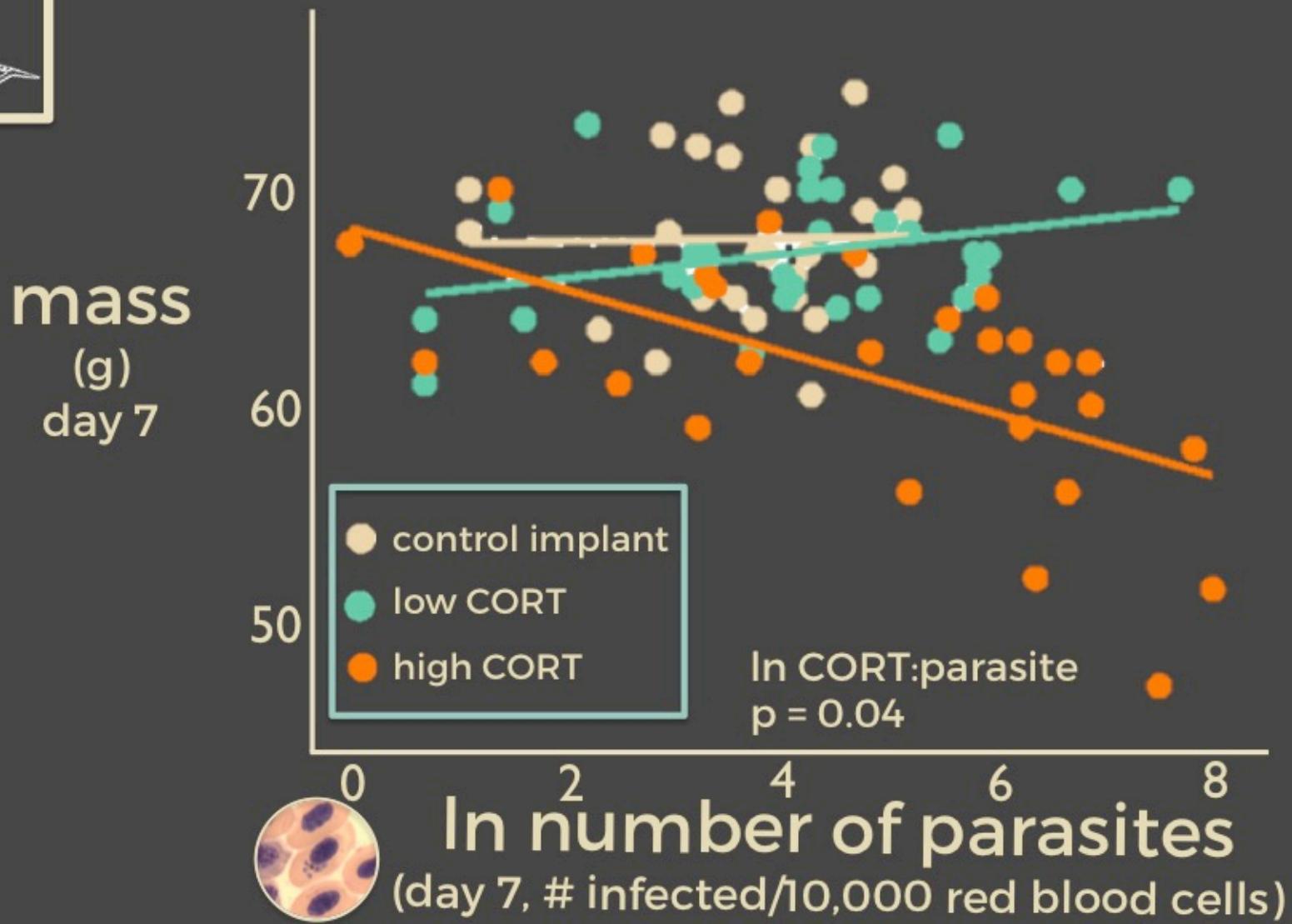


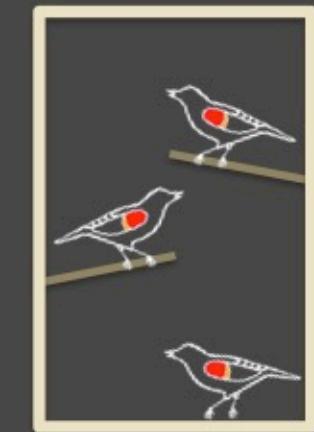


mass
(g)
day 7

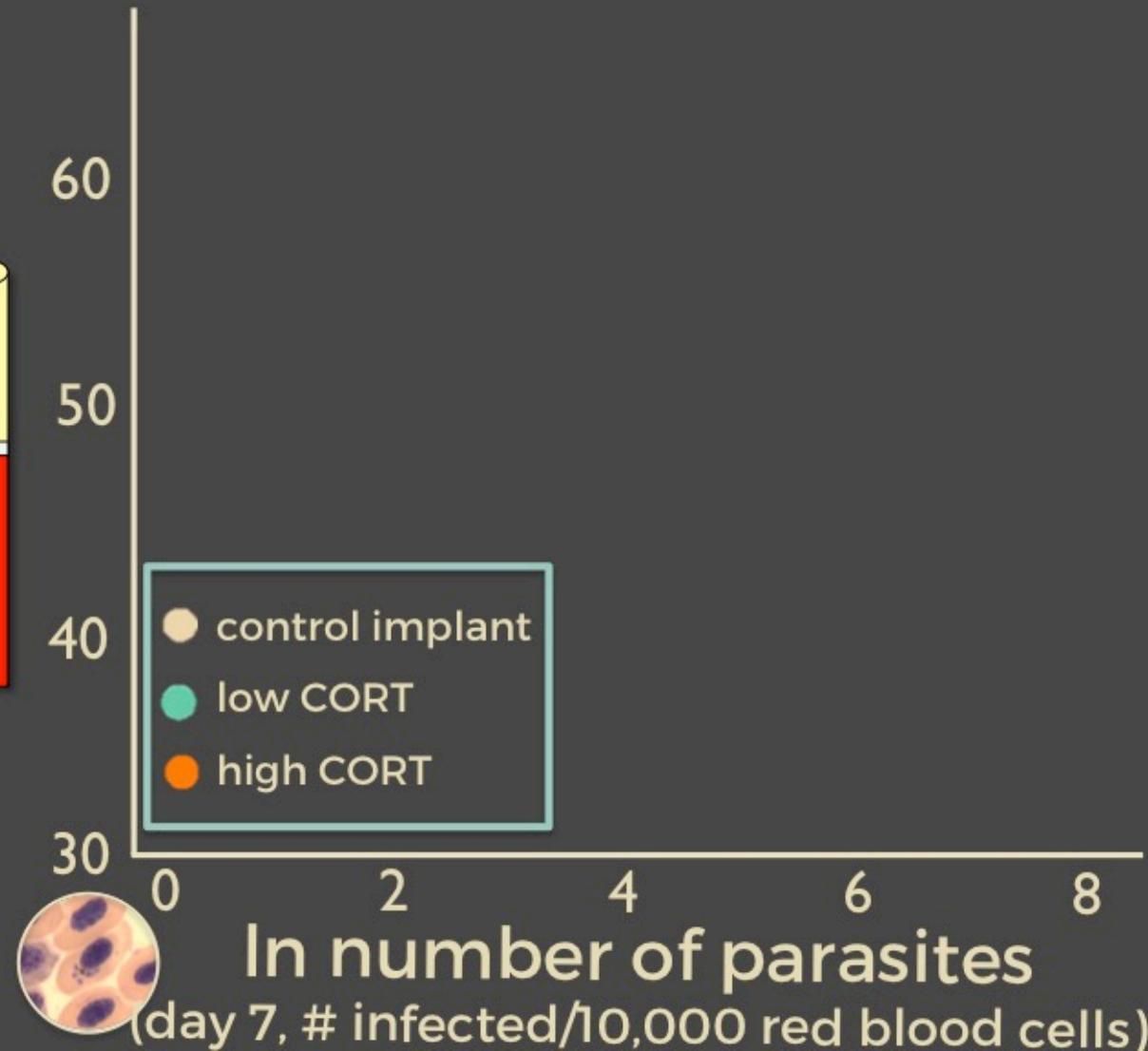


MASS DECREASES WITH PARASITE BURDEN WHEN CORT IS HIGH

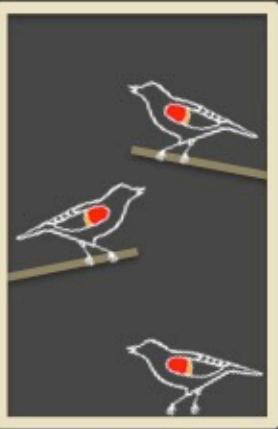




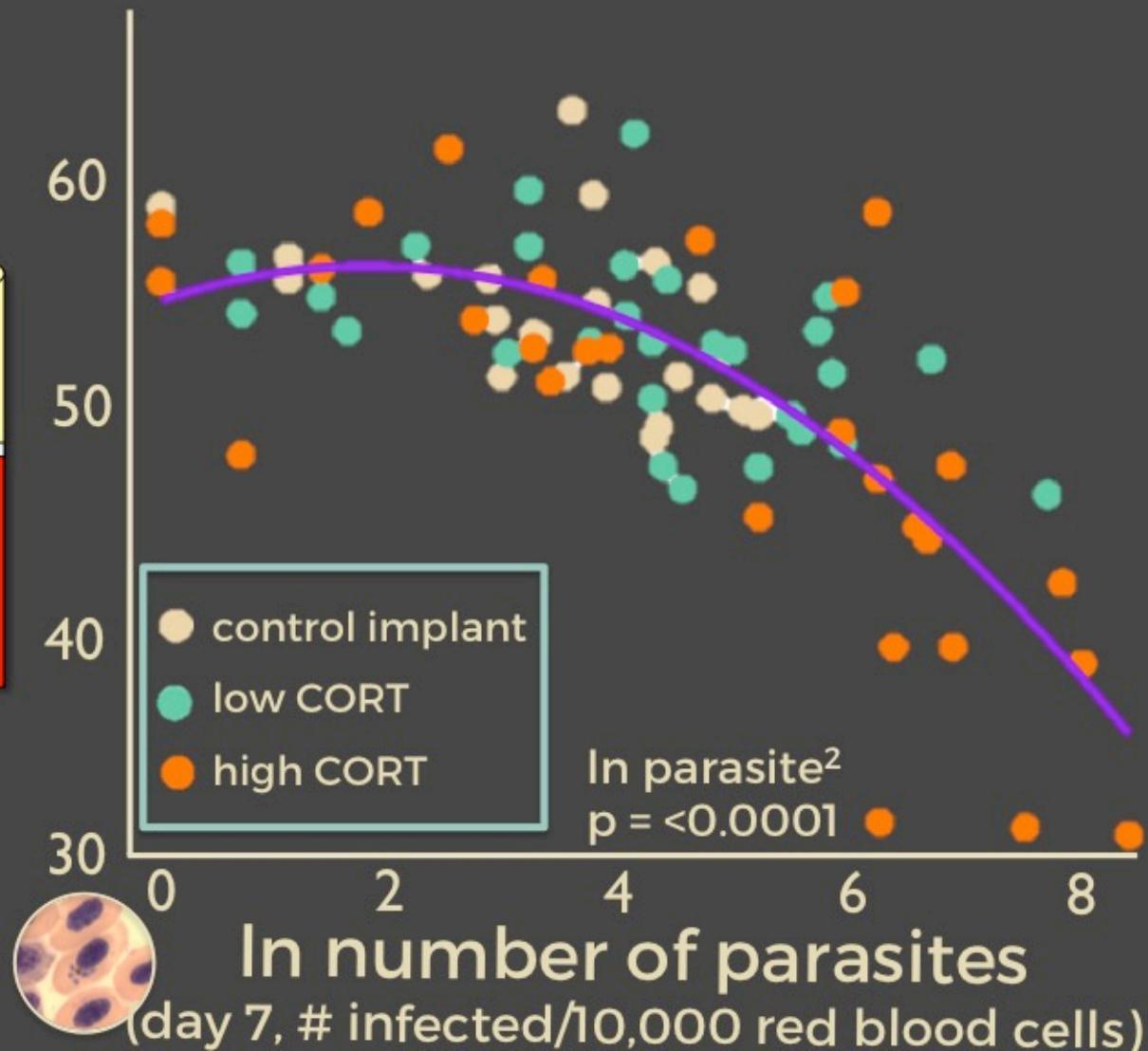
hematocrit
day 14



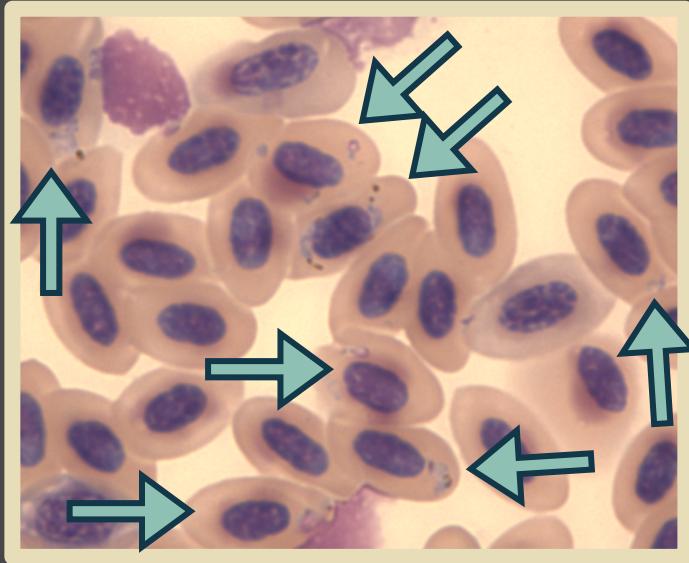
PARASITE BURDEN ALONE DECREASES HEMATOCRIT



hematocrit
day 14



TWOFOLD COST OF HIGH CORT



- increased
parasite burden
(unless co-infected)
- reduced tolerance
(mass loss)



CORT

immune
response

tissue
repair

RESISTANCE

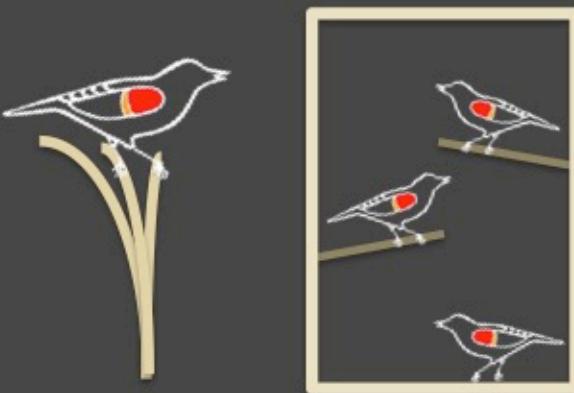


TOLERANCE



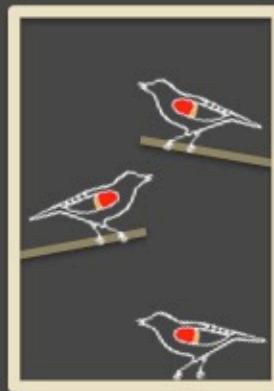
DO GLUCOCORTICOIDS MEDIATE RESISTANCE AND TOLERANCE TO MALARIA?

DO GLUCOCORTICOIDS MEDIATE RESISTANCE AND TOLERANCE TO MALARIA?



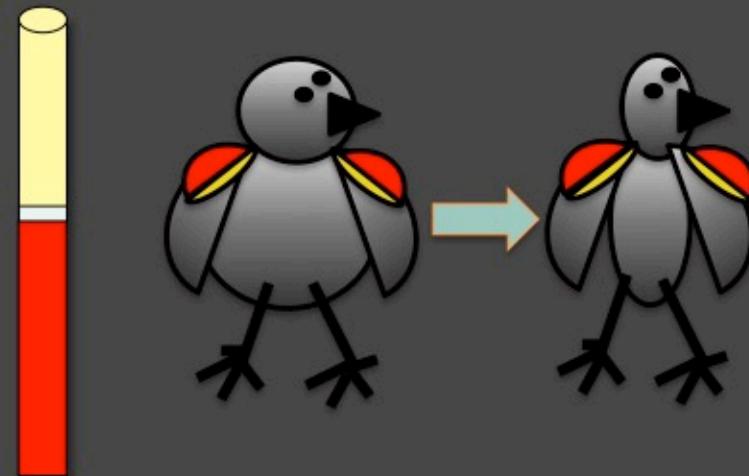
context dependent

DO GLUCOCORTICOIDS MEDIATE RESISTANCE AND TOLERANCE TO MALARIA?

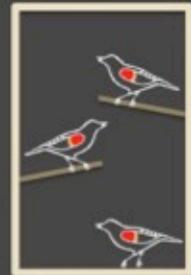


context dependent

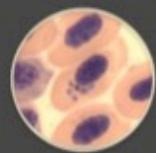
metrics matter



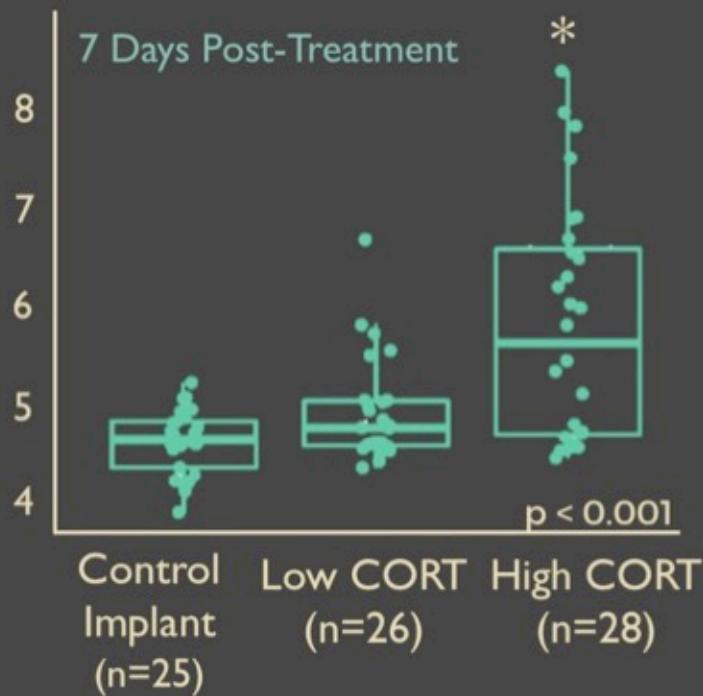
FUTURE DIRECTIONS



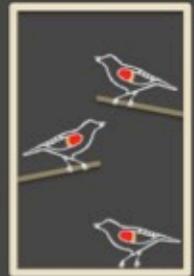
In change in
number of
parasites
(in 10,000 RBCs)



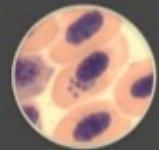
HIGH CORT INCREASES INFECTION INTENSITY



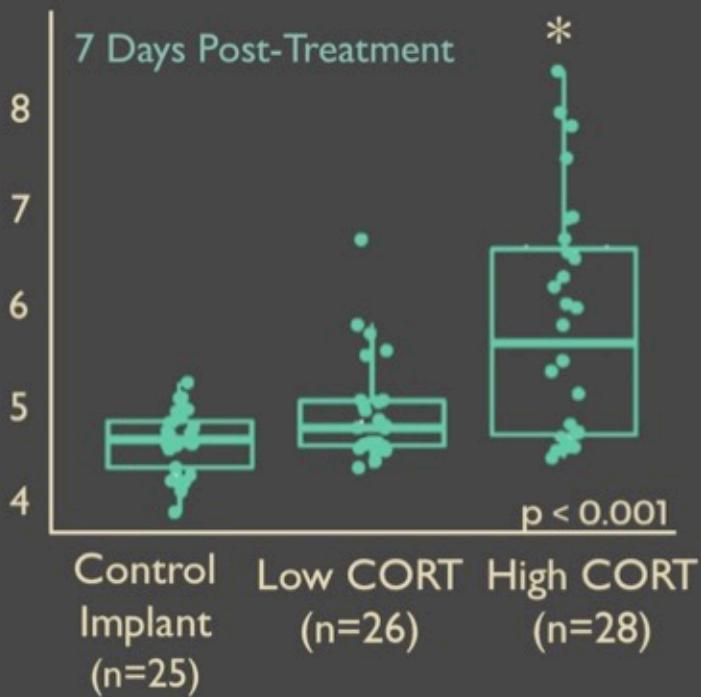
FUTURE DIRECTIONS



In change in
number of
parasites
(in 10,000 RBCs)



HIGH CORT INCREASES INFECTION INTENSITY



Manipulate
social and
environmental
stressors



THANK YOU!

COMMITTEE

Advisors: Fran Bonier & Ignacio Moore

Dana Hawley, Bill Hopkins, & Jeff Walters

FUNDING SOURCES

Society of
Canadian
Ornithologists

Société des
ornithologues
du Canada



VT Sigma Xi
VT Graduate School



Moore,
Bonier,
Martin, &
Hawley Labs

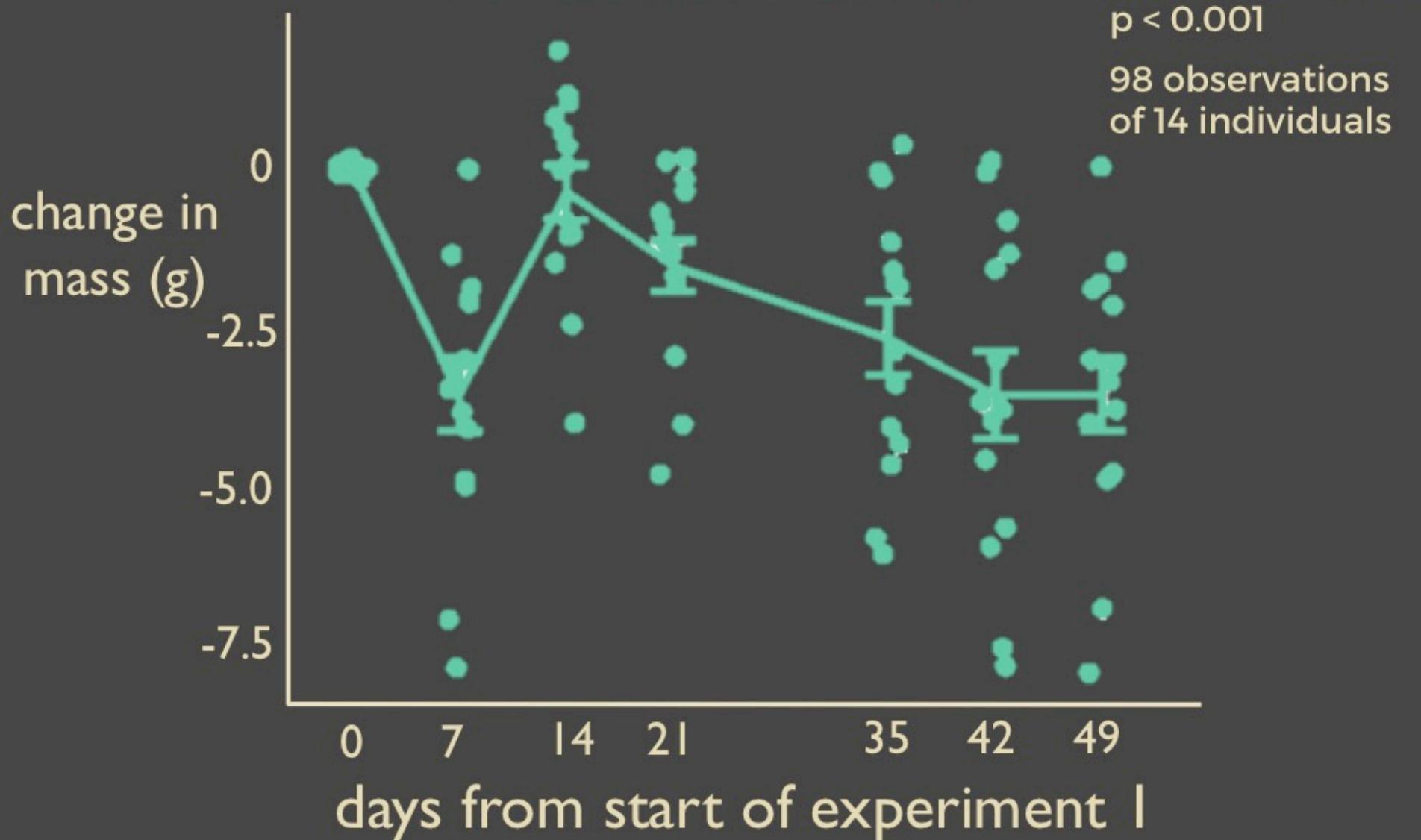
FIELD CREWS



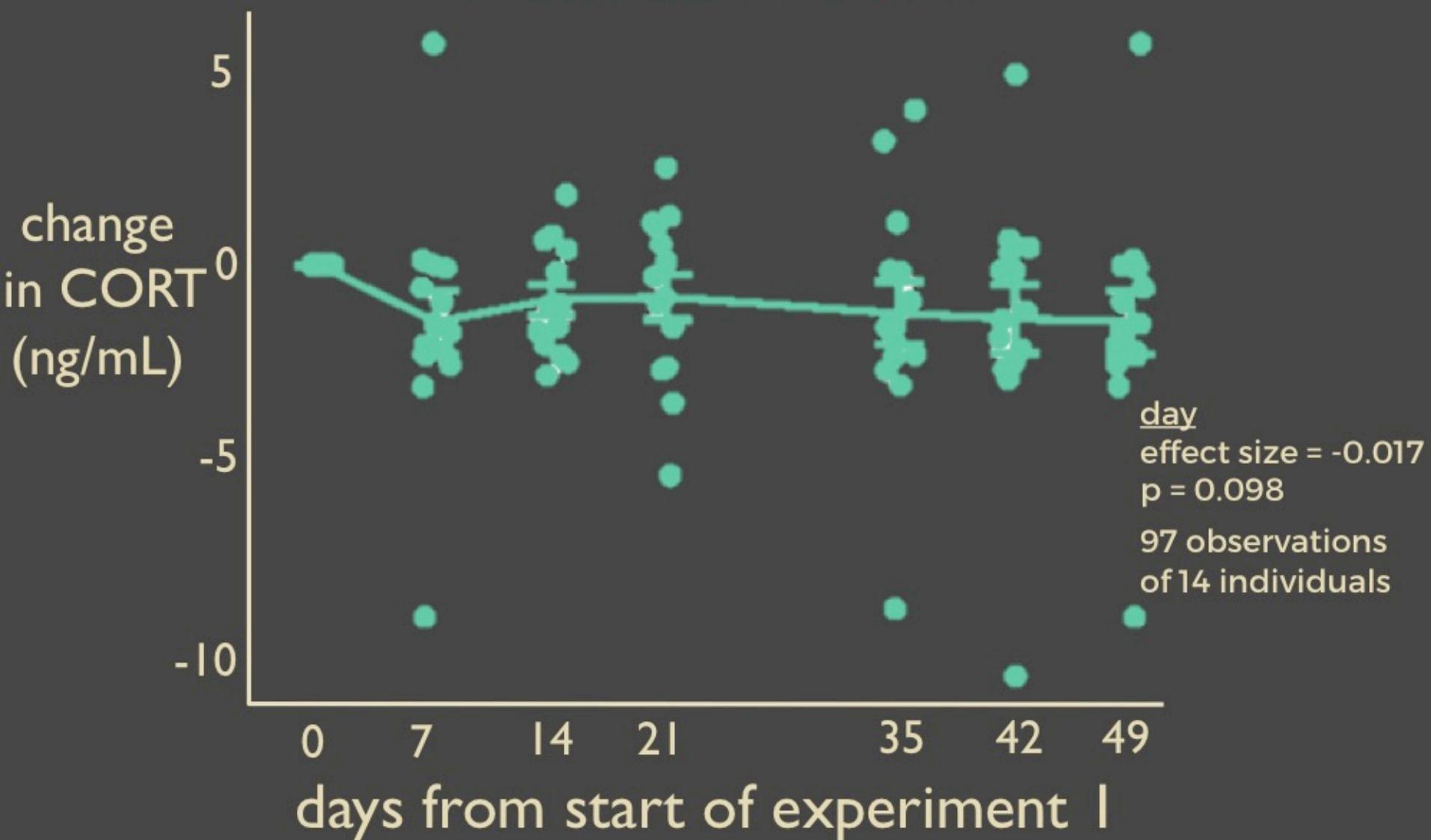
INSTITUTIONAL SUPPORT

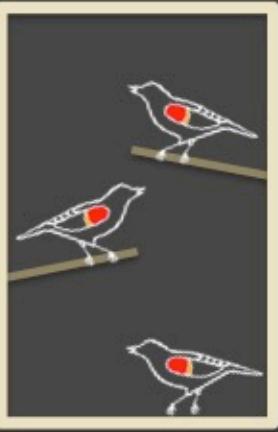


MASS CHANGE IN CAPTIVITY (CONTROL BIRDS)



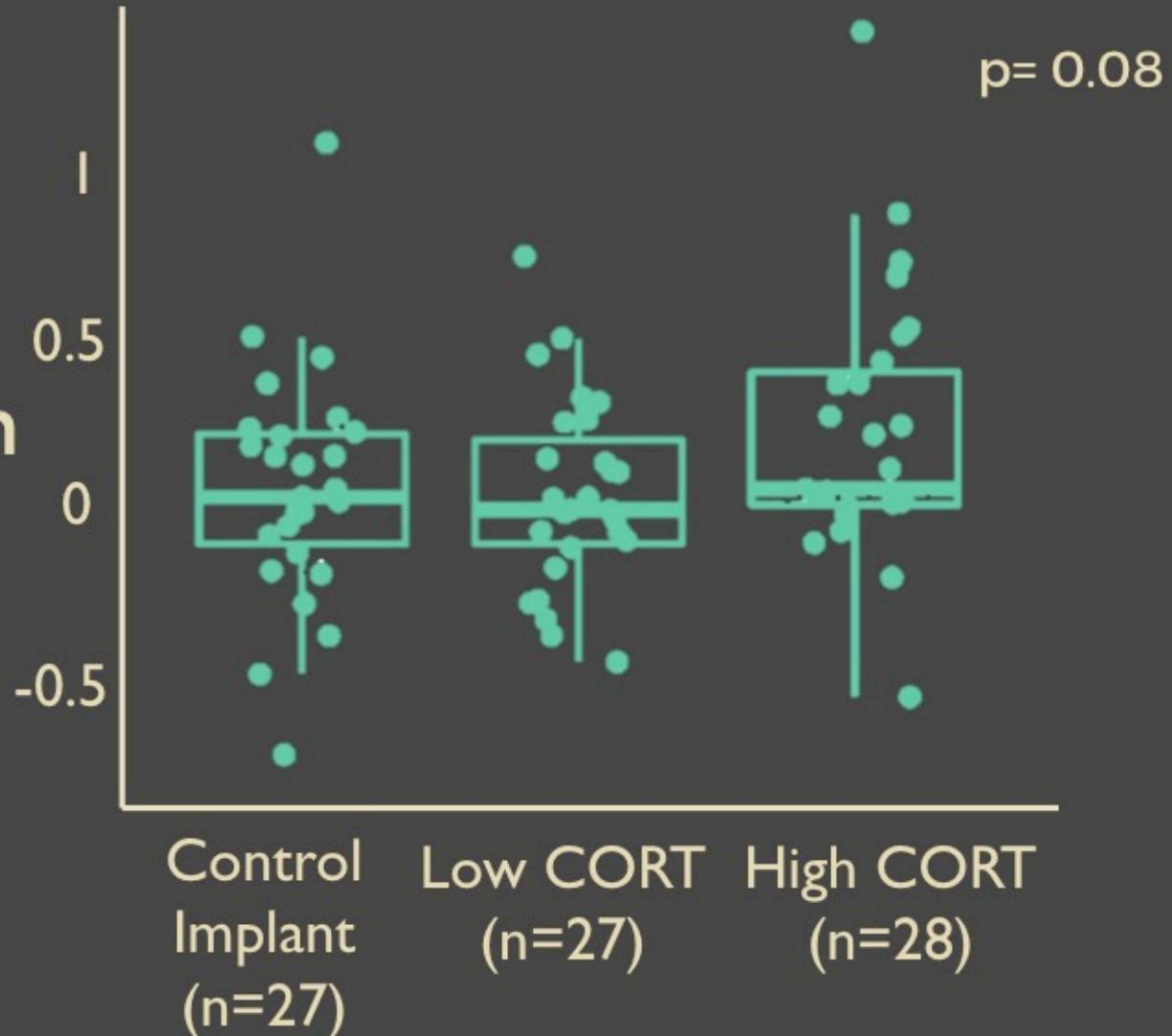
CHANGE IN CORT IN CAPTIVITY (CONTROL BIRDS)



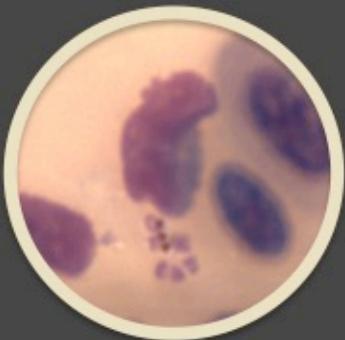


HIGH CORTICOSTERONE TENDED TO INCREASE INFLAMMATION

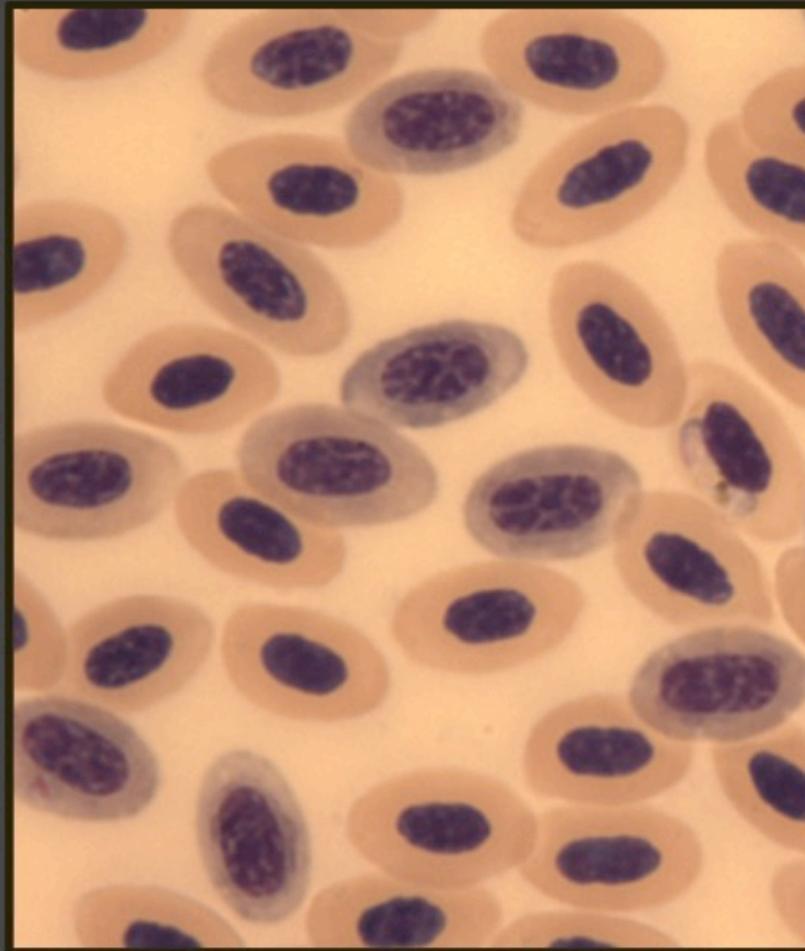
change in
haptoglobin
(ng/mL)
day 14- day 0

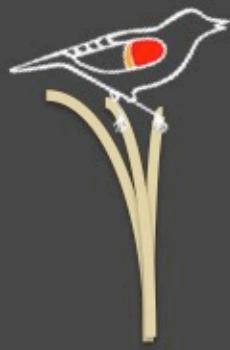


TISSUE REPAIR & AVIAN MALARIA

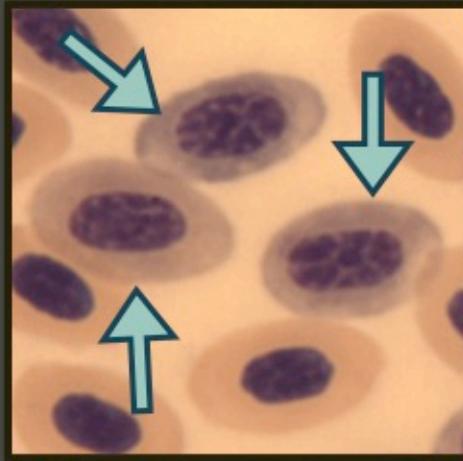


polychromasia

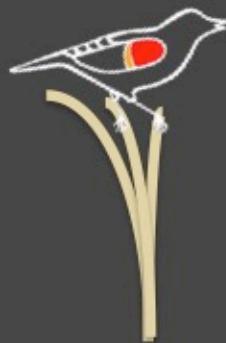




polychromasia

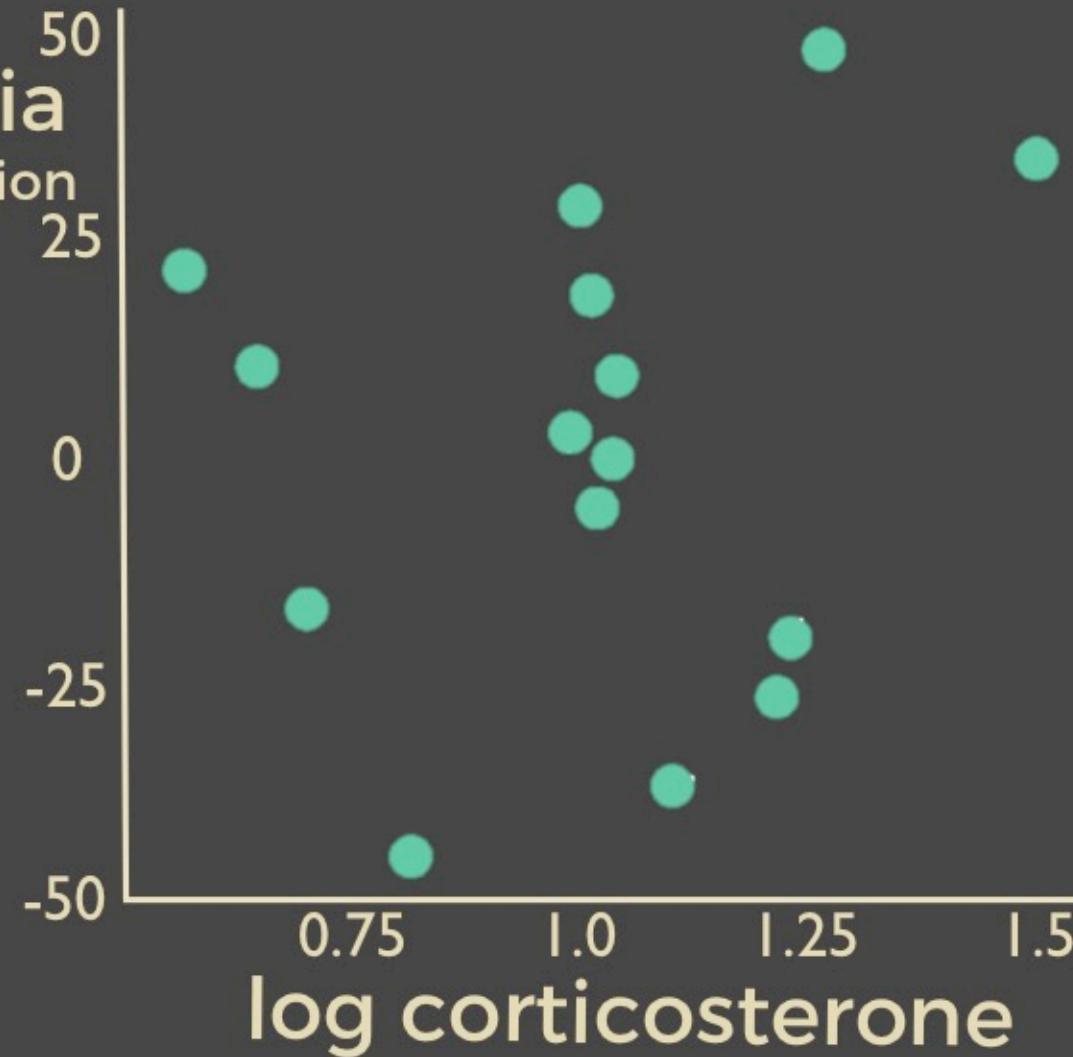
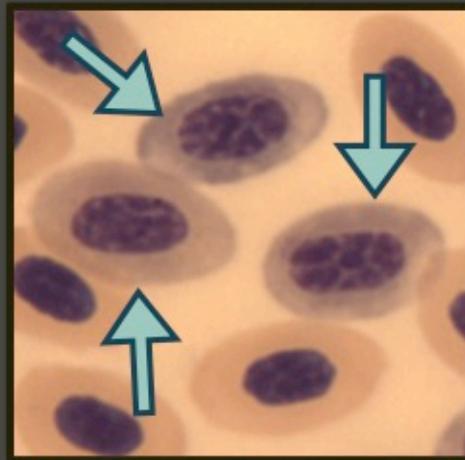


log number of parasites
(# infected/10,000 red blood cells)

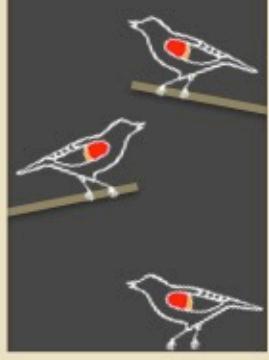


CORTICOSTERONE IS NOT RELATED TO POLYCHROMASIA

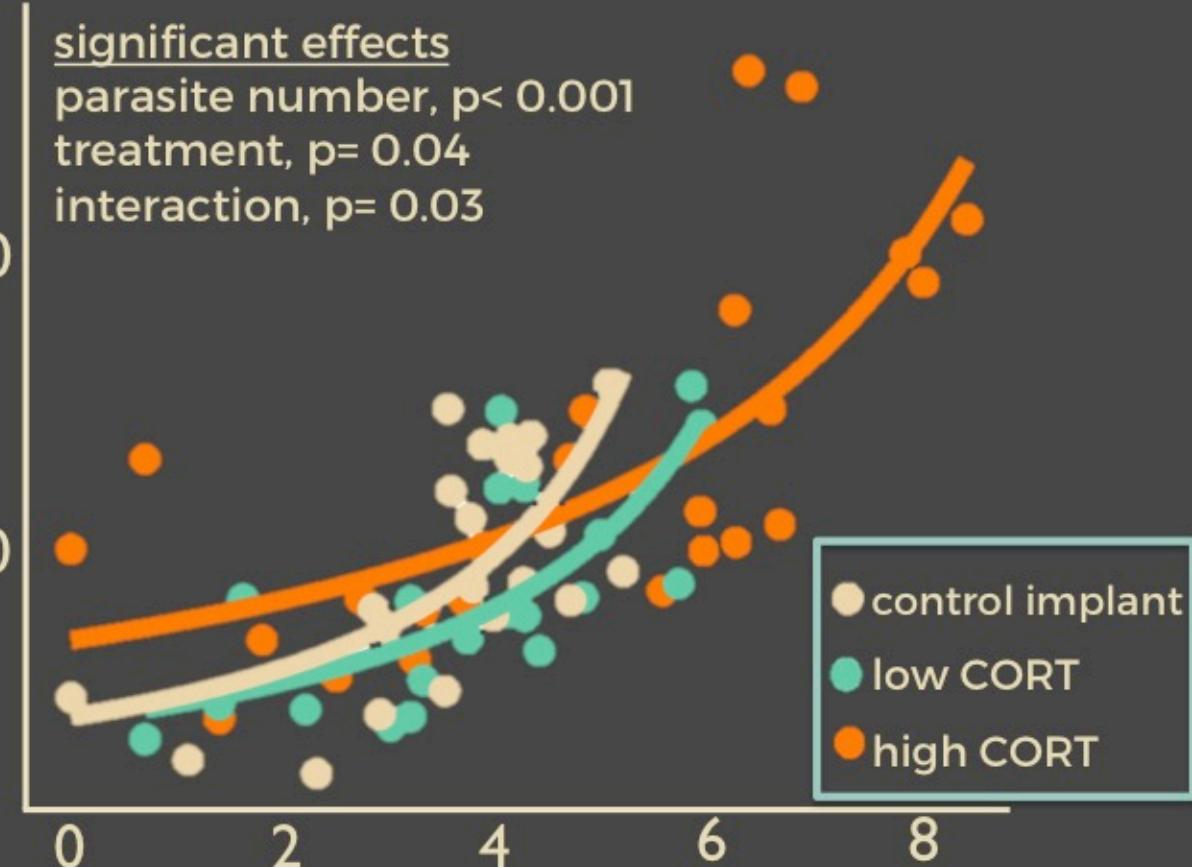
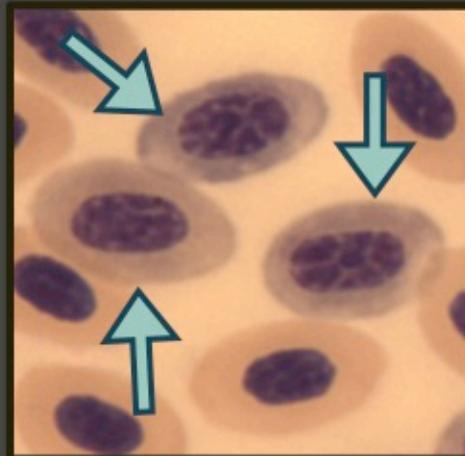
polychromasia
controlling for infection
intensity



HIGH CORTICOSTERONE AFFECTS TISSUE REPAIR



polychromasia
day 14, in 5000 RBCs



log number of parasites
day 7, (# infected/10,000 red blood cells)