

**A Fine Kettle of Moths:
How Creationists Have Defiled
An Icon of Evolution**

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The peppered moth (*Biston betularia*)

Britain, mid-1800's

Air pollution, soot kill lichens, blacken trees

Moths evolve black (*melanic*) form for camouflage

1950's: Clean air acts

Moths evolve back to light-colored (*typica*) form

Bernard Kettlewell's studies, mid-50's

1. *Release—recapture experiments in woods*

Compared *Industrial* with *rural*, or

Polluted with *unpolluted* habitats



Photo by Bruce Grant

Procedure

Marked and released both melanic, typica moths

Recaptured some in wee hours of next morning

Used both optical and pheromone traps

Results

Polluted woods — more melanic

Unpolluted woods — more typica

2. Direct observation and filming

Observed and filmed birds eating moths directly off
trunks of trees

Controversial result at time

3. Camouflage

Visually rated camouflage of moths on different backgrounds

Compared effectiveness of camouflage with predation rates

In aviary

In field

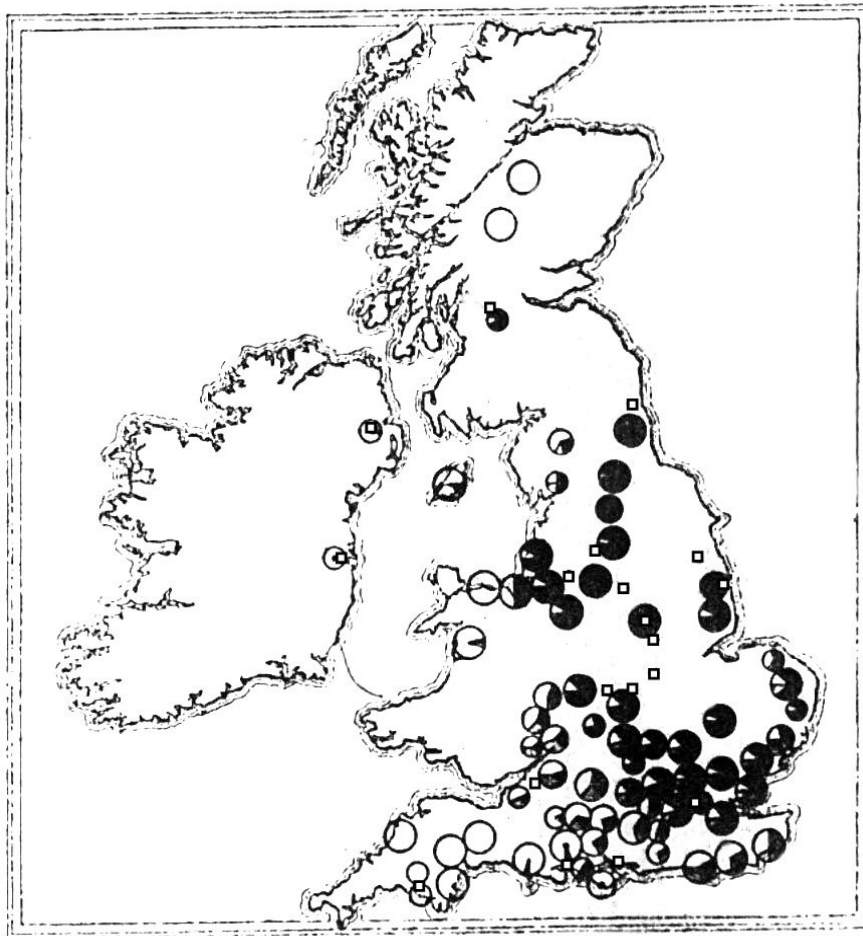
Good correlation between camouflage and predation

Despite birds having ultraviolet vision

Moths camouflaged in the ultraviolet as well (we now know)

4. Geographic distribution

Distribution of melanic moths matched areas of industrialization



○ Typica

● Melanic + insularia

▣ Industrial area

(Kettlewell, 1959)

Wells's *Icons of Evolution*

Moths do not “normally” rest on trunks

25 % of the time they do

Birds hunt at all levels in canopy

Photos of moths staged

So are portraits

Typical form reappeared *before* lichens reappeared

Trees lightened as soot decreased

Typical moths better camouflaged on clean trunks,
branches, leaves than on sooty

Bird predation not only factor

So, nu?

Charges of Fraud

Of Moths and Men, 2002

Judith Hooper charges fraud:

Sudden increase in recapture rate directly follows
“threatening” letter from mentor

But

Moths released *as they hatched* from cocoons

No control over hatching

Letter to Kettlewell from E.B. Ford

Received *after* increase in recapture rate

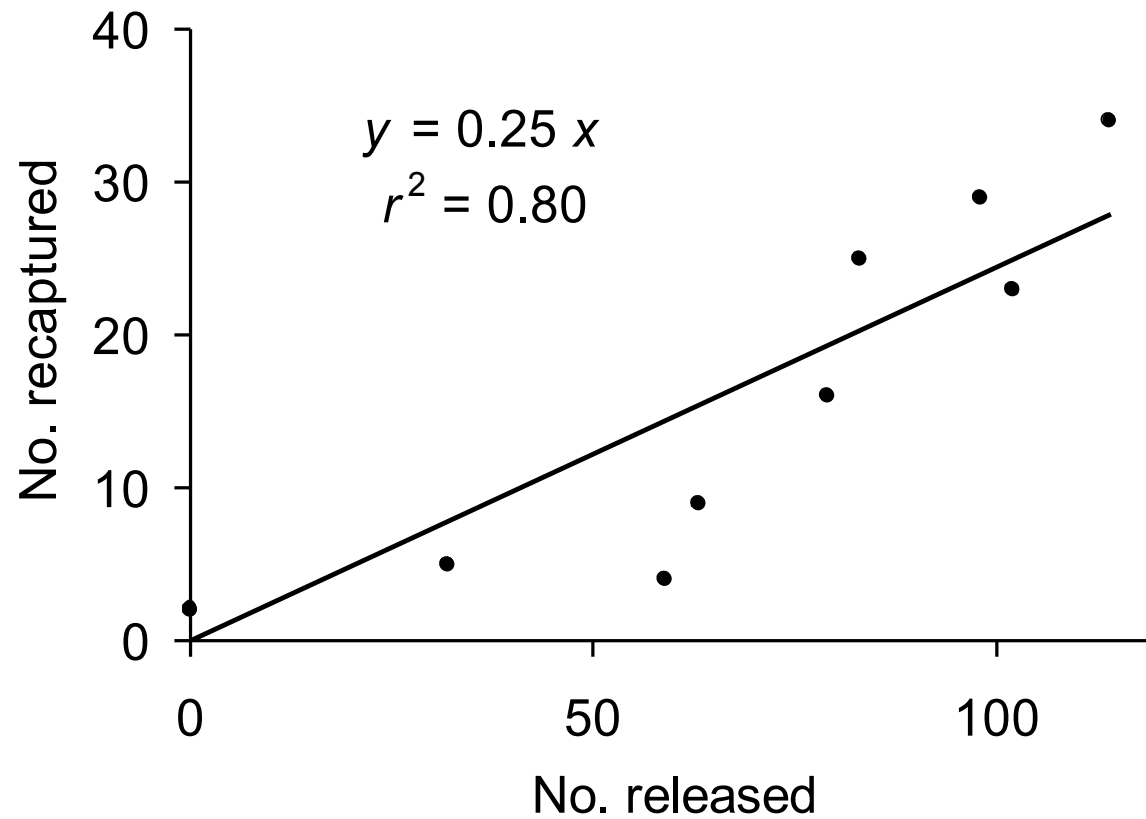
“It is disappointing that the recoveries are not better ...
However, I do not doubt that the results will be very well
worth while”

Hooper's interpretation:

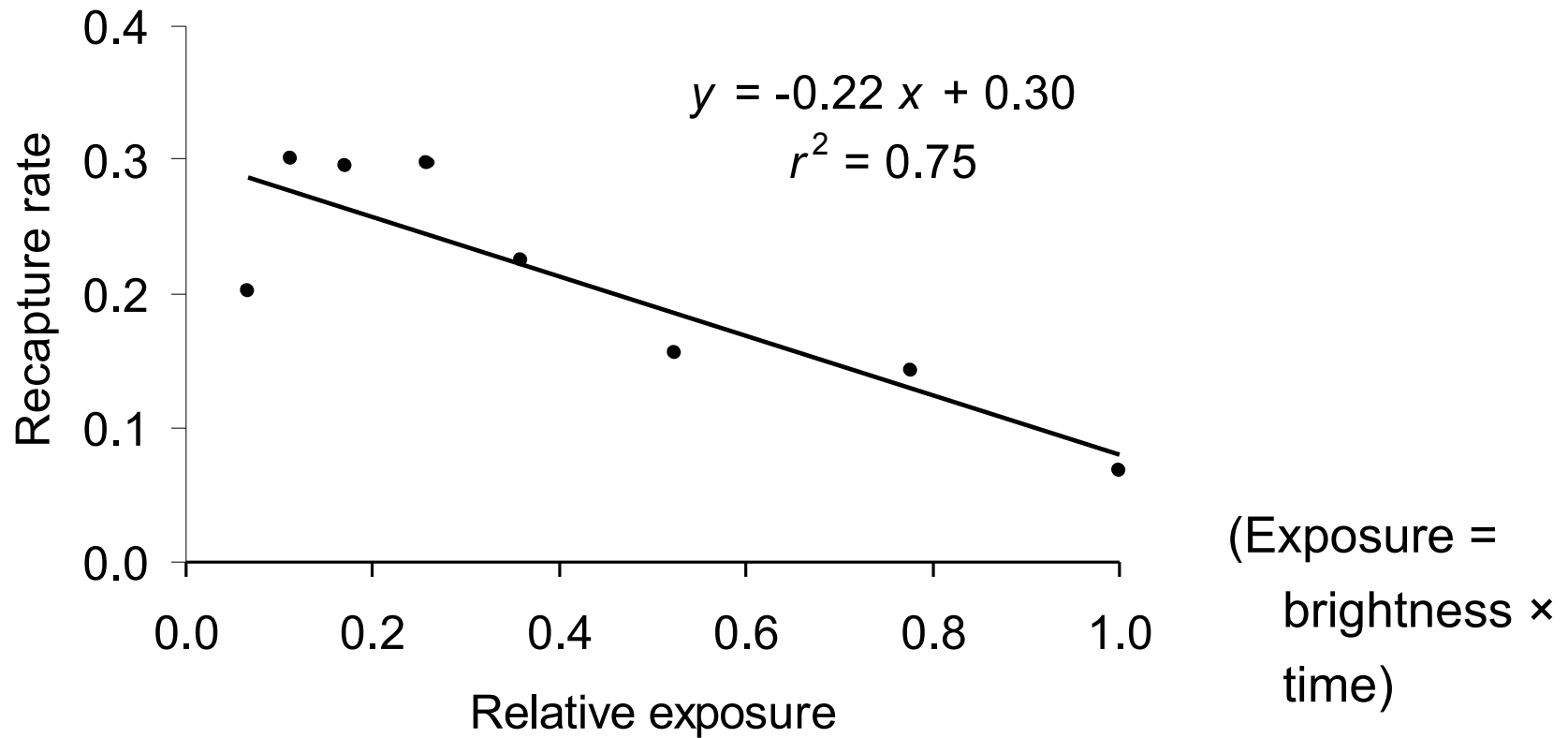
“Now I do hope you will get hold of yourself and deliver
up some decent numbers.”

Physical model (Young and Musgrave, 2005) [Draft of paper](#)

Estimated 1- and 2-day recapture rates from data



Included effect of *moonlight*



Recapture rate falls with increasing exposure to moonlight
(optical traps)

For experts: Calculated *standard uncertainty* of data points

Binomial distribution: Variance, $\sigma^2 = N p (1 - p)$

N = number of moths released on given night

p = probability of recapture (recapture rate)

$u = \sigma$ = standard uncertainty

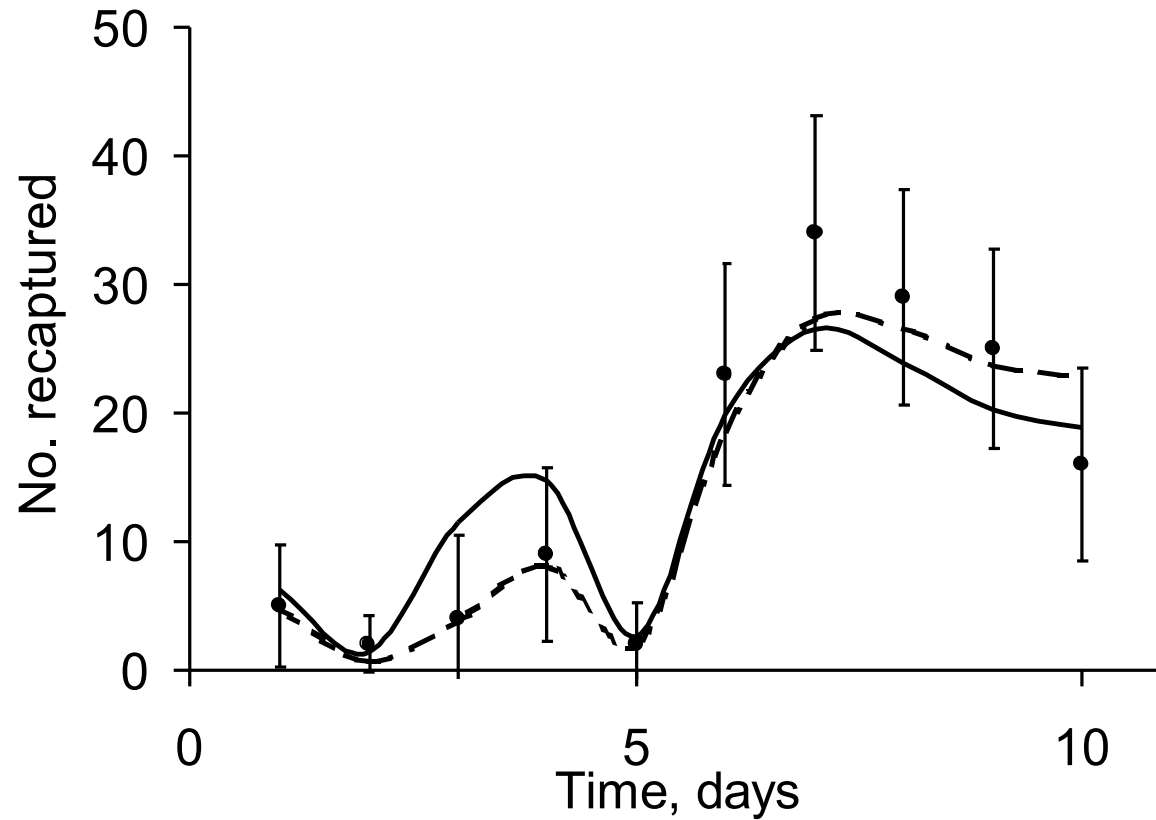
Graph 95 % *confidence interval*, or $\pm 2 u$

Chi-squared test compared model with data

$p = \mathbf{0.17}$, no moonlight; $p = \mathbf{0.75}$, with moonlight

$p < \mathbf{0.05}$ if model statistically different from data

Error bars overlap both curves



Data and theory are indistinguishable

— simple model, - - - model with moonlight

What Hooper believes

Everything her informant Ted Sargent says

Competing theory (induction) not accepted by experts

Nothing Kettlewell says

What Hooper does not understand

Science

Biology

Vagaries of experimental science

More erratic vagaries of field measurements

Confirming evidence

Kettlewell was first — a pioneer

Made mistakes

Work has been replicated

In moths

In other species

In other locales

Industrial melanism understood beyond reasonable doubt

Conclusion

All scientific experiments in some way flawed

(All unscientific experiments too)

Black-and-white thinkers wrongly think

Any mistake \equiv wholly wrong

Cf. attacks on “Darwinism”

Countless other studies support Kettlewell’s pioneering work

Peppered moth properly remains icon of evolution