SLIDE 1.

PLEASE NOTE: Slide numbers are upper left of each Slide and do not correspond to numbers in left panel.

Testing hypotheses about behavioral interactions between cats, coyotes, and birds at carcasses

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Photo Jon Nelson

OSU
Oregon State
UNIVERSITY

SLIDE 1b

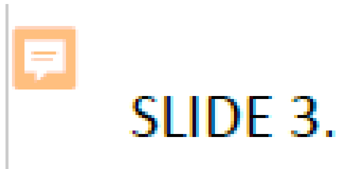
If you are using the Powerpoint version of this presentation…

- There are notes associated with each slide at the bottom of each slide.
- You can open and close the notes at the bottom of a slide by hitting “ctrl-shift-h.”
- You can change the size of the notes panel by clicking on the dividing line between the notes and the slide and dragging it up or down.
- When the notes are longer than the size of the panel, you can read down by dragging the scroll bar.

SLIDE 1c

If you are using a pdf version of this presentation…

- We recommend the Powerpoint version, but if it is too big for you to download then you can also use the pdf version. You can read the notes associated with each slide in the pdf version by clicking on the icon on the top left of each slide.
- The relevant icon is the orange quote box, as shown in a screenshot here from slide 3:



- If the note is too long to read, click on it.
- To open all notes in every slide, right click on the icon in one slide and choose “open all popups.”

SLIDE 2a.

Type of interaction	Sign	Effects
Mutualism	+/+	Both species benefit from interaction
Commensalism	+/0	One species benefits, one unaffected
Neutralism	0/0	Populations do not affect one another
Ammensalism	0/-	One species is unaffected, one is disadvantaged
Predation, Parasitism	+/-	One species benefits, one is disadvantaged
Competition	-/-	Each species affected negatively

SLIDE 2b.

Other terms:

Exploitative competition – Competition is indirect (e.g. one species uses up a resource before another species accesses it).

Interference competition – Competition is direct (e.g. physical aggression).

Conspecific – Individual of the same species.

Heterospecific – Individual of a different species.

Carcass – The dead body of an animal.

Carrion – The decaying flesh of dead animals.

Social information – Information gained by observing other individuals.

Cue - Any behavior that inadvertently provides social information during performance of an activity.

Signal – A behavior that intentionally conveys social information.

SLIDE 3.

Cats at Carcasses

Photos Jon Nelson

SLIDE 4.

Cats and Dogs

Photos Jon Nelson

SLIDE 5.

Cougars

Photo Jon Nelson

SLIDE 6.

Birds & Dogs

Photos Matt Orr

SLIDE 7.

Golden Eagles & Coyotes

Photos Jon Nelson & Matt Orr

SLIDE 8.

Birds and Birds

Photo Jon Nelson

SLIDE 9.

Photos Jon Nelson

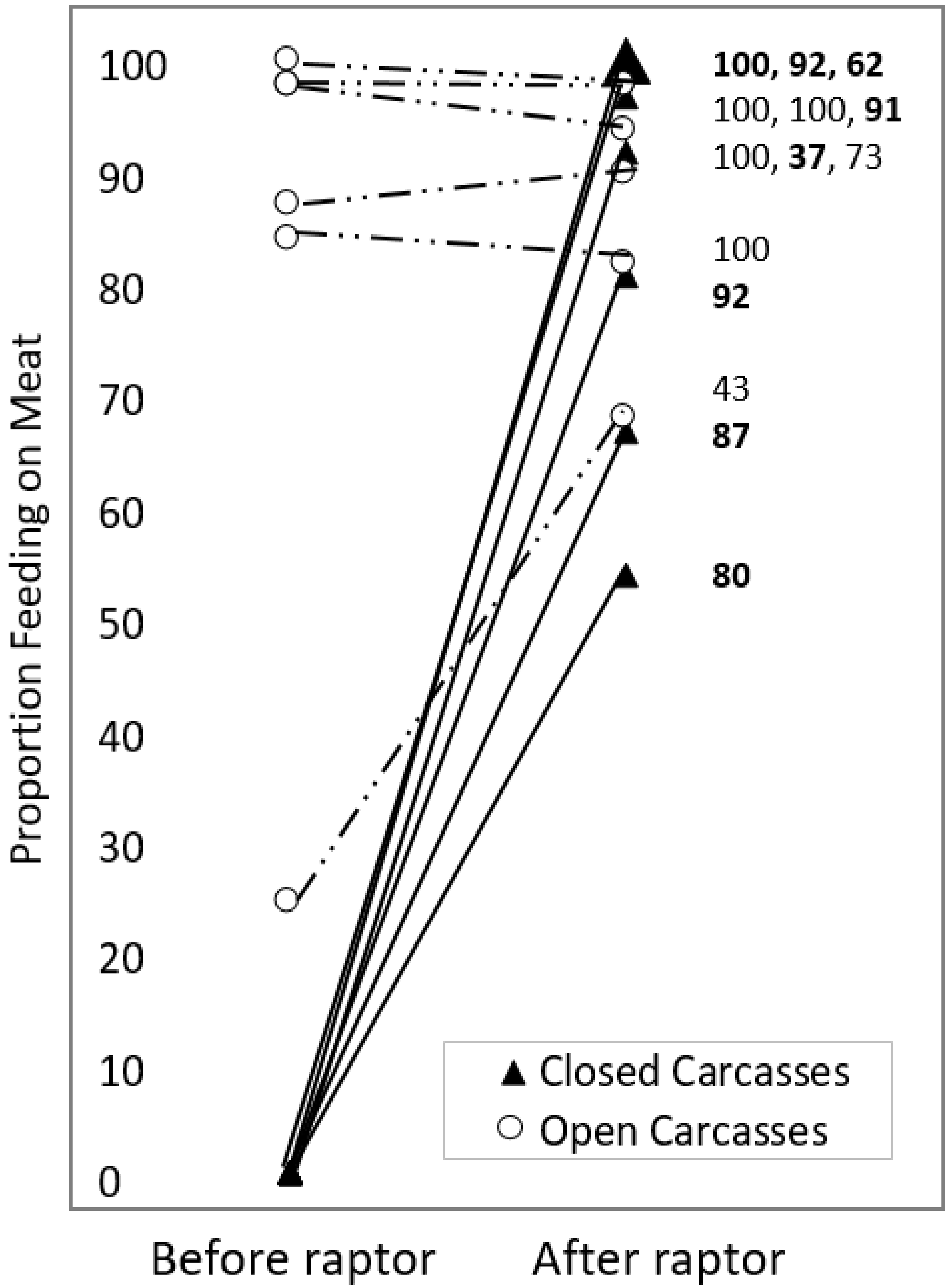
SLIDE 10.

Using a hatchet to experimentally pre-open a carcass.

Photo Jon Nelson

SLIDE 11.

Proportion of instances of ravens or magpies photographed feeding at meat before versus after raptors arrived at closed (dark triangle, solid line) and experimentally pre-opened (open circle, dashed line) carcasses. The proportion of feeding instances on meat increased at closed but not at pre-opened carcasses after a raptor arrived (P < 0.01). Numbers to the right represent number of individual feeding location photos for each carcass (bold = closed carcasses). The large triangle represents 3 different carcasses that had the same result.



Summary of Corvid Benefit - 1. Magpies feed at eyes and anus. 2. Ravens feed at eyes and anus. 3. Golden eagle opens skin. 4. Corvids feed on meat.

SLIDE
13.

Bird Arrival Times

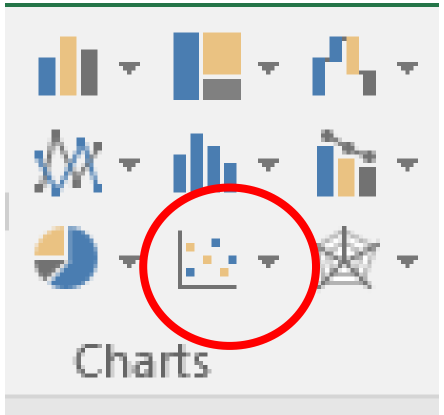


Photo Matt Orr

SLIDE 14.

Synthetic Carcasses

This photo shows a synthetic “carcass,” consisting of a deer hide and an antler, seen just in front of the person. Experimental treatments added raven decoys and audio playbacks of scavenging ravens (in a speaker hidden in the bush beneath the raven on the stick). Nearby control treatments, which were observed simultaneously, had no decoys or playbacks—just the “carcass.”

Each experimental and control together was one replicate.

Investigators conducted 16 replicates across a large area.

SLIDE
15.

Summary:
Raptors
use corvids
to locate
carrion.

Photo Matt Orr

Social information

- An animal (including you!) acquires information both individually, through direct trial and error, and socially, by observing other individuals.

- A cue is any behaviour that inadvertently provides social information during performance of an activity.

  - ✓ For example, safari groups in Africa forming a cluster around an interesting wildlife sighting inadvertently provide a cue to distant groups that something interesting is happening.

  - ✓ Fishing boats may also use one another or seabirds as cues for where the action is.

SLIDE 17.

- In contrast to a cue, a signal *intentionally* conveys information.

  ✓ For example, one safari vehicle (or boat captain) may transmit a radio signal to another to come and check out a wildlife sighting (or catch opportunity).

- Signals are likely to occur only if they benefit both receiver and sender.

  ✓ For example, safari vehicles from the same company may be more likely to signal one another than vehicles from different companies. What about boat captains?

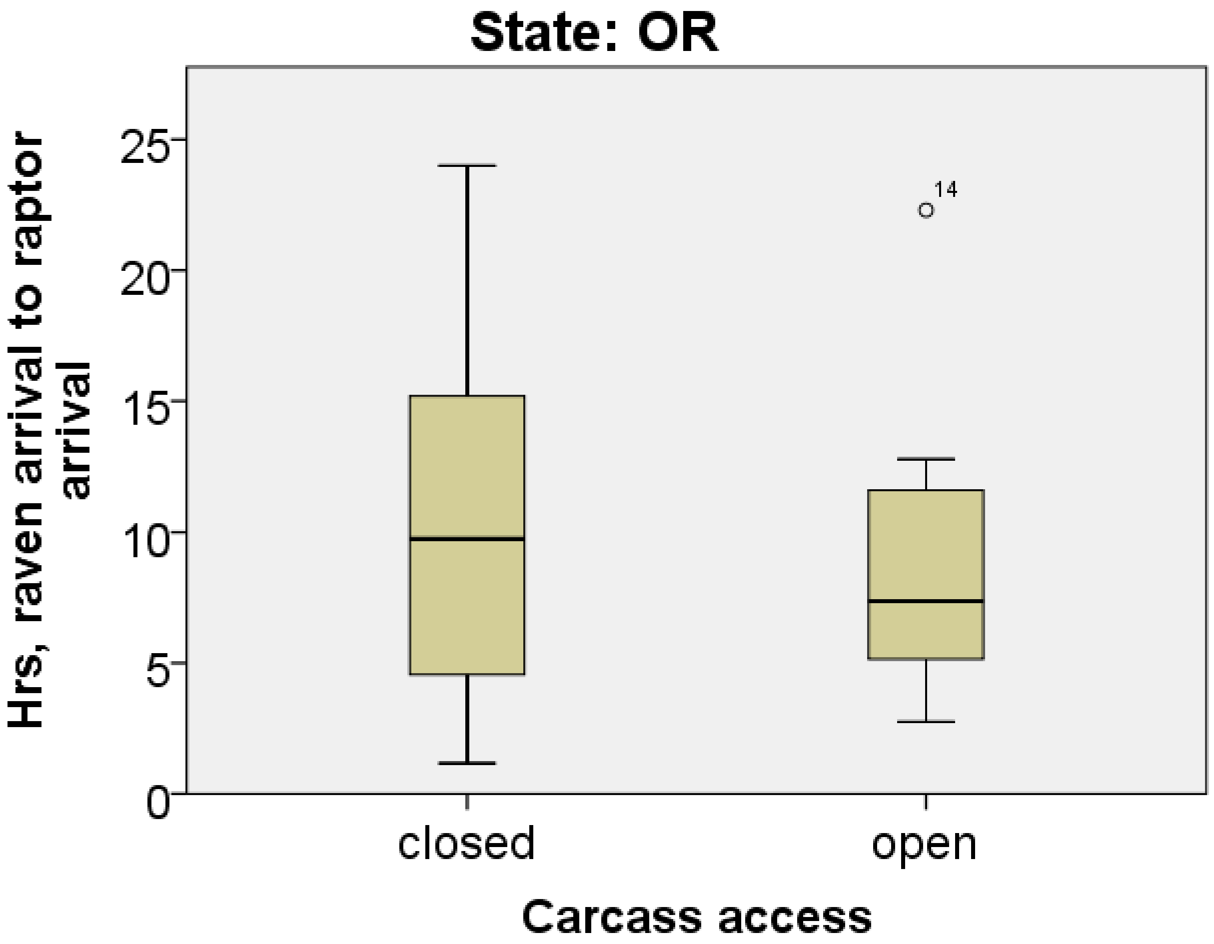
- Both raptors and corvids benefit when raptors use information from corvids to find carcasses, so it is appropriate to ask whether corvids send a cue or a signal about the location of carrion.

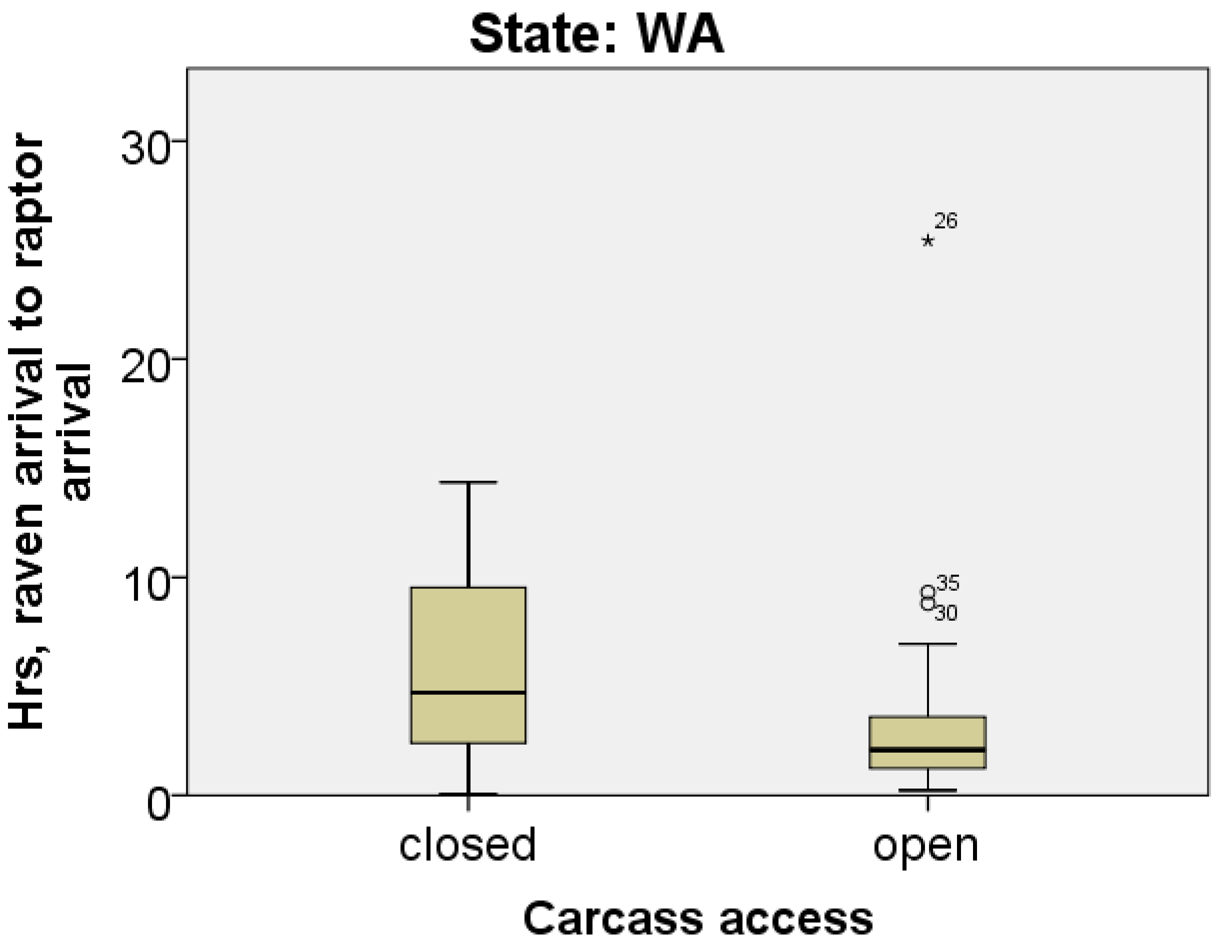
To test whether corvids may *signal* the presence of carrion, scientists set out carcasses so that corvids would benefit from raptors at some carcasses but not at others.

How did they do that? You already know: Some carcasses were pre-opened with a hatchet, whereas others remained entirely covered by deer hide.

At which type of carcass do you think corvids would be more motivated to intentionally signal the location of the carcass to raptors?

SLIDE 19.





Box and whisker plots show the time lag (Y axis) from when ravens first appeared at a carcass to when raptors first appeared at a carcass in Oregon (left) and Washington (right). “closed” = intact carcasses and “open” = pre-opened carcasses.

SLIDE 20.

Photo – Jon Nelson

SLIDE 21.

Hadza: How did they find carrion?

O’Connell et al. 1988 Current Anthropology 29: 356 – 363.

	Guided by…	Not Guided
Vultures	2	7
Hyenas	1	
Leopard (kill sounds)	1	

SLIDES 22 +

Behind the Scenes of the Science

This section is for fun. It is intended to give you some sense of how science is "made," which may not always be evident from textbooks or journal publications. While the story told here is unique, it contains some useful generalities.

This project was initiated by Jon Nelson in 2011, who at the time was an undergraduate student in Matt Orr's upper division Ecology class at OSU-Cascades in Bend, Oregon. Matt assigned students a 1-credit independent ecology project. Jon, who worked at the High Desert Museum near Bend, had noticed one day that a wide array of animals showed up when he had to dispose of some fish remains (for the museum's otters) in the woods behind the museum. Based on this observation, Jon wanted to do a project on scavenging dynamics.

Jon in 2018 at work as Head Curator at the High Desert Museum

In terms of how science is "made," all it took to get this project started was one observation and some curiosity (not to mention a course requirement ☺).

Photo J. Nelson

Our first challenge was to devise a hypothesis to test. We started with the idea of looking at discovery dynamics in habitat that had closed canopy, like a ponderosa pine forest, with habitat that had more open canopy, like sage-steppe. Both habitats are common around Bend.

We were also interested in devising a dominance hierarchy among scavengers visiting these carcasses.

In terms of how science is made, you have to start somewhere!

A third challenge was to find a somewhat uniform source of carrion. We started with cow heads from a slaughterhouse. (Again, you have to start somewhere.)

<u>Above</u>: After being scavenged.

<u>Below</u>: Just after being placed in the field.

Photos J. Nelson

Jon’s class project put out six replicates and found a correlation between the appearance of ravens and the subsequent appearance of hawks or eagles at 5 of the 6 carcasses.

We thus reoriented our project toward discovery cues and signals and started it all over.

In terms of how science is “made,” this illustrates that you should not get too attached to your original ideas and should always be on the lookout for unexpected surprises to pursue.

Jon obtained permits to use roadkill carcasses instead of cow heads for the new experiment.

(In addition to being more realistic, they were also more photogenic.)

Photo: J. Nelson

After getting a long way into the study and finding strong correlations in arrival times between ravens and eagles, we started to have doubts about what the pattern meant.

Was it possible that eagles waited around for other scavengers to approach the carcass, and only came down after it was safe?

If so, the limited views through our game cameras could provide a misleading view of discovery sequences.

In terms of how science is made, it is always good to be skeptical of your own findings and modify or add experiments to address alternative explanations, if necessary.

Photo M. Orr

Risks to eagles scavenging at carcasses seemed real given that they never once appeared in a photo along side a bobcat or mountain lion. In fact, no bird of any species ever appeared with a cat in a photo. Clearly, eagles knew how to be careful.

(What is this cougar looking at?)

- To address our curiosity about whether eagles may wait around a carcass before descending to it, we contacted an eagle expert, Jim Watson, from the Oregon Department of Fish and Wildlife. Jim had experience netting eagles, which required hanging around at a bait and therefore getting a sense of what eagles did when they arrived at it.

- Matt called Jim, whom he had never met before, to ask Jim this question. There was an awkward moment when Jim said he, too, was putting out game cameras at deer carcasses to assess scavenger behavior.

- It sounded like a possible case of competition, but we turned it into a mutualism by agreeing to pool our data sets for more replicates and a wider geographic range of study.

- In terms of how science is made, successful projects increasingly require broad collaboration.

Jim Watson banding an eagle

Photo: M. Orr

- One way we sought to resolve the question of whether raptors hang around for a long time and descend to a carcass only after they see a raven “test driving” it, was to place carcasses under the only good perch in an area and aim our cameras on both the carcass (lower left) and the perch.

- Although this showed that raptors spend only a few minutes perched before descending to a carcass, we still had further doubts about alternative explanations for our findings. This goes back to the same issue of being skeptical of your discoveries.

Another alternative explanation that concerned us is that if some habitats are better for all birds while others are worse, then different species would appear at carcasses early in high-density bird habitats and later in low-density habitats. This could create a correlation in arrival times between species that was based only on bird densities. This was another alternative explanation for our findings that we could not ignore.

Photo: J. Nelson

In terms of yet another alternative explanation, we knew that in Yellowstone ravens follow wolves around hoping for opportunities to feed at a wolf kill. If any of our focal species followed each other around like that, then they would appear coincidentally at carcasses without one species having provided a cue or signal about the carcass to the other.

- To alleviate these concerns, Matt ran some ideas for an experimental study past Jon to try to address these alternative explanations.

- Jon's expertise trapping eagles led him to propose artificial carcasses.

- The thought was that during very cold times of year, raptors might be desperate enough to investigate even a fake carcass.

- In terms of how science is made, observational studies can be a good start, but experimental manipulations are often needed to cleanly answer a question. Synthetic carcasses made it easy to create and deploy a lot of replicates with or without "ravens."

- In hindsight, the synthetic carcasses, which consisted of raven decoys and a game caller playing the sound of scavenging ravens, were unlikely to attract raptors due to their widespread distribution on the landscape and the narrow radius of the game caller playing back raven scavenging sounds.

- In addition, static raven decoys would not have alerted raptors to the notion that anything of importance was happening.

- In terms of how science is made, we are back to the idea of "you have to start somewhere."

Photo: Soren Orr

Photo – M. Orr

- We were probably a bit lucky that the synthetic carcasses did attract both ravens and magpies, who sometimes circled over them.
- These, in turn, attracted raptors.
- The control carcasses did not attract ravens or magpies and did not attract raptors.
- So, our question was answered, but not in the way we expected.
- In terms of how science is made, a little luck never hurts.

After conducting two different observational studies and an experimental study, all of which pointed to heterospecific cues, we thought we had some convincing findings.

Photos J. Nelson

However, in terms of how science is made, we still had to convince peer reviewers, whose job is to tear into your work with a helpful yet critical eye.

Problems posed by peer reviewers…

- Our manuscript was rejected without being reviewed by the journals *Ecology Letters* and *Oecologia*.

- It was reviewed by the *Journal of Animal Ecology*, but rejected for three main reasons:
  - Reviewers felt that we may have been measuring the same eagle repeatedly in some cases if our carcasses were not spread far enough apart.
  - Reviewers had a problem with the fact that in our experimental study we used the same 8 minute loop of raven foraging sounds (which we had made at a carcass) instead of using a different set of sounds for every replicate.
  - Reviewers felt our statistical analysis of our carcass discovery data should use more up-to-date generalized linear mixed models (GLMMs).

Responses to peer reviewers…

We addressed these problems as follows and resubmitted to *Animal Behaviour*, which accepted the manuscript after some further revision.

- Using data on the sizes of eagle territories, we eliminated any possible replicates from within the same territory. There were only a few of these, and eliminating them did not change our results.
- We emphasized that it was live ravens and magpies, not the raven audio recording, that attracted the raptors to synthetic carcasses, so using the same recording was not a problem because individual live ravens and magpies differed at each synthetic carcass, suggesting it was not just the behavior of one whacky corvid that attracted raptors.
- Jim Watson reanalyzed our data using GLMMs.

In terms of how science is made, comments by peer reviewers greatly improved the scientific quality of our manuscript. Another lesson about how science is made is that initial rejection from a journal does not necessarily mean your research is worthless. It may just mean that your peer reviewers were diligent and thorough.

Further discussion – What about humans?

Human anatomical adaptions for endurance running may have originated to outrace other species to carcasses (see en.wikipedia.org/wiki/Endurance_running_hypothesis under "Endurance running and scavenging"). If so, it is not unrealistic to imagine that races to carcasses may have been precipitated by cues such as those provided by circling vultures. Perhaps this is a bit of a stretch to say this, but similar heterospecific cues to those studied here may have made humans faster.

Photo J. Nelson