Title

Using accelerometer "smart collars" to identify wolf behavioral states and energetic costs

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Using accelerometer "smart collars" to identify wolf behavioral states and energetic costs

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Background

- Wolves are **apex predators** and cursorial hunters
- **Locomotion is energetically costly**
- Wolves directly impact prey and indirectly affect many other species by initiating a **trophic cascade**
- As large carnivores, wolves require **substantial prey populations** for survival
- If available prey are insufficient, **negative energy balance** leads to wolf population decline
- **Quantifying the energetic demands** of wild animals is difficult
- A **novel approach** is needed to assess the hunting costs of free-ranging wolves in order to predict (and avoid) wolf-livestock conflict

Questions

- To what extent will wolves be able to modulate their locomotive performance (and hence energetic requirements) to cope with the stressors of ecosystem change?

Fig.1 A lone elk (Cervus elaphus) flees from wolves

- Can quantifying the energetic costs of locomotion in these animals help inform researchers of predatory events resulting from an animal's caloric deficiency, thereby giving predictive power for impending human-wildlife conflict or population decline?

Abstract

Habitat loss and fragmentation are the primary threats to most wildlife populations[1,2]. Additionally, anthropogenic climate change is disrupting predator-prey interactions as interactors often respond differently to ongoing change[3]. Increasingly degraded landscapes and declining prey populations have magnified these effects on apex predators such as grey wolves (*Canis lupus*)[4] which must maintain large territories to accommodate their large nutritional demands[5]. Consequently, **wolves may cope with climate change by altering foraging patterns[6], resulting in elevated daily energetic costs to track shifting or diminishing prey populations[7] as well as increased conflict with humans and livestock[8]**. Wild canids in general (e.g. African wild dogs, coyotes, foxes) and wolves in particular may be especially sensitive to increased energetic demands because they operate at the upper limits of mammalian aerobic metabolism[9], exhibiting maximum aerobic performance over three times greater than most placental mammals[10]. **This research will develop the technology necessary to quantify these additional movement costs and generate models for predicting wolf locomotive responses to ongoing environmental perturbation**.

Methods

1. Collar Calibration

Accelerometer collars

Time-matched video recordings

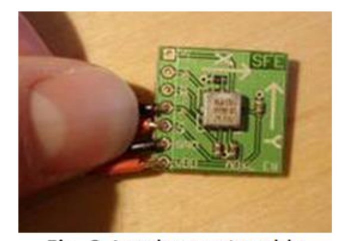


Fig. 2 Accelerometer chip

Fig. 3 Accelerometer collar

Fig 4 Siberian husky wearing accelerometer collar during calibration trial

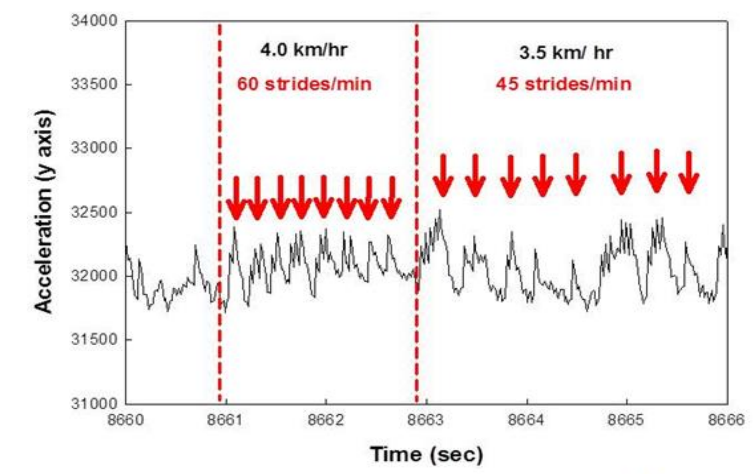


Fig. 5 Acceleration signature for a mountain lion (*Puma concolor*). Footstrikes are clearly identified by spikes in the signal and are used to remotely determine speed and behavior. From T.M. Williams (*unpub*).

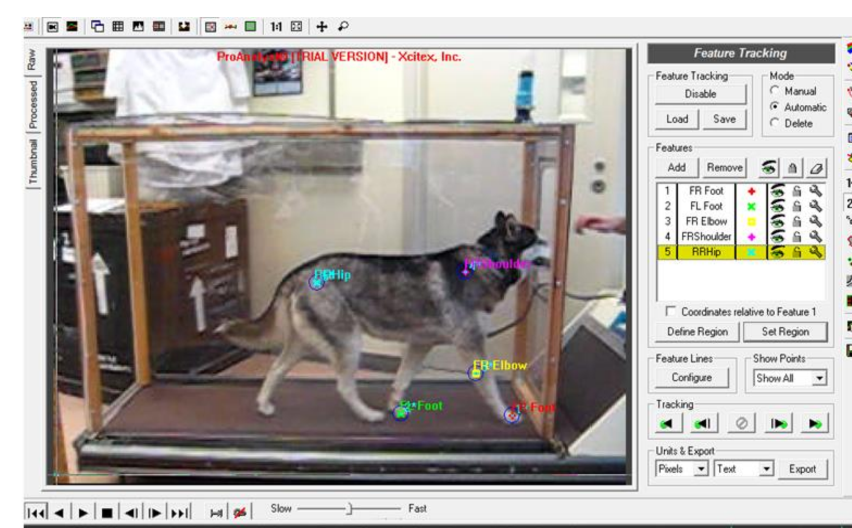


Fig. 6 Biomechanical & kinematic gait analysis using ProAnalyst video software.

2. Determination of Energetic Costs

Open-flow respirometry

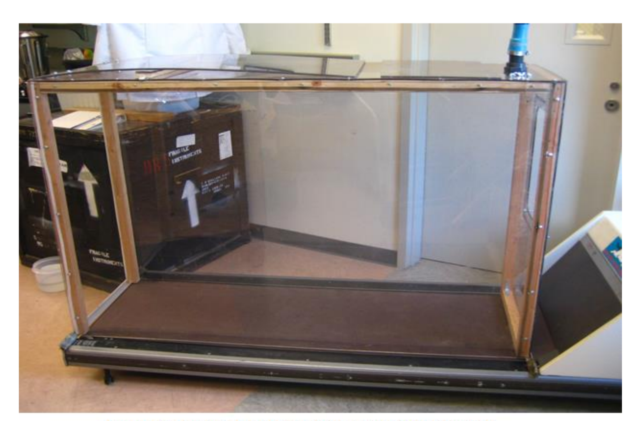


Fig. 7 Metabolic chamber sitting above treadmill belt

Fig. 8 Alaskan malamute being measured for caloric costs of locomotive gaits

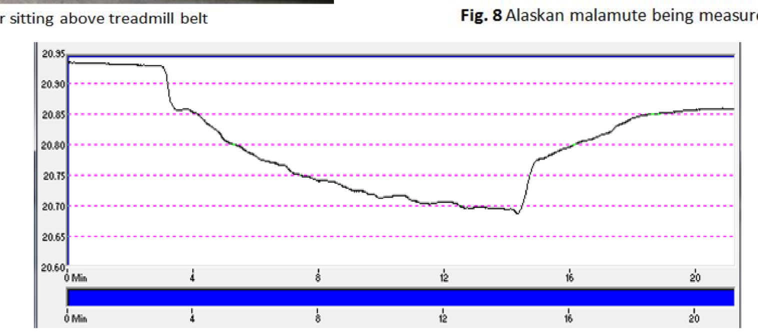


Fig. 9 Typical O_2 depression curve for an exercising animal in a metabolic chamber

3. Model Construction & Validation

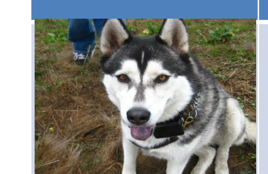
Dynamic state variable model

1. Incorporate caloric costs of locomotion
2. Predict foraging movements in wild wolves

Field Validation

1. Ground-truth accelerometry technique with captive wolves
2. Investigate field metabolic rate on free-ranging wolves

Collaboration

	Canid	Sample Size	Collaborator	Location	Status
	Dog (*Canis familiaris*)	20	Local owners	Santa Cruz, CA	Ongoing
	Wolf (captive)	10	San Diego Zoo CA Wolf Center Grizzly & Wolf Discovery Center	San Diego, CA Julian, CA W Yellowstone, MT	Pending
	Wolf (wild)	5	Yellowstone Wolf Project	Yellowstone NP, WY	Pending

Implications

For wolves:

- Assess how wolves partition their energy into various behaviors
- Gain insights into ecosystem consequences of elevated canid metabolisms
- Develop validated models from free-ranging wolves for predicting foraging activities and predatory events

Fig. 10 Wolves in hot pursuit of elk in Yellowstone

For other species:

- Develop a more physiological, mechanistic understanding of how the metabolic costs of transport for individual animals translate into community-wide effects
- Promote animal-borne accelerometry technology for assessing field metabolic rate of various rare and/or elusive species
  - E.g. "smart collars" currently being deployed by collaborators on mountain lions (*Puma concolor)* and mule deer *(Odocoileus hemionus)* in CA & CO

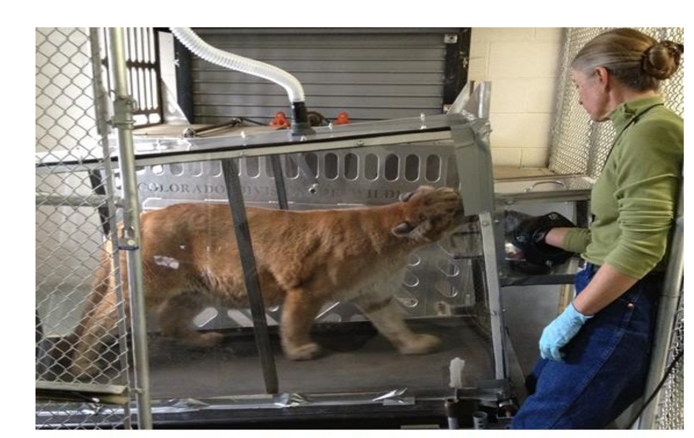


Fig. 11 Mountain lion walking on treadmill within metabolic chamber

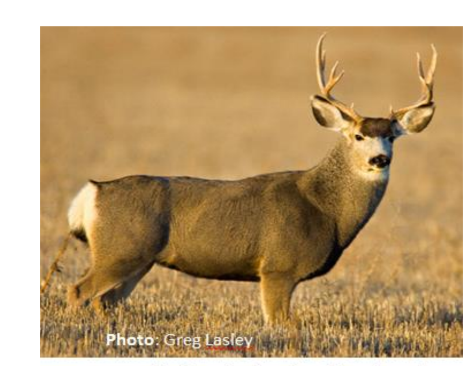


Fig. 12 Mule deer (*Odocoileus hemionus*)

Conclusions

- **Calibrated accelerometer collars may provide a critical link** between movement ecology, behavior, energetics and environmental characteristics in wild animals
- Species that are **rare, elusive or of particular conservation concern** are ideal "smart collar" candidates because the collars measure how hard animals must work to survive, which is predicted to change with environmental circumstances

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