Breeding better working dogs with genomics

Claire Wade University of Sydney

TOPICS (for today)

- Farm dogs

- Labrador Retrievers (Field Trial)
  - Genetic mapping of “drive”

The Farm Dog Project

- Identify valuable phenotypes (from a user perspective)
- Assess phenotypes
- Use phenotypes to inform better dog breeding and reduce wastage

Team members:

Paul McGreevy
Elizabeth Arnott
Jonathan Early
Lisa Mascord

Identifying valuable phenotypes:

- Discussion with stakeholders
- Observation of trialling metrics
- Analysis of relevant training literature

ELSEVIER

Journal of Veterinary Behavior: Clinical Applications and Research

Volume 9, Issue 6, November–December 2014, Pages 370–374

Short Communication

Manual muster: A critical analysis of the use of common terms in Australian working dog manuals

Jonathan B. Early, Elizabeth R. Arnott, Claire M. Wade, Paul D. McGreevy

Fig 1. Top 10 terms for General Behavioural attributes

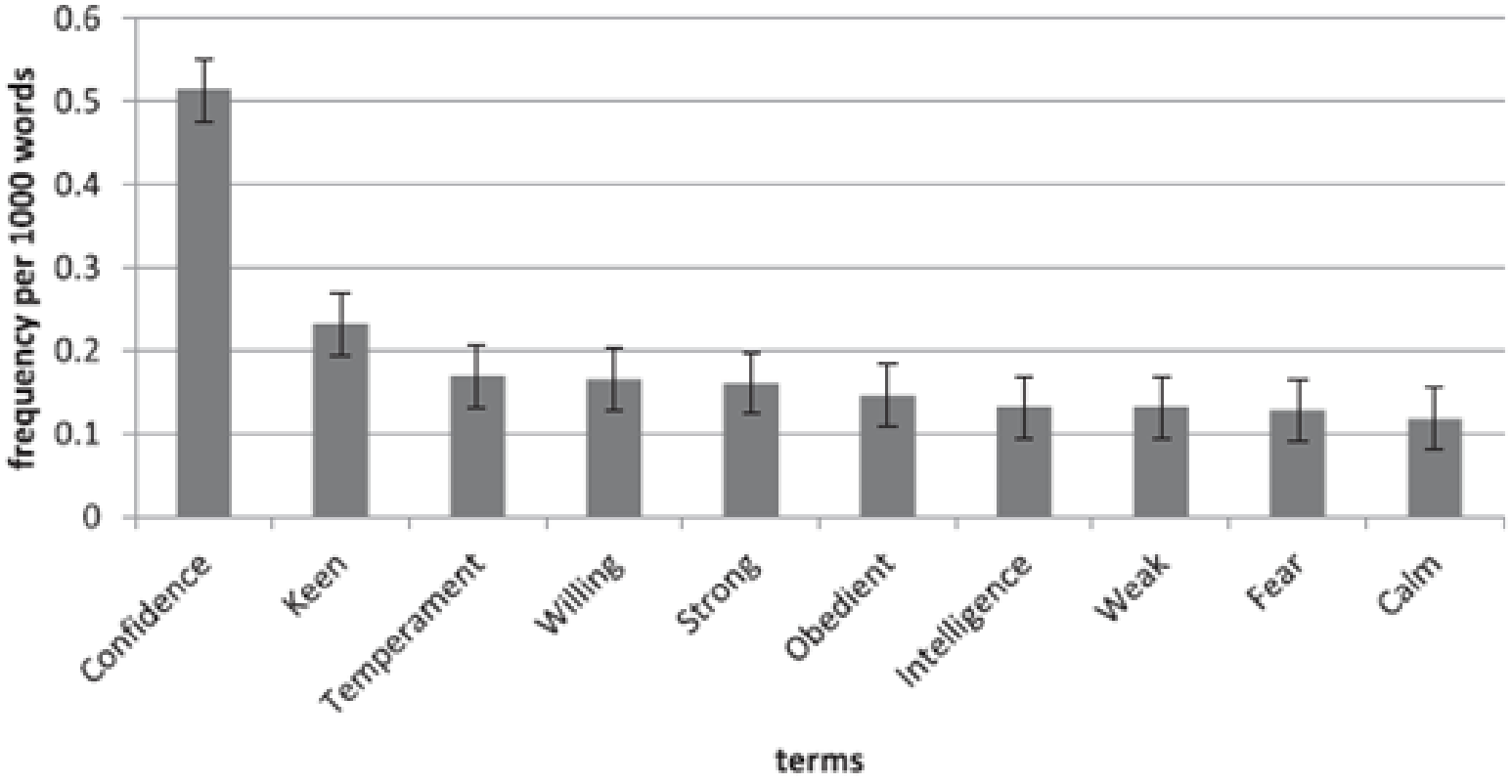
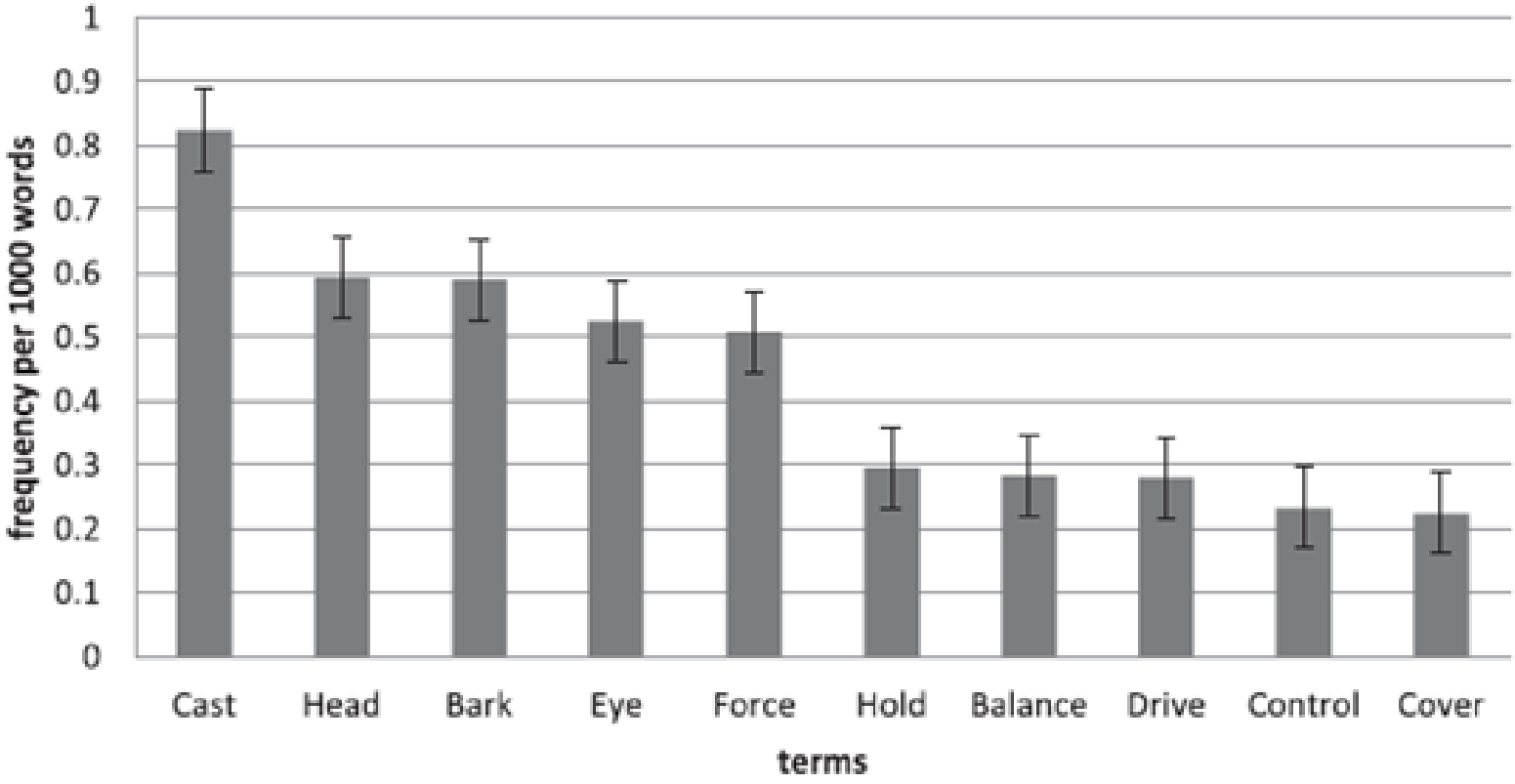
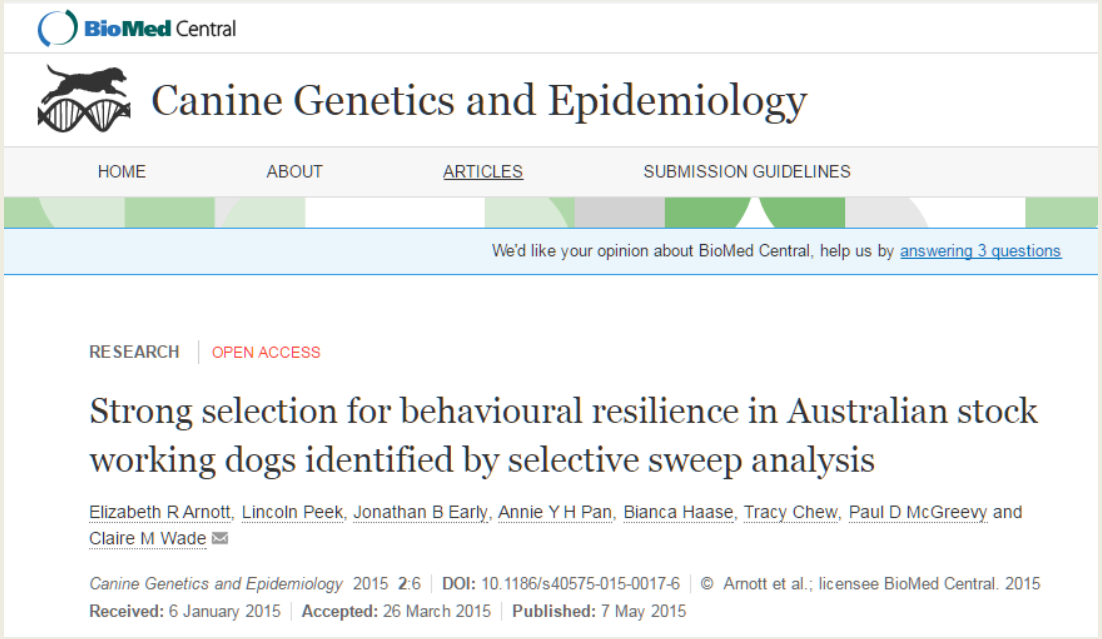


Fig 2. Top 10 terms for specialist working attributes of farm dogs



Identifying valuable phenotypes:

- …or looking at what breeders value without realizing it
- We do this by assessing the footprints of selection in the DNA



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RESEARCH | OPEN ACCESS

Strong selection for behavioural resilience in Australian stock working dogs identified by selective sweep analysis

Elizabeth R Arnott, Lincoln Peek, Jonathan B Early, Annie Y H Pan, Bianca Haase, Tracy Chew, Paul D McGreevy and Claire M Wade

Canine Genetics and Epidemiology 2015 **2**:6 | **DOI:** 10.1186/s40575-015-0017-6 | © Arnott et al.; licensee BioMed Central. 2015

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Livestock working (Herding) Dog Assessment Form

This form is produced by The University of Sydney Farm Dog Project to collect trait information on Australian stock herding dogs. For participant information on the project please go to: http://sydney.edu.au/vetscience/research/animal_behaviour/farmdog/.

This form should take about 5 minutes to complete. It is important that all questions are answered. You may complete the form anonymously as you are not obliged to leave your personal details. Your personal details will not be linked to your responses and your contact details will not be passed on to any third party. By completing this form you will be contributing to our knowledge of stock herding dogs. The information you provide will assist with ongoing research at the University of Sydney. We believe this will benefit working farm dogs and their owners/handlers/breeders.

This project is supported by a grant from the Australian government's Rural Industries Research and Development Corporation, Meat and Livestock Australia and in kind, support from the Working Kelpie Council of Australia.

*Required

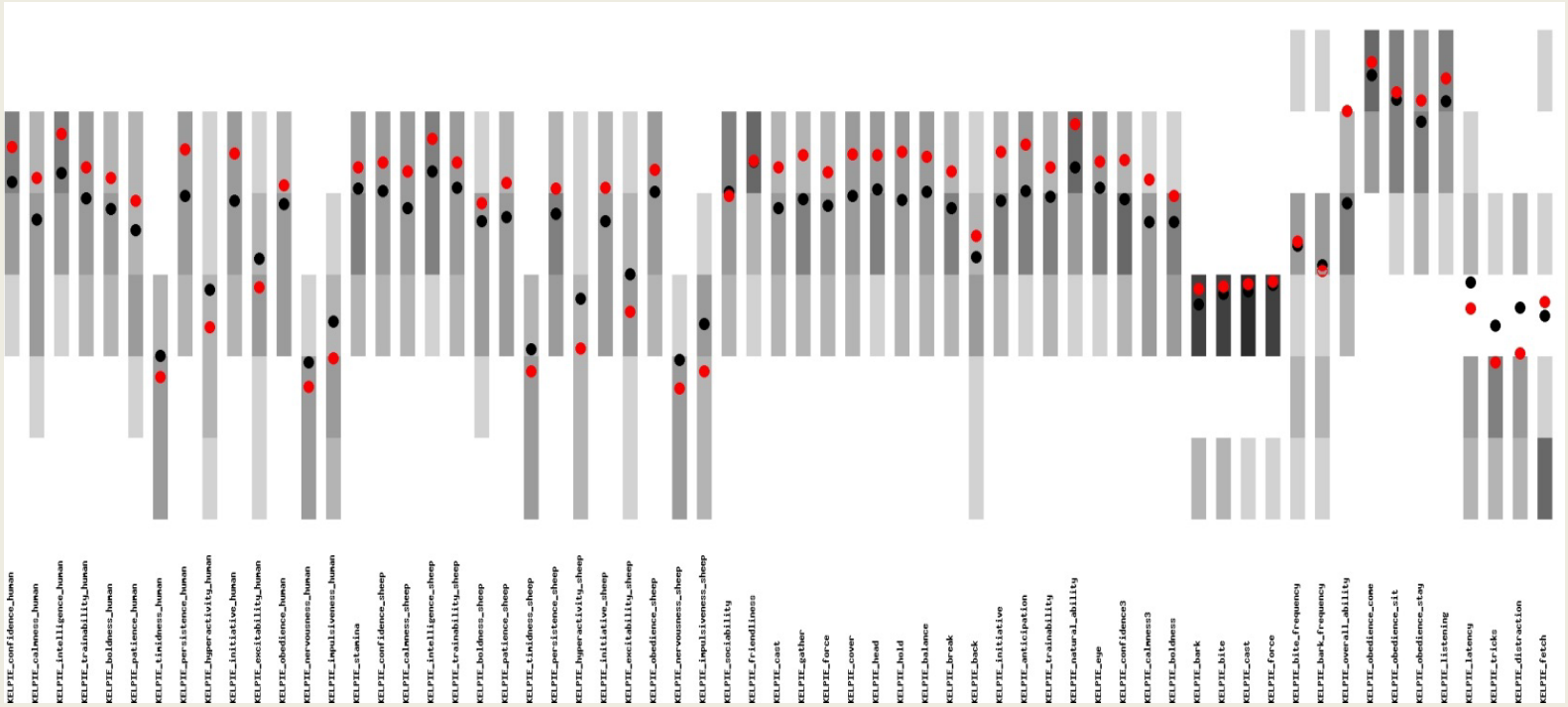
THE UNIVERSITY OF SYDNEY

Livestock working (Herding) Dog Assessment Form

- Targeted owner-driven phenotyping of 62 traits
  - As of March 2017 359 participants
- DNA samples collected from phenotyped dogs
  - As of March 2017 we have collected DNA from and genotyped 210 Kelpies we have samples from a further 100 Kelpies
  - We have whole genome sequence from 12 Kelpies including some that are competitive and successful trialling dogs
- Pedigree information and registration information collected
  - The entire Working Kelpie Council pedigree database was provided in collaboration with project

Giving back

- Profiling the average dog (●) within a breed
- Profiling elite working dogs (●) within a breed



Giving back

- If we choose the animals with the highest overall ability and compare these with the mean, we have a powerful insight into what breeders value
- Scores relate to a Likert scale
- These small computationally derived charts show scores in the range of 1-5 or 1-6 (most/highest at the top)
- Darker hues describe a higher proportion of dogs at that score

Elite dogs

Mean

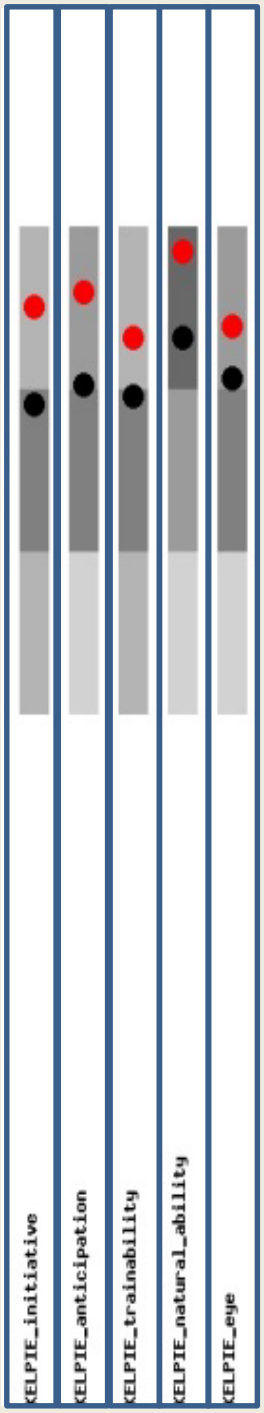
Giving back

Elite Kelpies (●) have more than average (●):

- Initiative
- Anticipation
- Trainability
- Natural ability
- Eye

● Elite dogs

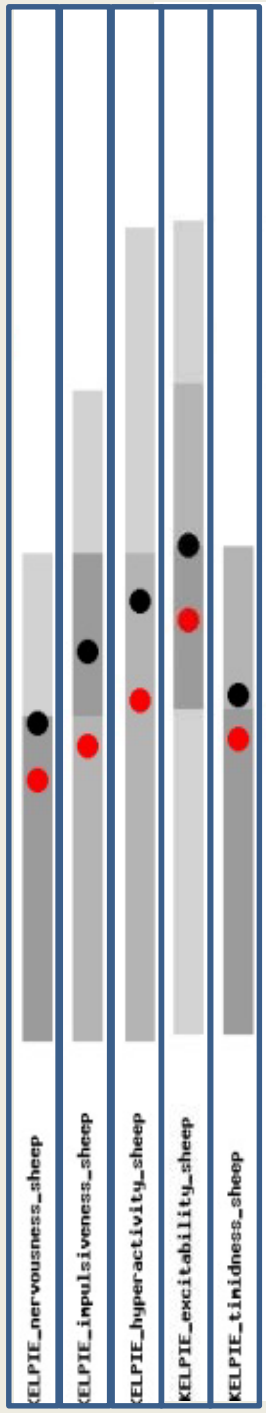
● Mean



Giving back

And elite Kelpies have less:

- Nervousness
- Impulsiveness
- Hyperactivity
- Excitability
- Timidness



Elite dogs

Mean

Giving back

Kelpie breeders are readily able to fix:

- Bark
- Bite
- Cast
- Force

…although different work types have different requirements
e.g. dogs that work on trucks and in yards should bark and bite versus those that work in the field should not

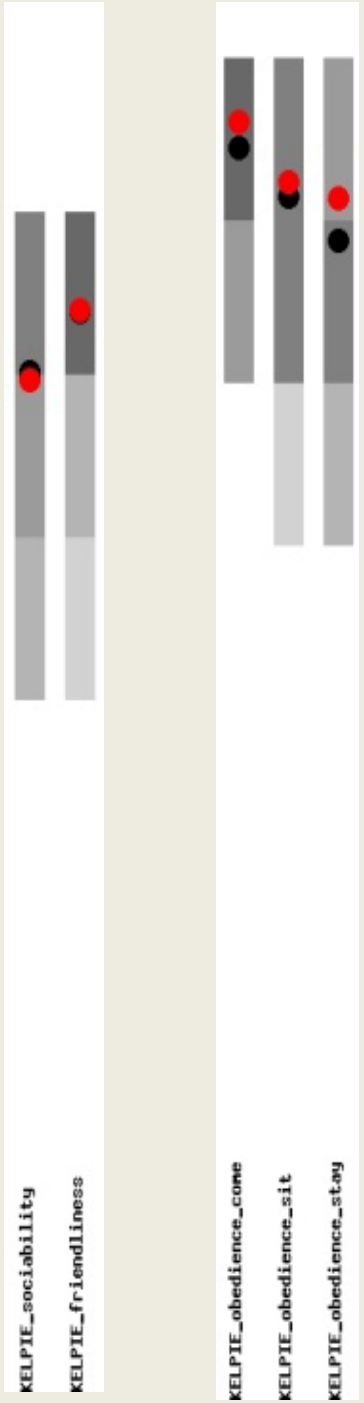
Giving back

…and nobody judging a kelpie as an elite worker cares too much about:

- Sociability
- Friendliness
- Come
- Sit
- Stay

Elite dogs

Mean



…since most kelpies are in the appropriate zone for those things

Next steps:

- Add Functionality:
  - Identify the best breeders
  - Provide a means for users to find breeders producing the kind of dogs they need for their work type
  - Map traits
  - Generate Estimated Breeding Values
  - Overcome data curation challenges!

Farm Dog Project Summary

- This is a long-term project and we are still collecting data
- We have clearly identified traits that describe elite working dogs
- We are actively collecting DNA and pedigrees for genetic and genomic analysis

Elite Retrievers

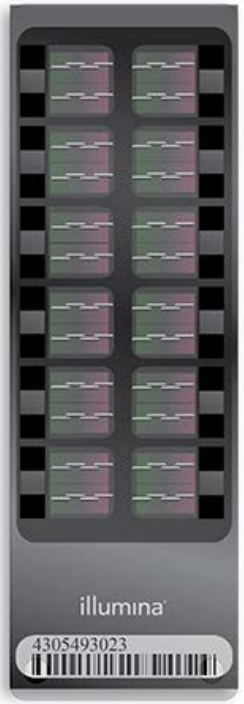
- Comparison of elite field trial Labrador retrievers with other Labradors
- Can we gain insight into the genetic characteristics that underpin elite retrieving?

Background

- Dogs with elite retrieving ability in Australian trials are admixed USA Labrador bloodlines
  - Very high drive
  - Very high energy
  - Lean
  - Muscular (which may equate with low subcutaneous fat)
  - Skeletal differences
    - Taller/Finer than English/Show type

Data (population screening)

- High density and Ultra-high density DNA genotyping arrays (Illumina Canine HD and UHD)

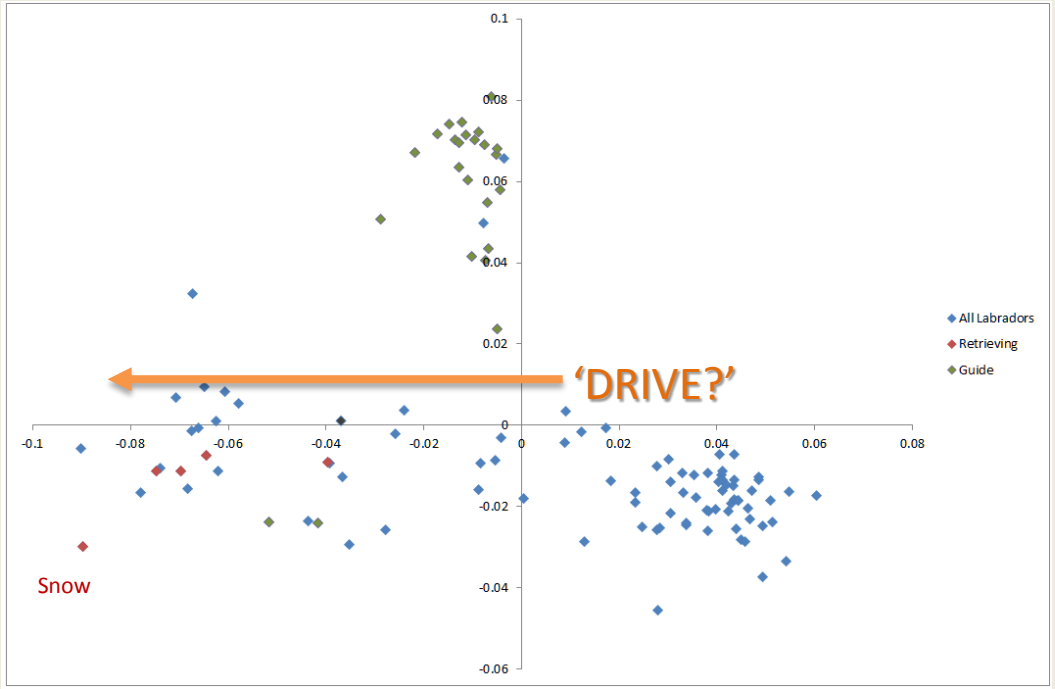


High resolution data (mutation level)

- Whole genome sequencing (Illumina HiSeq2K and Illumina X10)

Samples

- Elite trialling families ascertained by successes in National and State trials
- Admixed population
  - (USA retrieving trial champion semen imports by Australian working dog lines)



"Extremely high drive. No quit. Athletic. Outstanding work ethic. Missy keeps everyone on their toes!"

"Snow has a high work ethic, loves training, great memory, loves water, excellent fluid movement, hunt all day, sociable."

Admixture mapping

- Identifies regions according to population of origin
- Using known pedigree this can include heterozygous regions
- Hypothesis that USA-type affords skill

Admixture mapping

- Admixture of individuals in our study is known by their pedigree
- We identify variants that are enriched in dogs with USA type ancestry
- We identify variants with homozygosity/heterozygosity according to pedigree expectation for individuals
- Probabilities are typically stronger than those from association

Preliminary signals from admixture analysis

- On chromosome 20 in a region where there are several genes with a strong influence on adiposity ($p=4.04E^{-25}$)
  - Haplotype is shared with whippet and boxer
- A signal on chromosome 9 near a gene that is associated with hyperactivity in mice ($p=2.026E^{-22}$)

Association mapping

- Cuts the study cohort down to include only retrievers of USA “type” by the MDS plot
- Looks at characteristics enriched in the retrieving elite dogs
- Cut down cohort only includes 25 USA-type dogs so p-values are more modest

Association mapping

- Mechanosensitivity

  (p_{raw} = 1.502e-08)|(p_{genome}= 0.03)

  The haplotype includes a coding variant predicted to be damaging to the protein in the underlying gene

- Stress response

  (p_{raw} = 2.772e-08)|(p_{genome}= 0.09)

  In particular there is a gene at this locus that shares a stress response pathway with one identified in the admixture analysis.

Association mapping

Mice that have been bred for different levels of acoustic startle and depression have different expression of the associated gene.

Springer JOURNAL OF MOLECULAR NEUROSCIENCE
springer.com

J Mol Neurosci. 2013 May; 50(1): 33–57. PMCID: PMC3622021
Published online 2012 Jul 27. doi: 10.1007/s12031-012-9850-1

Effects of Chronic Stress on Prefrontal Cortex Transcriptome in Mice Displaying Different Genetic Backgrounds

Pawel Lisowski, Marek Wieczorek, Joanna Goscik, Grzegorz R. Juszczak, Adrian M. Stankiewicz, Lech Zwierzchowski, and Artur H. Swiergiel

Retrieving summary

- Variants uncovered depend on the hypothesis
- Admixture (USA-type superiority) compares USA-ancestral alleles with Australian derived
- Association looks for elite family specific differences relative to other USA-type dogs
- Work is ongoing/preliminary

Retrieving summary

- Admixture mapping reveals regions associated with:
  - Adiposity
  - Stress response
  - Olfactory axon guidance

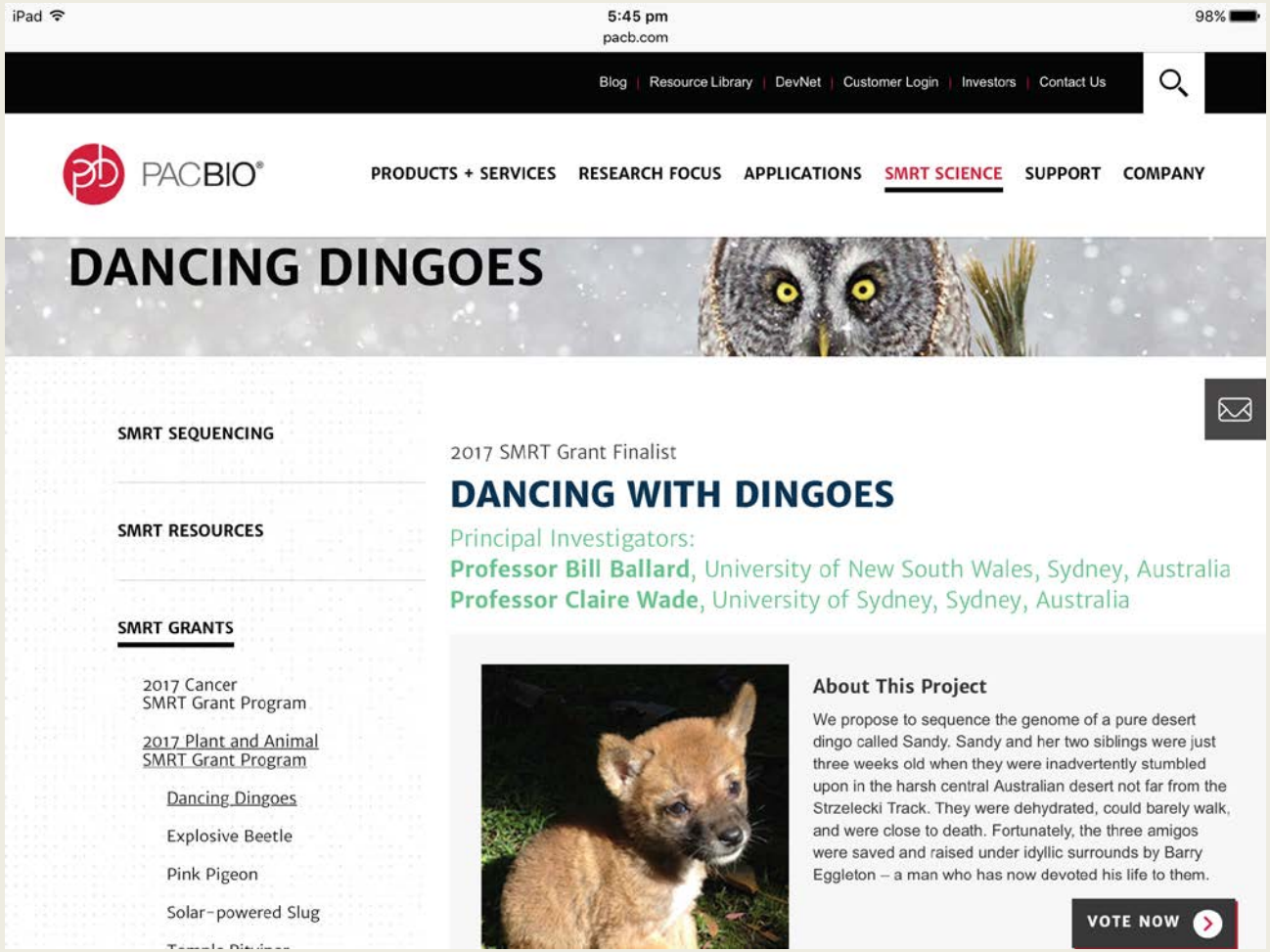
- Association (analysis restricted to dogs of USA-type) reveals regions associated with:
  - Mechanosensitivity
  - Stress sensitivity including acoustic startle (one gene in the same family as a gene in the admixture analysis)

Retriever project summary

- We are expanding the families to be sampled
- We are excited by the findings thus far
- We are mutation screening in the implicated regions and will validate these in a wider cohort before trying to publish

Please vote for our international competition entry to sequence the Australian Dingo

http://www.pacb.com/smrt-science/smrt-grant/pag2017/dancing-dingoes/



Acknowledgements

Dog community

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BIANCA WAUD (HAASE)

Retrieving Photos: Al Dodge