Conservation Dogs & Invasive Fish

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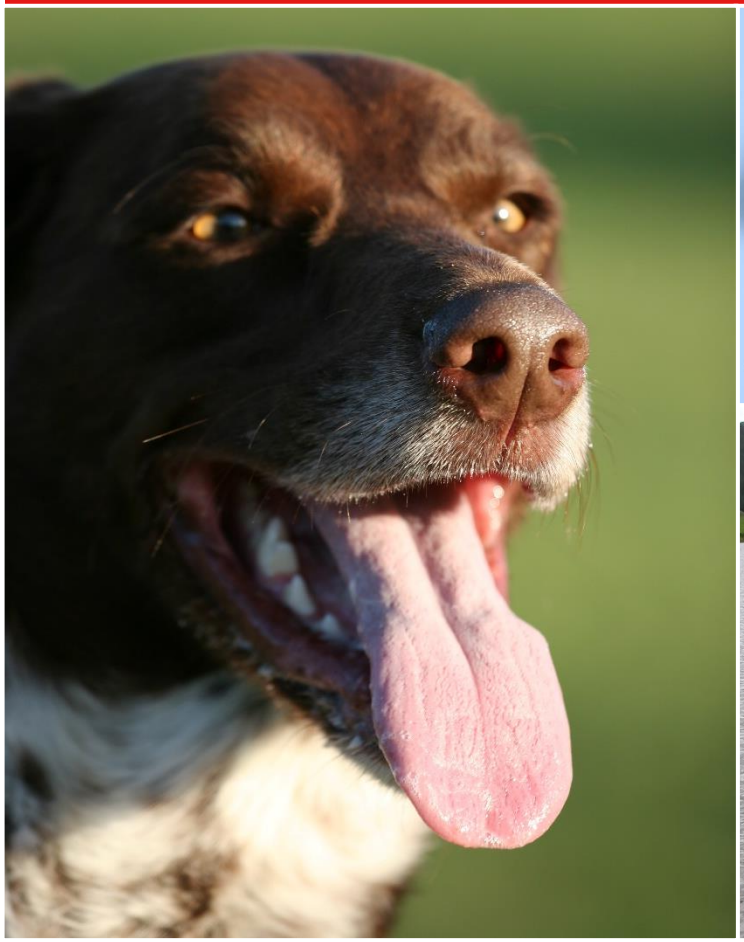

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Introduction

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I will introduce you some of the research being done at the University of Waikato on **conservation detection dogs**.

- Invasive fish.
- Future plans.

Other relevant research:

- Dogs' responses to different kiwi odours.
- Lung cancer detection with dogs.

https://www.tvnz.co.nz/shows/sunday/innovate---new/sniffing-out-lung-cancer

Introduction

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Detection dogs are a well-established conservation and biosecurity tool.

- Conservation dogs have been used in NZ since 1890s.
- Search for a wide range of terrestrial species.
  - E.g., protected birds and reptiles; invasive mammals, invertebrates, and plants.
  - Limited aquatic targets.

https://www.youtube.com/watch?v=VnFTzH1IjmU

https://www.youtube.com/watch?time_continue= 118&v=19NBYCdOl_U

Invasive Fish in NZ

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Fig. 2

Fig. 3

Fig. 4

Fig. 4

Invasive Fish in NZ

Introduced fish comprise ~30% of NZ's fish species, and some are widespread.

Koi carp
(*Cyprinus carpio*)

Catfish
(*Ameiurus nebulosus*)

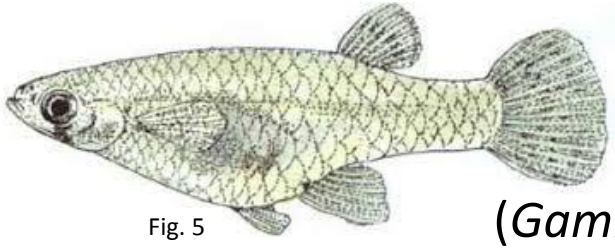
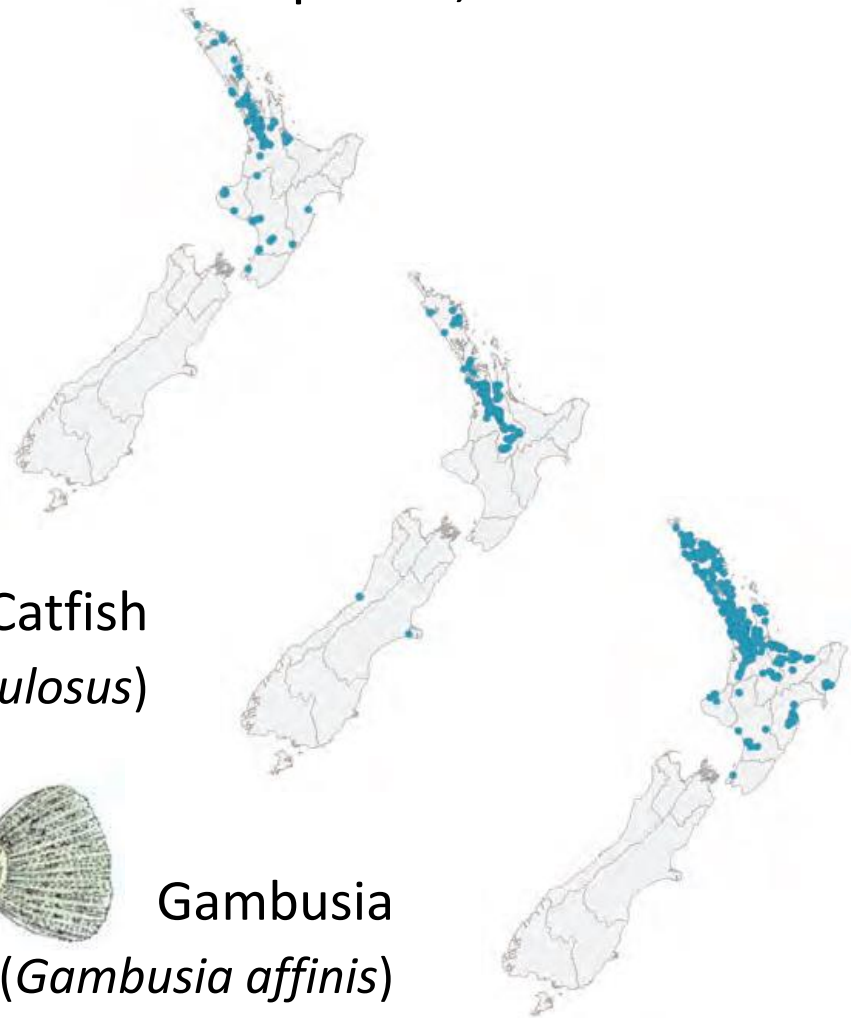


Fig. 5

Gambusia
(*Gambusia affinis*)



Invasive Fish in NZ

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Invasive fish are associated with **habitat degradation** and **loss of biodiversity**.

- **Declining water quality** – resuspension of sediments, dislodging roots of macrophytes, undermining banks.
- **Competing** with, and **preying upon**, **native** species.

Koi carp have invaded 65% of lowland North Island lakes

Reducing spread is a priority

Early detection methods are crucial – eradication is easier and cheaper

Detection Options

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Current methods of detecting these fish are limited by cost and sensitivity.

- Electro-fishing and netting – expensive and time-intensive.
- Environmental DNA (eDNA) – promising, but also expensive.

Fig. 6

Aim of This Research

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Aim: examine if dogs can detect invasive fish from water samples.

- This is laboratory-based research.

Research questions:

- Can dogs detect koi carp odour?
- Can dogs detect koi carp at biologically relevant levels?
- Can dogs discriminate between koi carp and other fish?

Jesse Quaife looked at these questions for his Master's project

Method

Our subjects are pets (N = 5).

- Visit our lab on their 'work days'.
- Trained by us.

Advantages:

- Low cost.
- No issues involved re. housing dogs.
- Provides enrichment for the subjects.
- Promotes community engagement.

Mica

Luna

Ruby

Vincent

Louis

Method

Water samples were collected from aquaria.

- **Positive samples** = from aquarium containing **koi carp**.
- **Negative samples** = from **water-only** (control) aquarium, or aquaria containing **catfish** or **goldfish**.

Fig. 7

Fig. 8

Method

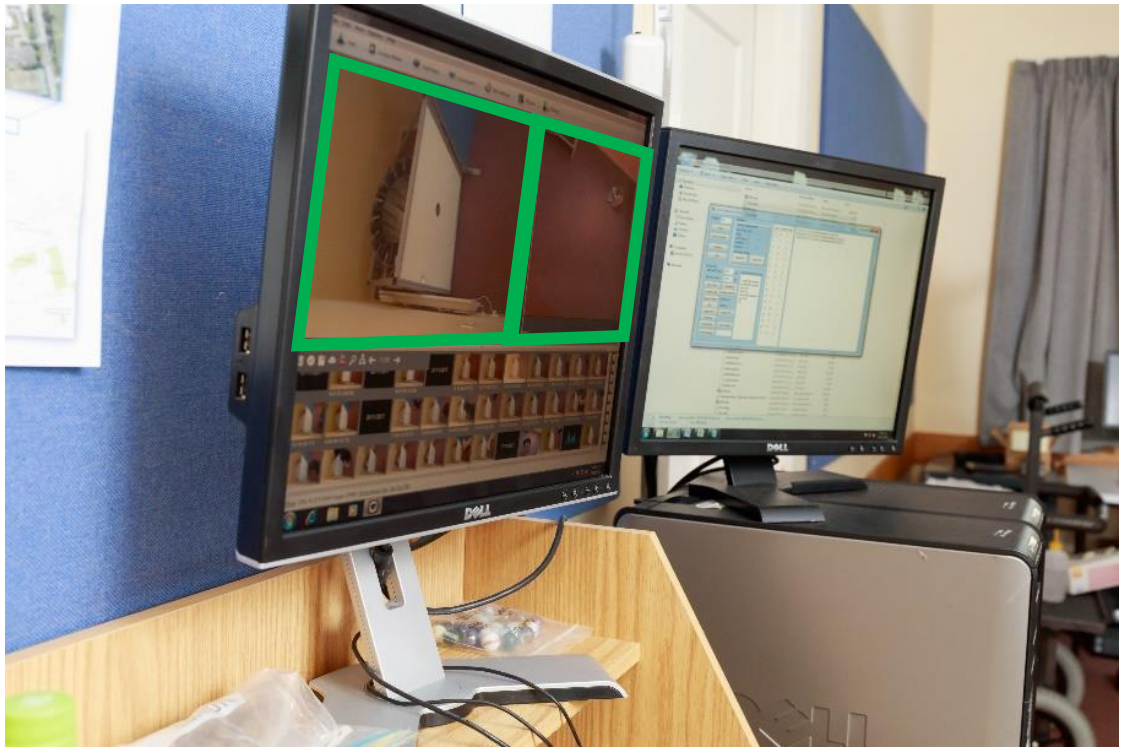
Dogs were trained to use an automated scent detection apparatus, in which water samples were presented.

- 17-segment carousel, rotates behind a panel.
  - Has a sample port (allowing access to one segment/sample at a time) monitored by infrared beams, and a switch.

Method

Experimenters stand outside the room, observing via CCTV.

- Removes possibility for human cueing, judgement errors.



Method

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Dogs are very receptive to human communicative cues.

- Humans' attentional states influences dogs' behaviour (Call et al., 2003).
  - Dogs forbidden to eat food

tching, compared to

ned their back, was

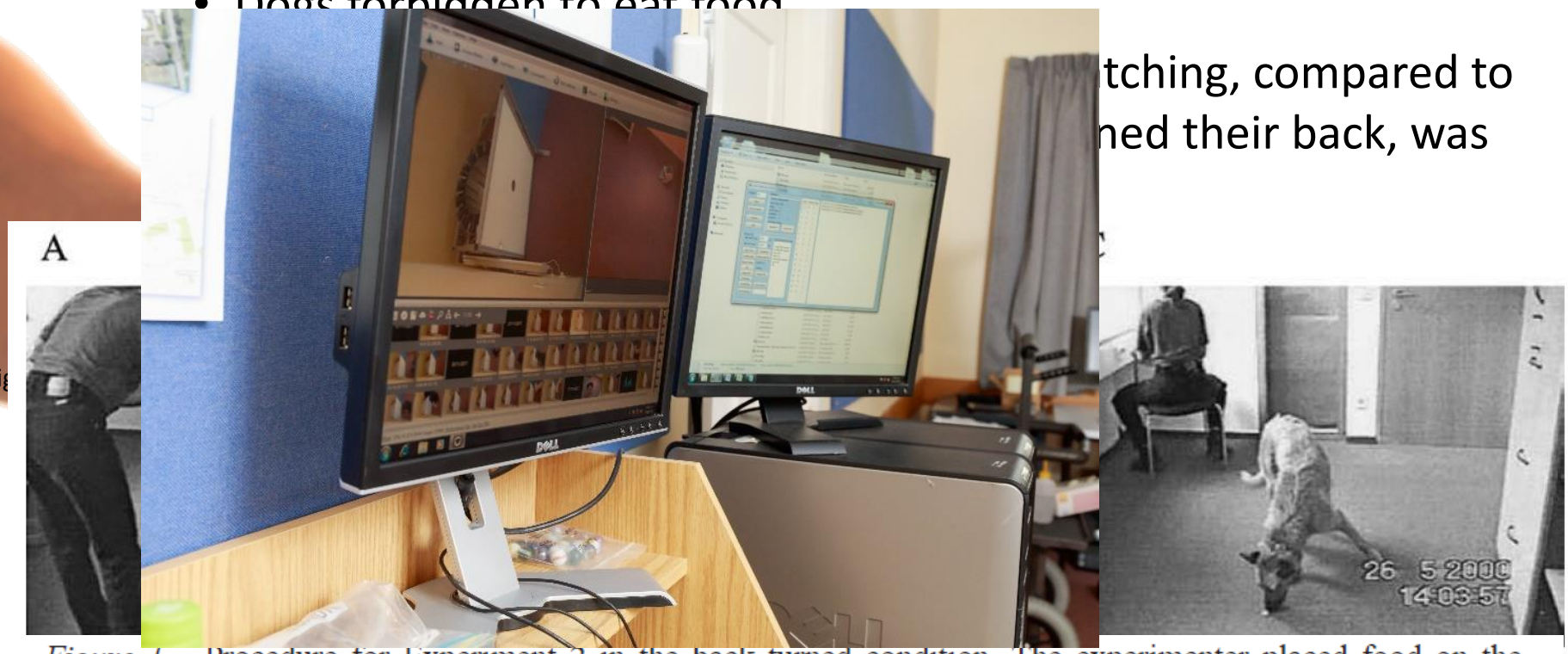


Figure 1. Procedure for Experiment 2 in the back turned condition. The experimenter placed food on the ground and forbade the dog to take it (A) and then sat on a chair with her back turned to the dog (B), and the dog took the food (C).

Method

This is relevant to scent-detection dogs.

Lit et al. (2011), Handler beliefs affect scent detection dog outcomes.

Series of short tests with drug- and explosives-detection teams.

No target scent was present.

- When the researchers influenced the handlers' beliefs (i.e., 'indicated where the targets were'), this influenced performance.
- Why?
  - Handler error.
  - The Clever Hans effect.

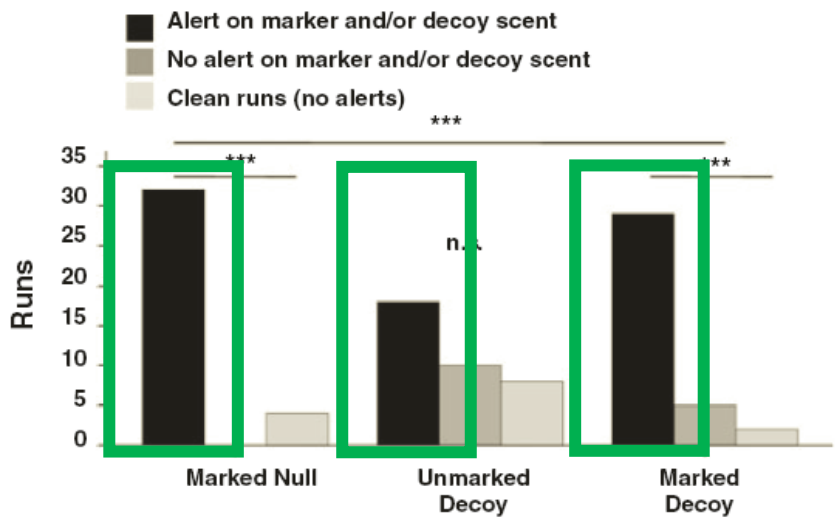


Fig. 2 Runs within each condition (combined $n = 36$) with alerts including marker and/or decoy scent (*black bars*), not including marker and/or decoy scent (*dark gray bars*), or clean runs (*light gray bars*). Asterisks represent statistically significant differences between groups as shown by log likelihood (across all conditions) and chi-squared test (within conditions); $***P < 0.001$; n.s. not significant

Method

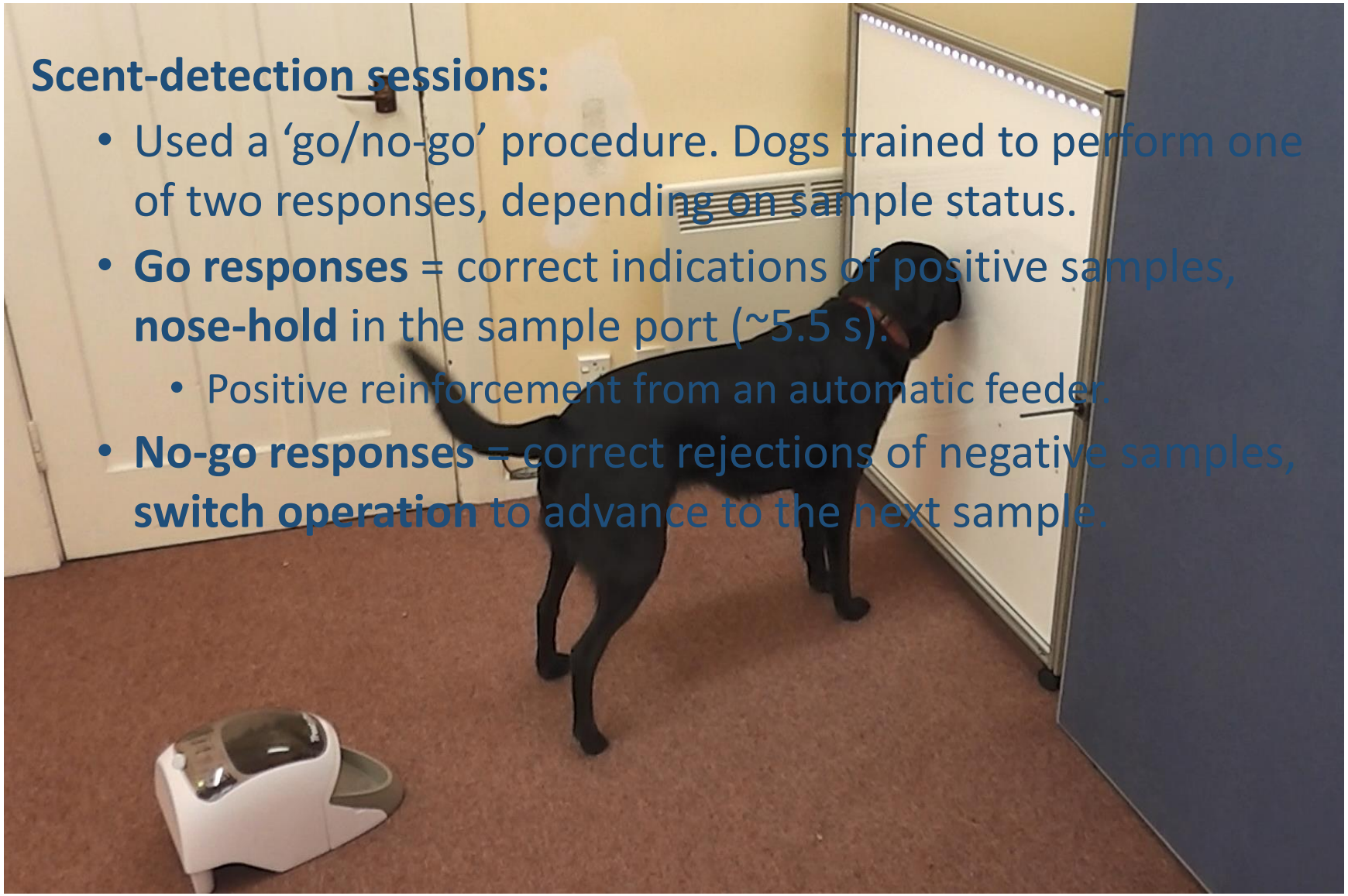
Training involved all segments containing positive samples at first.

- Then 9:8, positive:negative.
  - Every second sample was negative.
- Finally 7:10, positive:negative.
  - To avoid satiation, and encourage discrimination.

Each session was two full rotations (i.e., 34 samples assessed).

- Sample order was re-randomised in between sessions.
- Each session ≈ 5 min.

Method



Scent-detection sessions:

- Used a ‘go/no-go’ procedure. Dogs trained to perform one of two responses, depending on sample status.
- **Go responses** = correct indications of positive samples, **nose-hold** in the sample port (~5.5 s).
  - Positive reinforcement from an automatic feeder.
- **No-go responses** = correct rejections of negative samples, **switch operation** to advance to the next sample.

Method

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Example of dogs working with the apparatus.

Method

Success criteria included ≥80% accuracy across all samples, for four consecutive sessions.

- Move on to the next phase.

Calculated measures for detection of koi carp odour:

- Sensitivity: probability of correctly identifying a true positive.
- Specificity: probability of correctly identifying a true negative.

Results: Acquisition & Dilutions

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Dogs can detect koi carp from water samples.

Dogs can also detect koi carp in very diluted samples:

- 37.4 kg/ha.

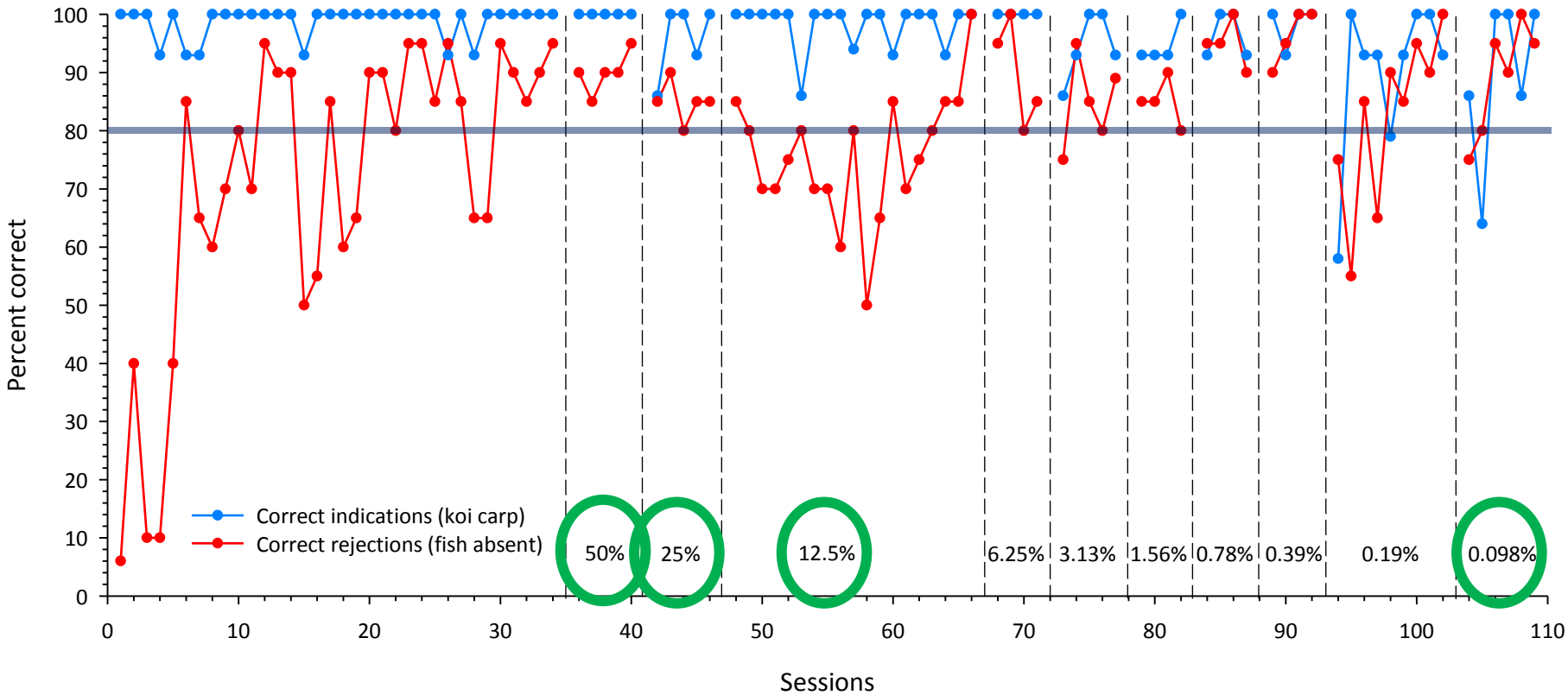

Figure 1. Example of one dog's data, showing acquisition of koi carp odour detection to performance criteria, and the dog's accuracy across systematic dilutions of koi carp water samples.

Results: Acquisition & Dilutions

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With **koi carp samples vs. fish absent samples**, the dogs' (N = 5) average detection of koi carp:

- Sensitivity = 97.5%, specificity = 92.3%.

With **koi carp samples diluted to equivalent of 37.4 kg/ha vs. fish absent samples**, the dogs' (N = 3) average detection of koi carp:

- Sensitivity = 97.0%, specificity = 90.8%.
- Equivalent to one koi carp in an Olympic-sized swimming pool.
  - High performance at lower dilutions also (data not presented).

Fig. 5

Results: Acquisition & Dilutions

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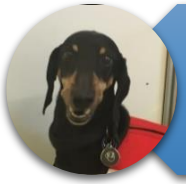
Two dogs were withdrawn (N = 3).

- Vincent's performance didn't meet criteria.
  - 25 sessions.
- Louis became less motivated to work; he turned out to have a food allergy.
  - Required special diet.

Mica

Luna

Ruby



Vincent

Louis

Results: Discrimination, Catfish

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Dogs can discriminate between the odours of koi carp and **catfish**.

- Water samples of both species were diluted to 0.098%.

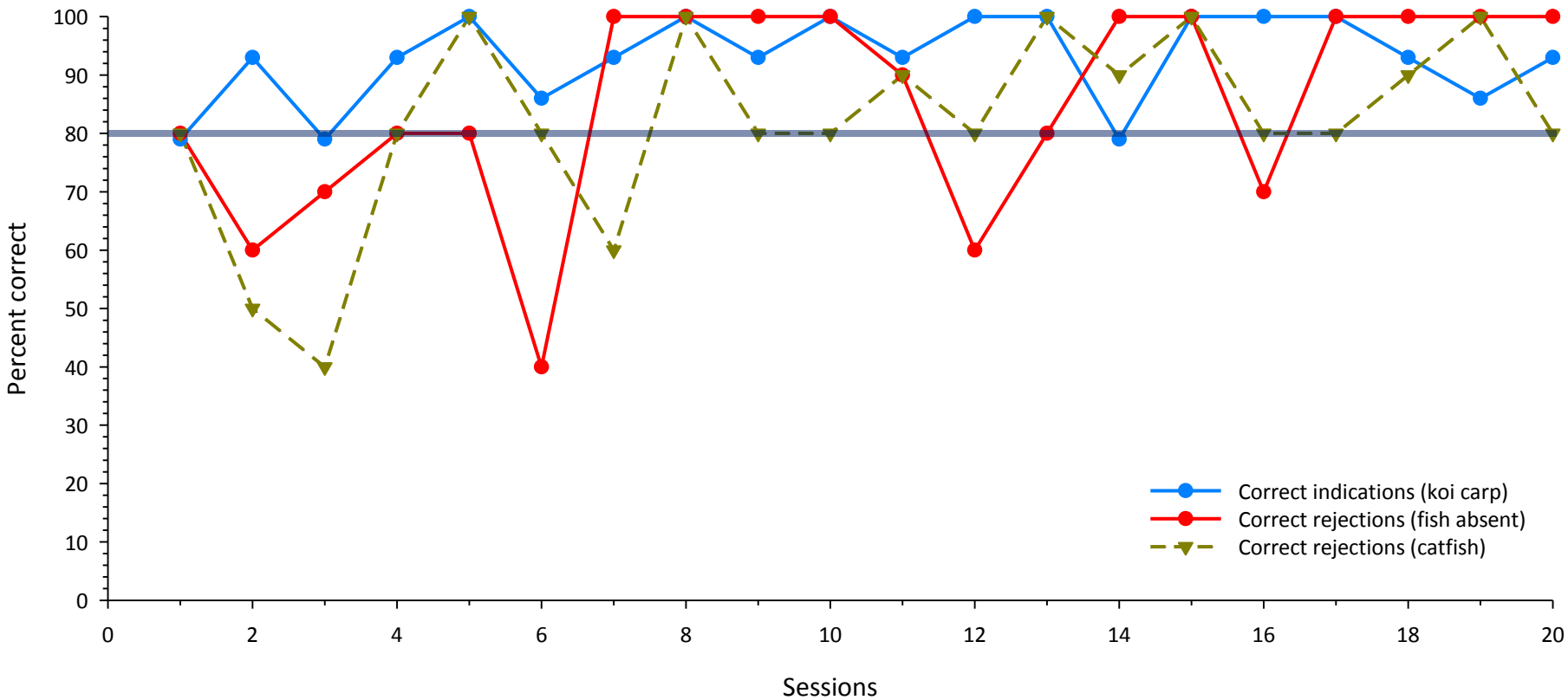

Figure 2. Example of one dog's data, showing the dog's accuracy at detecting koi carp odour in the presence of fish-absent water samples and catfish water samples.

Results: Discrimination, Goldfish

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Dogs can discriminate between the odours of koi carp and **goldfish**.

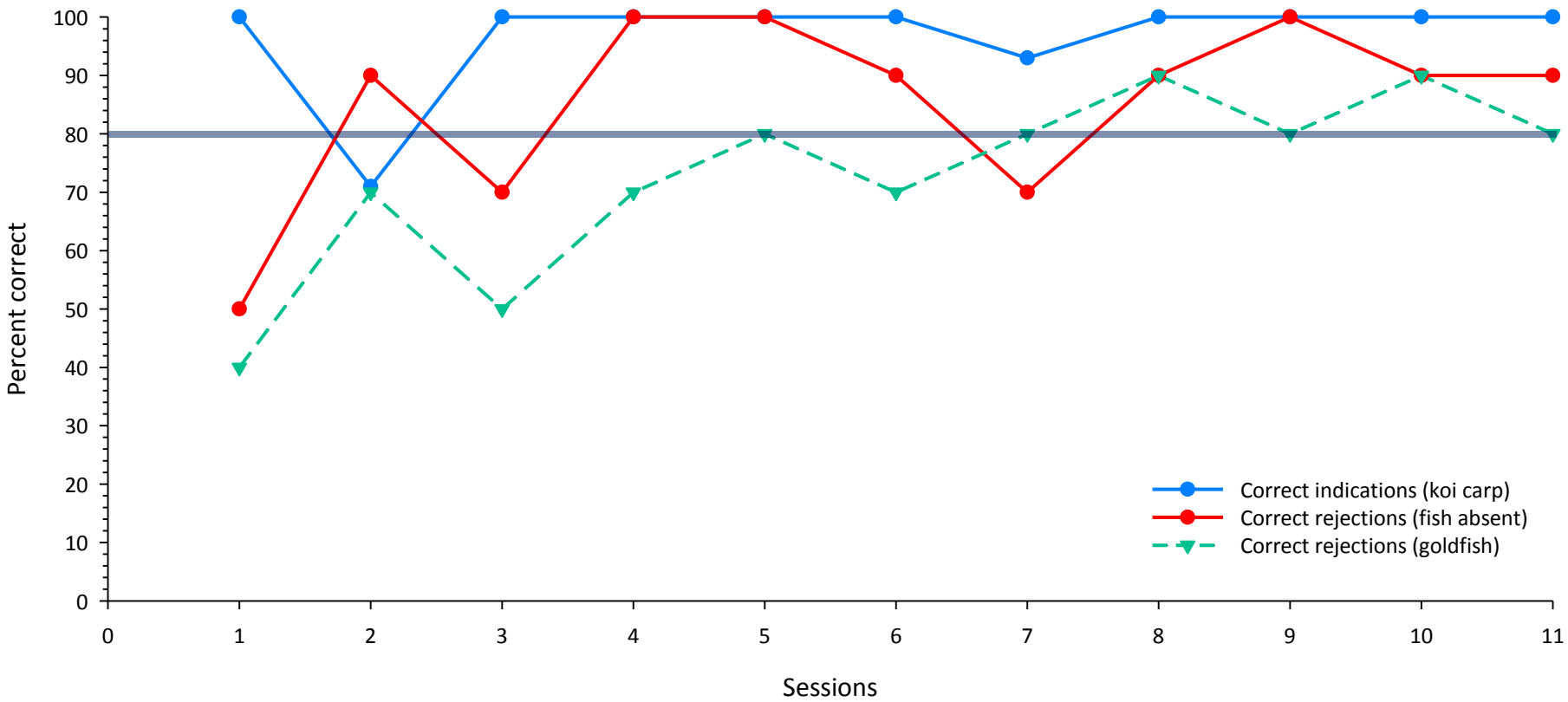

Figure 3. Example of one dog's data, showing the dog's accuracy at detecting koi carp odour in the presence of fish-absent water samples and goldfish water samples.

Results: Discrimination, Catfish & Goldfish

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With **koi carp vs. fish absent and catfish samples**, dog's (N = 3) average detection of koi carp:

- Sensitivity = 96.4%, specificity = 92.1%.

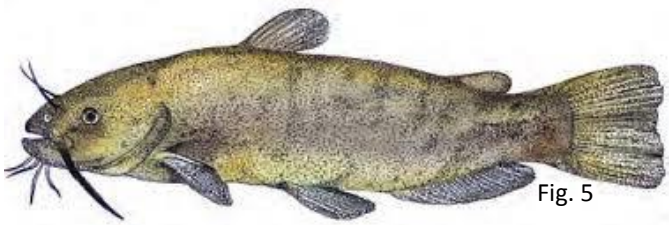

Fig. 5

With **koi carp vs. fish absent and goldfish samples**, dogs' (N = 3) average detection of koi carp:

- Sensitivity = 98.8%, specificity = 92.5%.

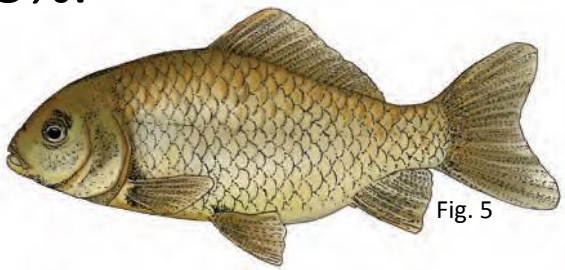

Fig. 5

Discussion

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This study demonstrates the potential use of dogs for this task.

- Dogs can detection koi carp at biologically significant dilutions - equivalent to biomass density of 37.4 kg/ha.
  - Population density of ~50 kg/ha is when koi carp start impacting ecosystem integrity. So detection of these fish at this density is useful (in terms of management/removal).
- They can discriminate between species of fish.
- Dogs are **more sensitive** and **cheaper** than other detection methods.
  - Including eDNA (40x).

Discussion

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Dogs can offer a novel biosecurity detection system with **greater accuracy** and **lower costs** than current methods.

Approximate costs of monitoring a site (e.g., a lake), NZD:

Boat electrofishing	Fyke net surveys	eDNA	Detection dogs
$1,500	$800	$780	**$100**

(Based on 500 samples/year throughput with the dog system.)

Discussion

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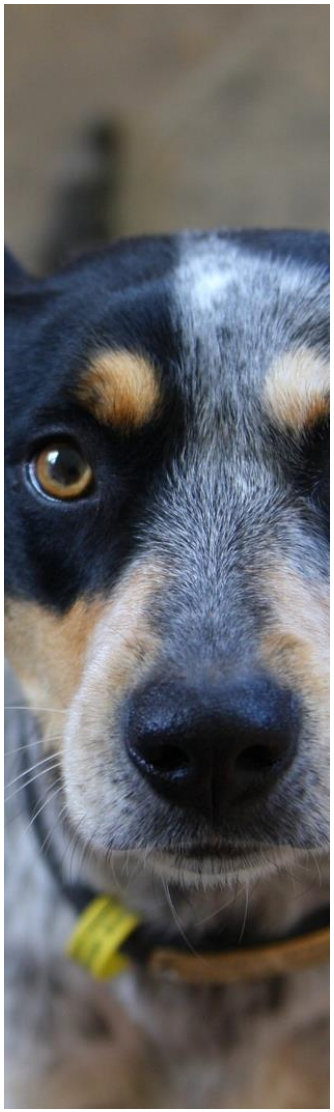
Future research:

- Progressing to field-sourced (natural) water samples.
- Comparing dogs' detection performances to eDNA.

- Volatile organic compound analyses to inform training protocols and detection results.
- Other species/detection problems.

Acknowledgements



Thanks to:

- **Dog owners and their dogs.**
- **Co-authors, esp. Jesse Quaife.**
- **The University of Waikato.**
- **Stakeholders supporting this project.**

Image credits:

- Fig. 1: https://exploringkiwis.com/why-new-zealanders-are-called-kiwis/
- Fig. 2: https://www.newzealand.com/int/plan/business/solitaire-lodge/
- Fig. 3: https://www.newzealand.com/int/plan/business/fearless-sail-lake-taupo/
- Fig. 4: https://www.bluelaketop10.co.nz/legend-of-the-blue-lake
- Fig. 5: Collier, K. J., & Grainger, N. P. J. (2015). Introduction to invasive fish. In K. J. Collier & N. P. J. Grainger (Eds.), *New Zealand invasive fish management handbook* (pp. 3-6). Hamilton, New Zealand: Lake Ecosystem Restoration New Zealand (LERNZ; the University of Waikato) & Department of Conservation.
- Fig. 6: https://www.dia.govt.nz/Motuoapa-Marina-Fish-Salvage
- Fig. 7: https://www.radionz.co.nz/national/programmes/ourchangingworld/audio/2018633888/dogs-that-sniff-out-pest-fish
- Fig. 8: http://www.cospak.co.nz/h1367.html

Thank You

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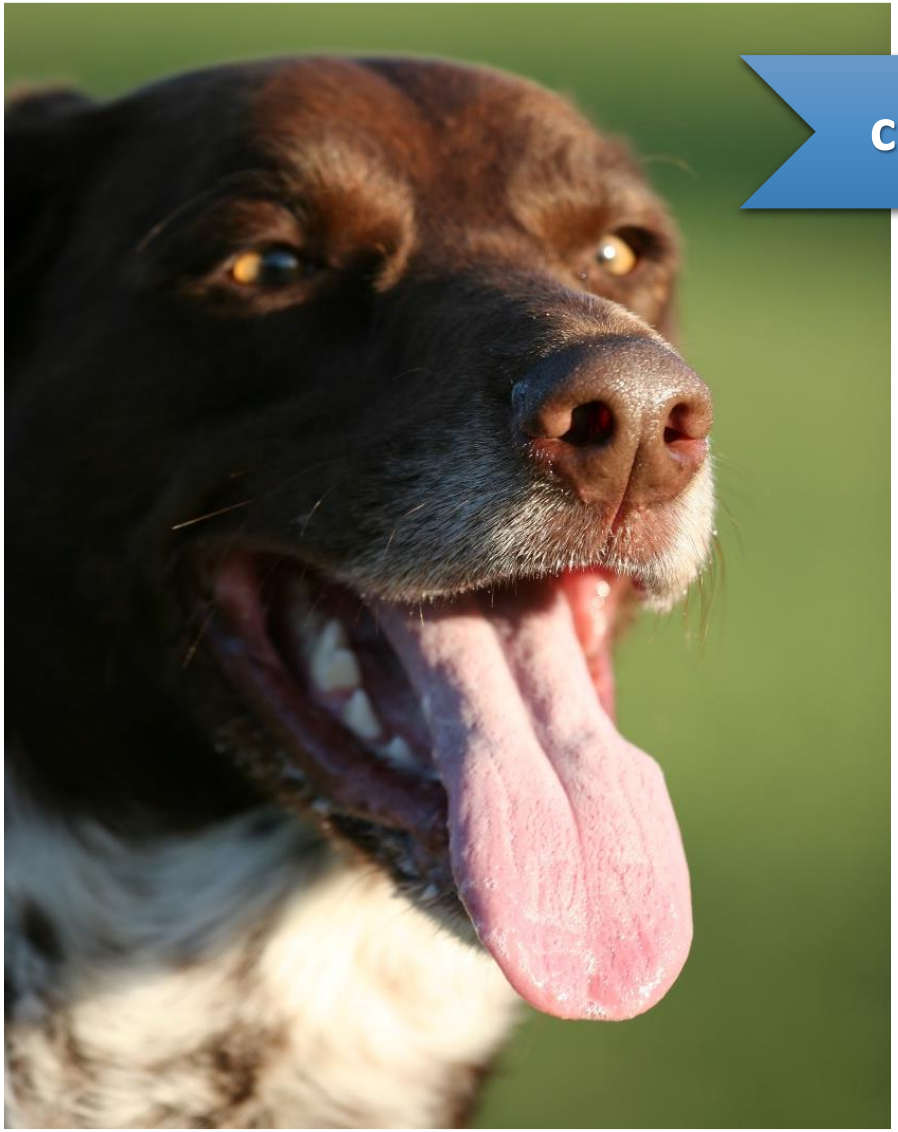

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