Animal personality, swimming and migration

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Leiden 2015

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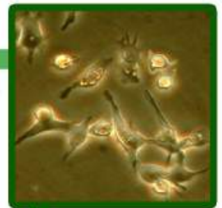
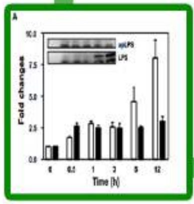
CELL CULTURE

MACROPHAGE BIOLOGY
PAMP-PRR INTERACTION

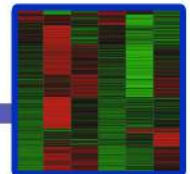




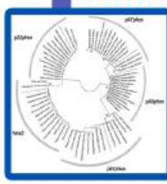
ENDOTOXIN

PEPTIDOGLYCANS

Host Pathogen



TRANSCRIPTOMICS
RNA-Seq, oligoARRAY



RNA-Seq

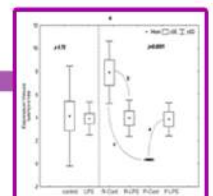
Oligoarrays

Nanotechnology

IMMUNO-
MODULATION

Formulation

Fever



BEHAVIOUR
AND IMMUNITY

Stress Coping
Styles

Dr Simon MacKenzie
Marine Biotechnology
Institute of Aquaculture
University of Stirling, UK

evolutionary immunology

ibb

NanoCee

SELECTED RECENT PUBLICATIONS

Morera *et al. J Fish Biol.* 2015
Rey *et al. Proc R Soc: Biol Sci.* 2015
Callol *et al, PLoS One.* 2015
Rey *et al. Zebrafish.* 2015
Valtanen *et al. Autophagy.* 2014
Pereiro *et al, PLoS One.* 2014
Jensen *et al.* J.Fish Dis. 2014
Boltaña *et al.Fish Shellfish Immunol.* 2014
Ruyra *et al. Vaccine.* 2014
Rey *et al. Mol Ecol.* 2013
Boltaña *et al. Proc R Soc: Biol Sci.* 2013

Group of Immunity and Evolution

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Chapman, B. B., Hulthen, K., Blomqvist, D. R., et al. (2011c).
To boldly go: individual differences in boldness influence migratory tendency.
Ecology Letters, 14, 871–6.

"Why do some individuals migrate and others stay resident?"

"There are various hypotheses to answer this contentious question, including evolutionary stable strategies, genetic differences or conditional differences. However, despite substantial theoretical work, data to test these or other hypotheses are scarce."

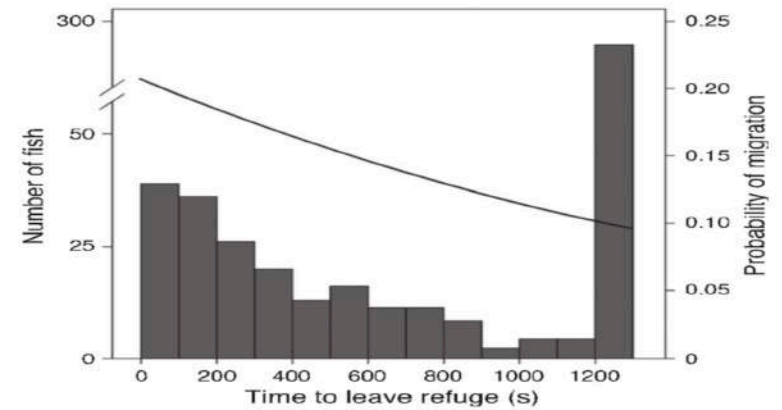


Figure 1 Distribution of boldness scores for fish assayed and tagged in 2009 and 2010, overlaid with the migratory probability of individuals for all boldness scores. Note that there is a high frequency of fish that had not left the refuge at 1200 s. These shy fish were given a ceiling value for analysis.

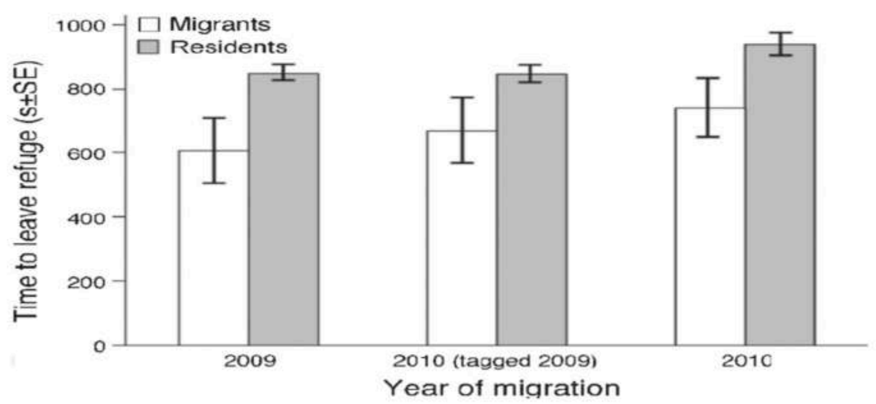
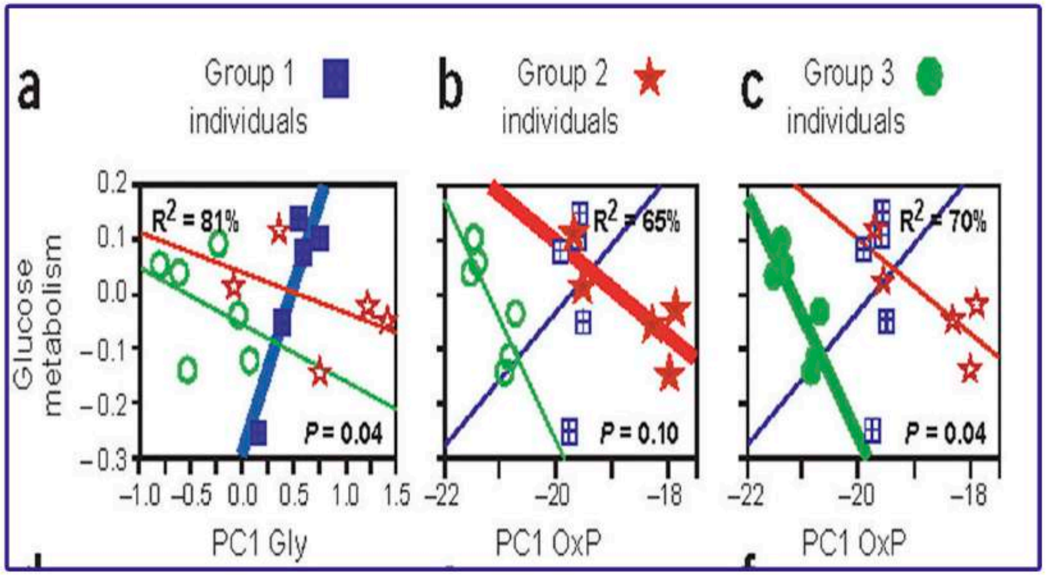


Figure 2 Mean time to leave the refuge (± SE) for migrants and residents in 2009 and 2010. Note that high scores denote shy fish.

Oleksiak *et al* (2002) Variation in gene expression within and among natural population. *Nat. Genet* 32:261–266
Oleksiak *et al* (2005) Natural variation in cardiac metabolism and gene expression in Fundulus heteroclitus. *Nat Genet* 37: 67-72
Crawford DL, Oleksiak MF. (2007) The biological importance of measuring individual variation. *J Exp Biol.*



Variation in metabolism-specific genes is higher within a population than between geographically distinct populations

Different individual patterns of gene expression correlate to physiological processes.

Failure to consider this type of biological variation can result in the misidentification of genes that merely represent standing genetic or natural biological variation as 'important'

Variation in physiological performance is related to the subtle variation in gene expression and that this relationship differs among individuals

Single-cell transcriptomics reveals bimodality in expression and splicing in immune cells.

Shalek *et al*, Nature,236 vol. 498,13 JUNE 2013.

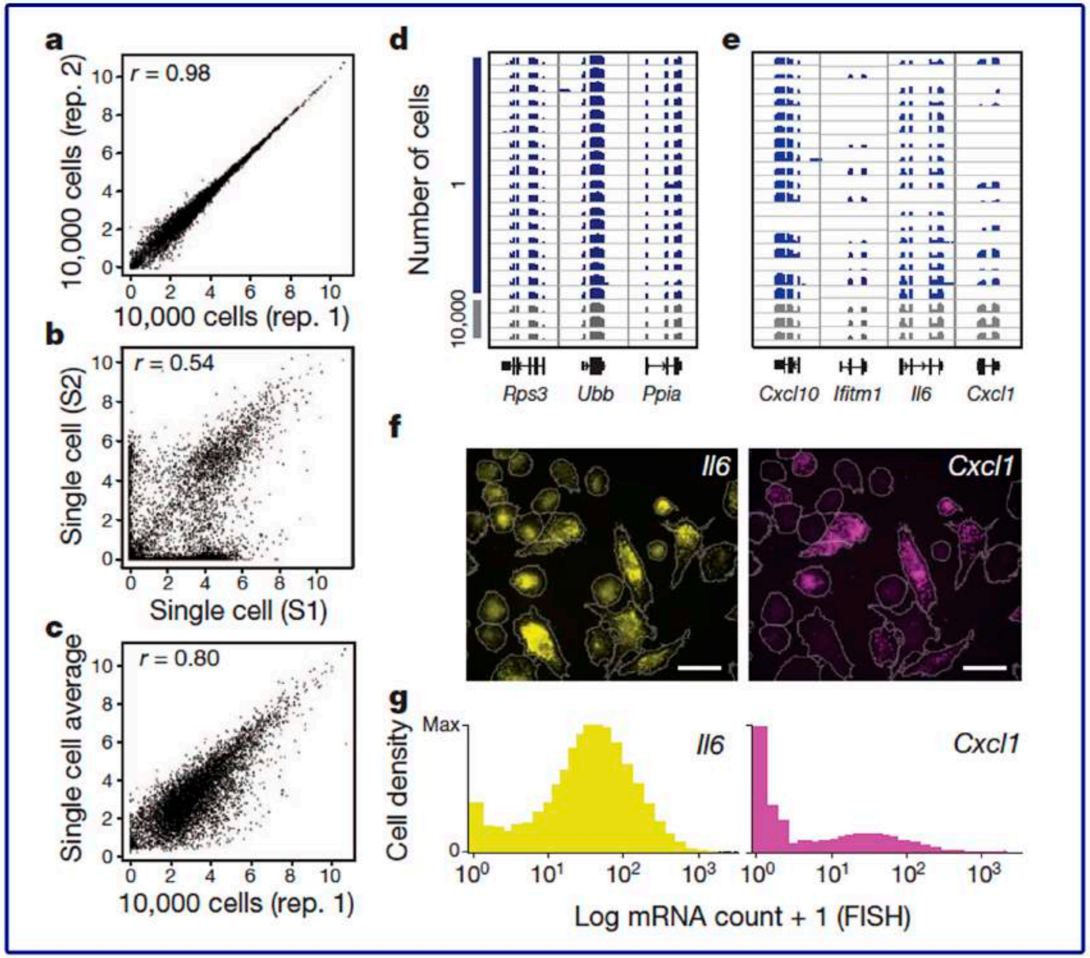


Figure 1 Single-cell RNA-Seq of LPS-stimulated BMDCs reveals extensive transcriptome heterogeneity.

Low input - High throughput - No output? Brenner 2010.Phil.Trans.Royal.Soc ∎

Variance

Expression heterogeneity due to technical, genetic, environmental, or demographic variables is common in gene expression studies.

In studying biological systems, we tend to think of groups as being defined by specific, measurable parameters, and the important differences between those groups are defined by a significant average difference.

Much of the language used to describe biological systems is based on this bias and we talk about genes being expressed in a tissue at a particular level, or about differences in gene expression between groups reflecting the mechanism driving their phenotypic differences.

Variance is not distributed randomly across signaling networks

Variance of Gene Expression Identifies Altered Network Constraints in Neurological Disease.
Mar *et al.* PLoS Genetics,
August 2011, Volume 7, Issue 8,
e1002207.

We understand that sequence variations in a gene may lead to phenotypic variations, but less well understood is how variation in the information flow itself might also impact on phenotype. (Connectivity, plasticity constraints)

Capturing Heterogeneity in Gene Expression Studies by Surrogate Variable Analysis.*Leek & Storey*. PLoS Genetics, September 2007, Volume 3, Issue 9, e161

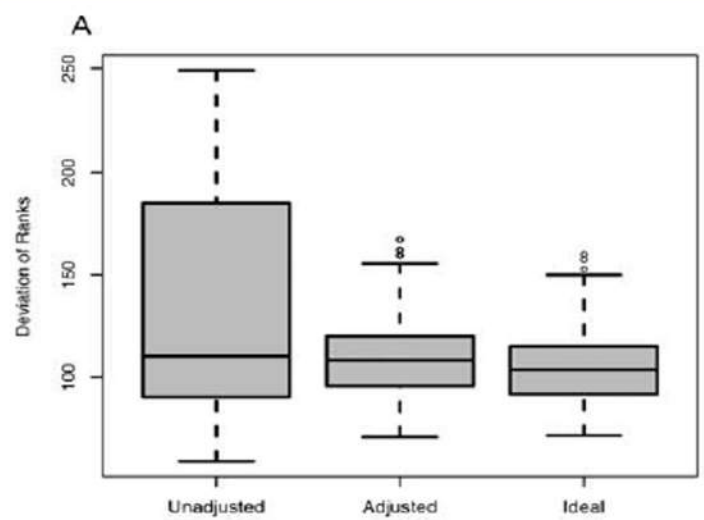


Figure 1. Impact of Expression Heterogeneity

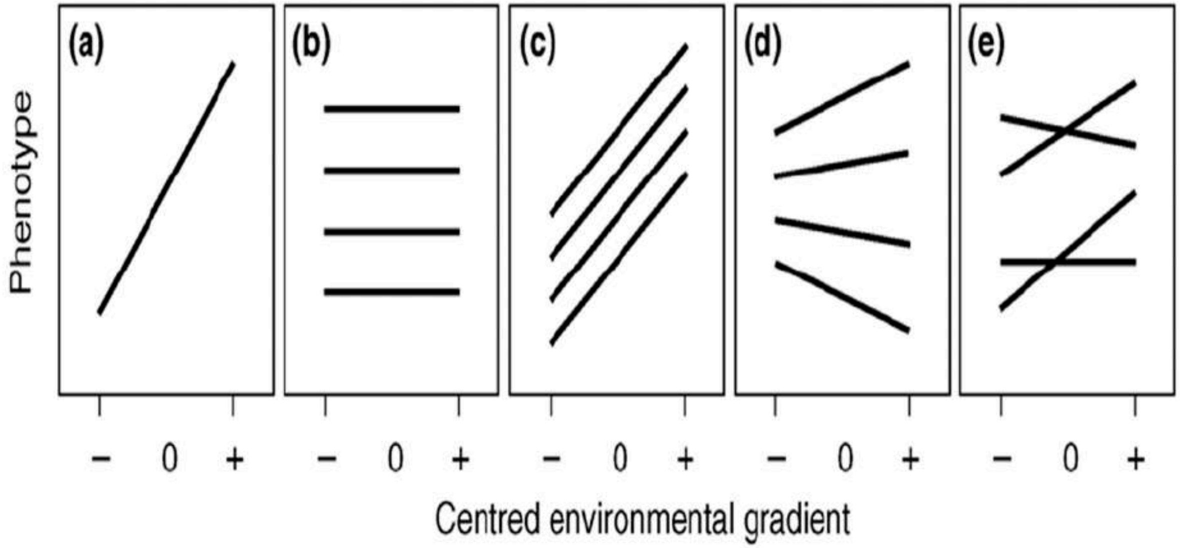
Gene x environment interaction (GxE)
environmental adaptation
in distinct genotypes

Dingemanse *et al* (2010) Behavioural reaction norms: animal personality meets individual plasticity. *Trends in Ecology & Evolution*, 25: 81-89

Sources of individual variation in RN elevation and slope

Genetic variation (G) genome variation affects phenotype

Gene x environment interaction (GxE) environmental adaptation in distinct genotypes



Permanent environment variance (PE); individual-specific variation (plasticity) (e.g.early-life conditions)

PE x environment (PxE) adaptation in PE individuals *(non-heritable)*

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Individual animals differ in their average level of behaviour displayed across a range of contexts (animal '***personality***'),and in their responsiveness to environmental variation (***plasticity***).
Dingesmanse et al, 2010, *Trends in Ecology & Evolution*, 25: 81-89

Life-history trade-offs favour the evolution of animal personalities.
Wolf *et al*, NATURE | Vol 447 | 31 May 2007.
Explorative behaviour and risk-related traits like ***boldness*** and ***aggressiveness*** are common characteristics of animal personalities

Personality: consistent individual behavior within the same situation and across different contexts.
We need to test for repeatability and consistency.
It's a continuous but we are interested on the extremes!

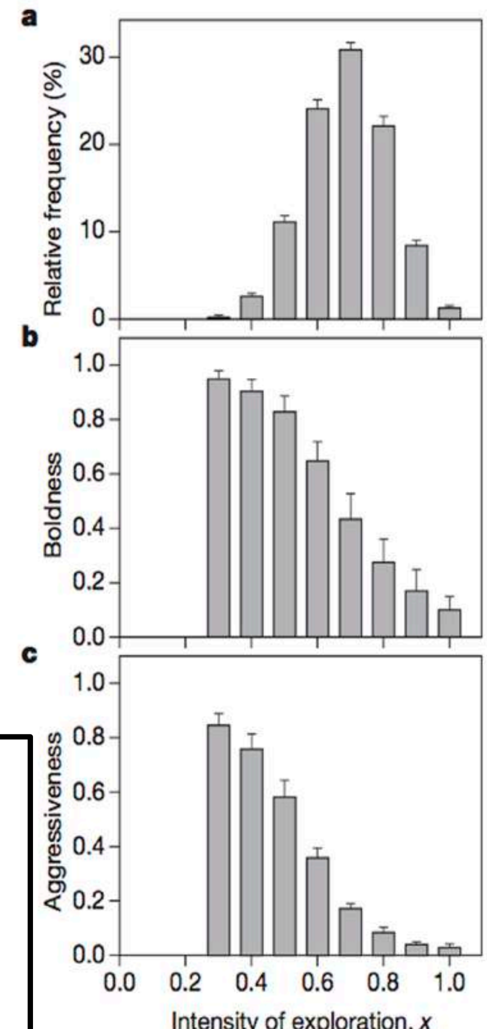

Figure 4 | Evolution of continuous variation in personalities. a, If all traits are encoded by multiple loci with small effects, disruptive selection on the exploration intensity *x* does not result in two discrete phenotype classes but in a broad distribution of exploration strategies. The graphs depict the average level of

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Wolf *et al*, NATURE | Vol 447 | 31 May 2007.

1

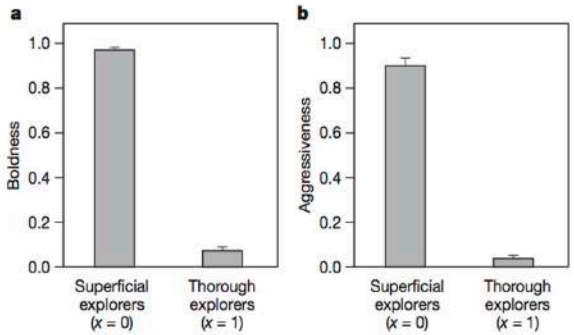


Figure 2 | Evolution of variation in risk-taking behaviour. The outcome of evolution after 3×10^5 generations of selection where individuals following the life cycle depicted in Fig. 1 play a single risky game between year 1 and year 2. **a**, In the case of an anti-predator game superficial explorers evolve high levels of boldness, whereas thorough explorers show low levels of boldness. **b**, In the case of a hawk–dove game superficial explorers are aggressive, whereas thorough explorers are non-aggressive. The bars correspond to mean trait values averaged over ten replicate simulations (error bars indicate standard errors).

3

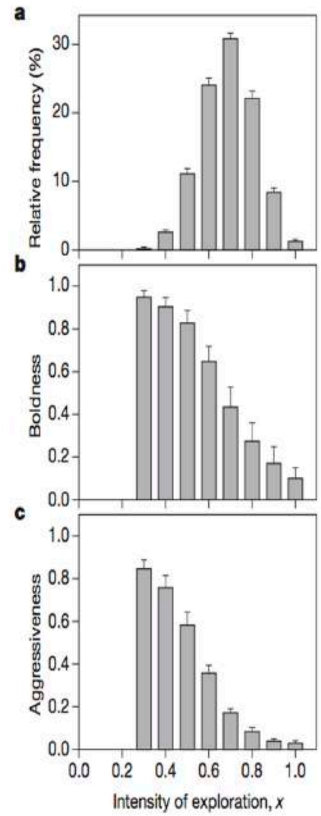
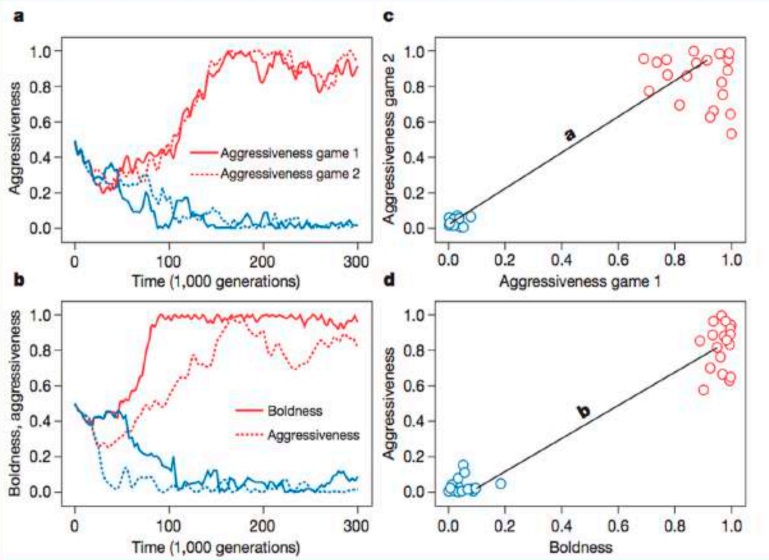


Figure 4 | Evolution of continuous variation in personalities. a, If all traits are encoded by multiple loci with small effects, disruptive selection on the exploration intensity *x* does not result in two discrete phenotype classes but in a broad distribution of exploration strategies. The graphs depict the average level of

2



An evolutionary ecology of individual differences.
Dall *et al*, Ecology Letters, (2012) 15: 1189–1198.

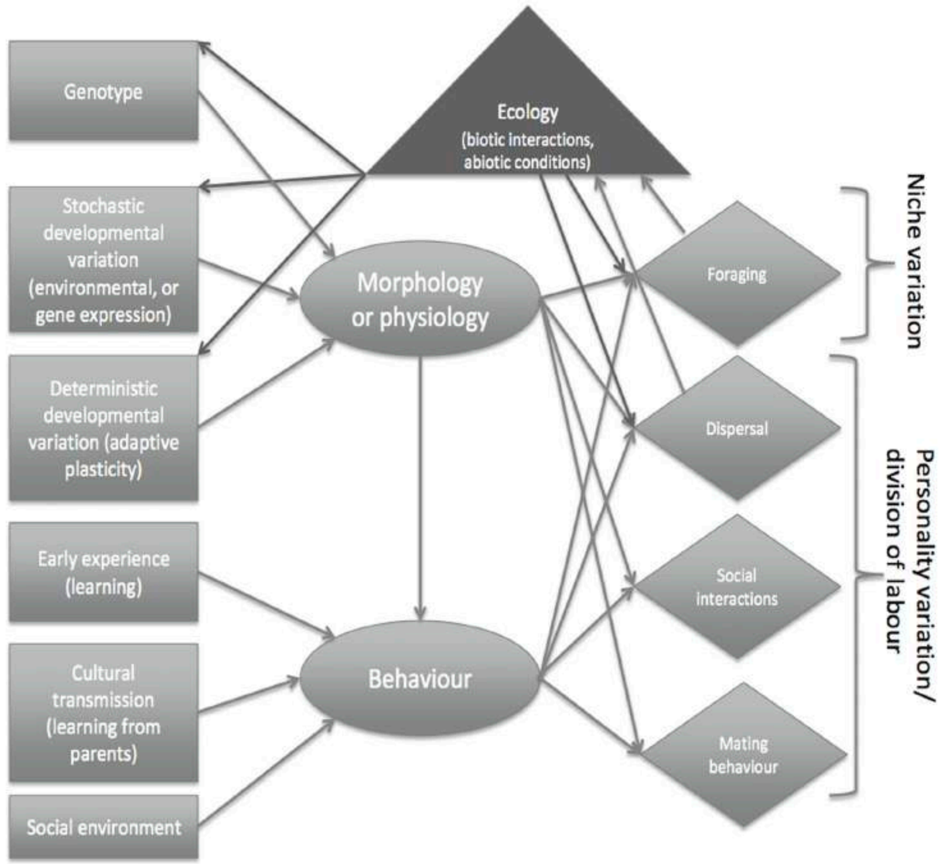


Figure 2 An evolutionary ecology of individual differences. The diagram illustrates how a complete understanding of individual differences must incorporate understanding of how basic biological factors/processes (rectangles: left-hand side) underpin the organismal features (ovals: middle) determining the behavioural specialisations that are the focus an evolutionary ecology of individual differences (kites: right-hand side). Ecological impacts and consequences (triangle) are linked to different levels of the framework, and influence evolutionary processes via links to genotypes. A key feature of this framework is that there is likely to be co-variation amongst the behavioural specialisations and so such links must be investigated explicitly.

Where's the immunology??

Coping Strategy

Table 1

The different gene–environment interactions in Hawks and Doves and the consequences for fitness depend heavily on their biological role in a population, the adopted behavioral strategy, the environmental context, food availability, and population cycle (see Sections 2.1–2.3)

	Hawk	Dove
Behavioral strategy	Fight–flight	Freeze–hide
Coping style	Proactive	Reactive
Emotional state	Aggressive and bold	Non-aggressive and cautious
Biological role	Establish territory or defend existing territory	Adopt strategy to avoid danger within territory, e.g. immobility
Exploration	Fast and superficial	Cautious and thorough
Behavioral flexibility	Rigid and routine-like	Flexible
Energy metabolism	High energy consumption	Energy conservation
Body damage (e.g. wounds, blood loss)	High risk	Low risk
Advantage according to food availability	When stable and abundant	During food scarcity
Advantage according to population cycle	When density is high	When density is low

Proactives vs Reactives

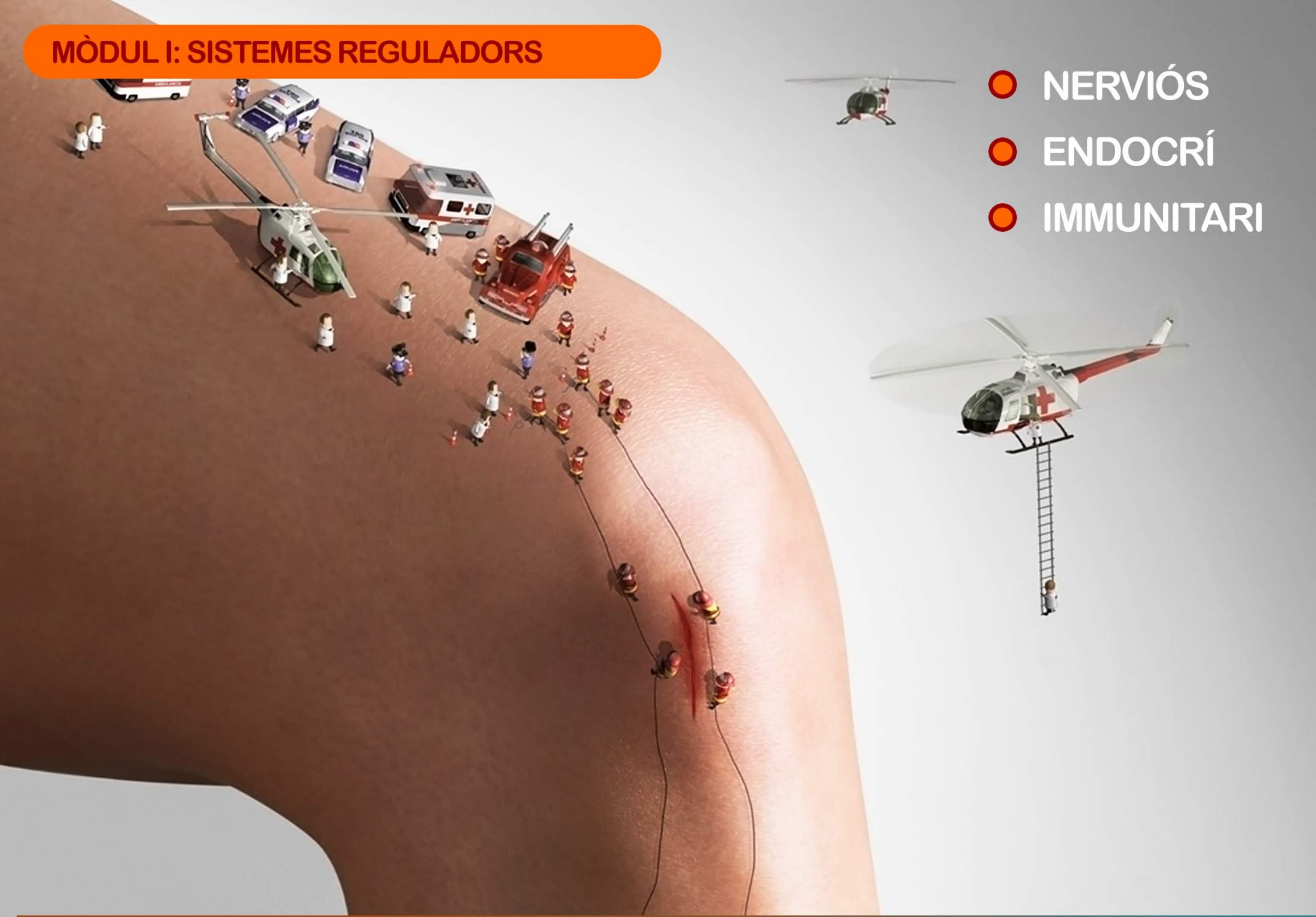
- Bold
- Aggressive
- Less exploratory
- Dominant
- Establish routine like behav.
- Faster learners
- Different physiological parameters under stress: lower corticoesterone/ cortisol levels, lower HPA/ HPI axis activity but higher sympathetic reactivity
- More resilient

- Shy
- Passive (submissive)
- More detailed exploratory
- Subordinate
- More flexible
- More time to learn
- Higher levels of corticoesterone/cortisol under stress, higher HPA/ HPI axis activity but higher parasympathetic activity
- http://www.youtube.com/watch?v=ZwW2vJ1we7c

Coping Strategy: Exploration

MÒDUL I: SISTEMES REGULADORS

- NERVIÓS
- ENDOCRÍ
- IMMUNITARI



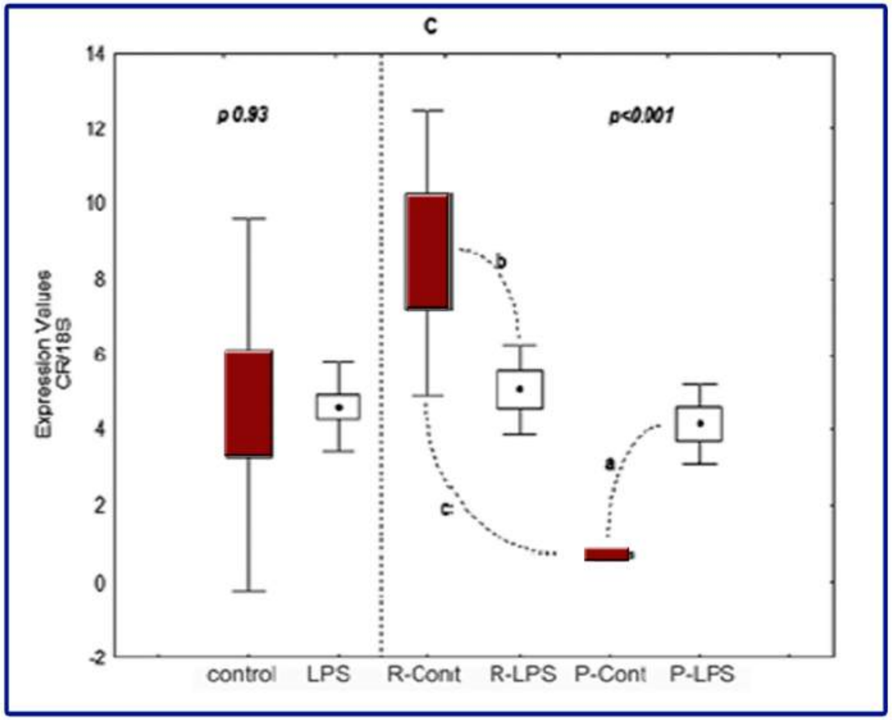
UAB
Dept. Biologia Cel.lular, Fisiologia i Immunologia
Unitat de Fisiologia Animal

Allostasis and the allostatic load

Adaptation in the face of potentially stressful challenges involves activation of neural, neuroendocrine and neuroendocrine-immune mechanisms. This has been called "allostasis" or "stability through change" and allostasis is an essential component of maintaining homeostasis. When these adaptive systems are turned on and turned off again efficiently and not too frequently, the body is able to cope effectively with challenges that it might not otherwise survive. However, there are a number of circumstances in which allostatic systems may either be overstimulated or not perform normally, and this condition has been termed "allostatic load" or the price of adaptation. Allostatic load can lead to disease over long periods. Types of allostatic load include (1) frequent activation of allostatic systems; (2) failure to shut off allostatic activity after stress; (3) inadequate response of allostatic systems leading to elevated activity of other, normally counter-regulated allostatic systems after stress.

Mackenzie et al (2009) Screening for coping style increases the power of gene expression studies. *PLoS ONE*, 4: e5314.

Cortisol receptor mRNA expression in the brain of carp, *C.carpio*, screened for Proactive/Reactive SCS.



Baseline mRNA abundance levels are different between Proactive and Reactive carp.

Response to challenge is diametrically opposed.

No screening would have led to a non-significant response.

Incorporating coping style as an explanatory variable can account for;
1.unexplained variation that is common to gene expression

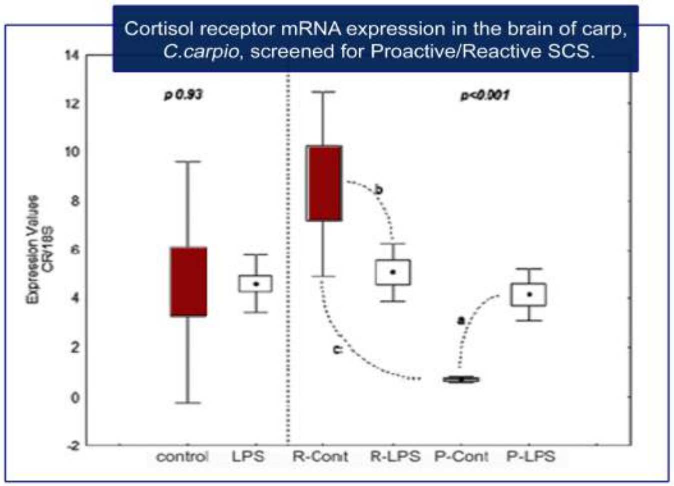
Behaviour, Variation and Immunity

Coping style/Personality

2010 MacKenzie S, Ribas L, Pilarczyk M, Capdevila DM, Kadri S, Huntingford FA. Screening for coping style increases the power of gene expression studies. ***PLoS One***. 2009;4(4):e5314

2010 Huntingford *et al.* Coping strategies in a strongly schooling fish, the common carp Cyprinus carpio. *J Fish Biol.* 2010 May;76(7):1576-91.

Intra-population Variation..



Baseline mRNA abundance levels are different between Proactive and Reactive carp.

Response to challenge is diametrically opposed.

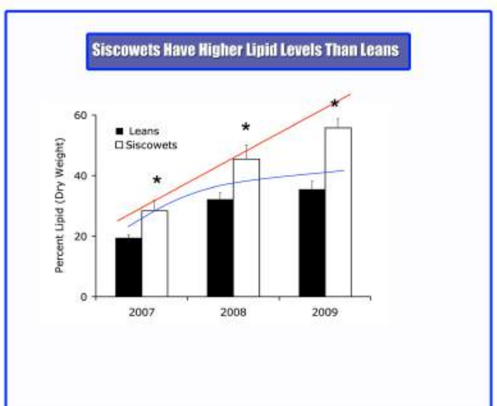
No screening would have led to a non-significant response.

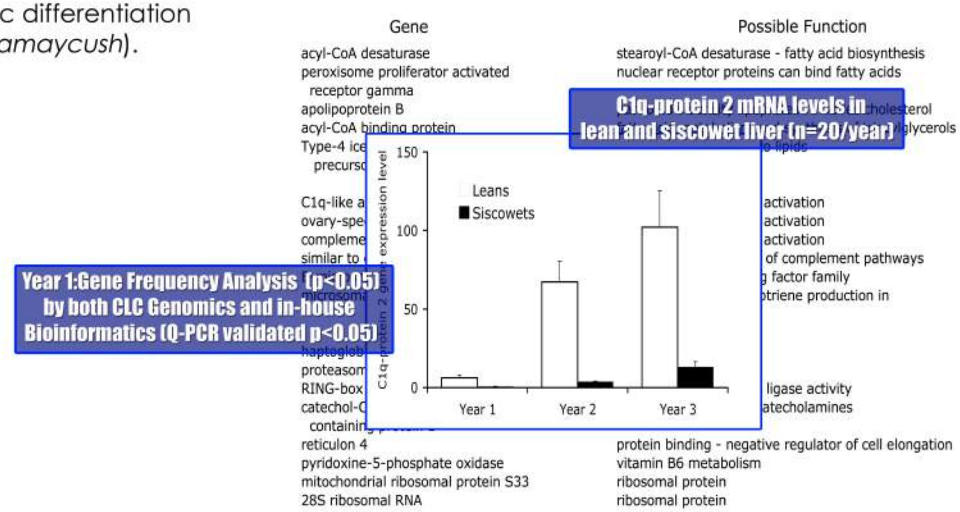
25%

2012 Boltana *et al.* Individual coping styles link unique transcriptome profiles to morphology and identify differences in neurobiological processes in the zebrafish (*Danio rerio*). *Mol Ecol*. ms prepared for submission July 2012.

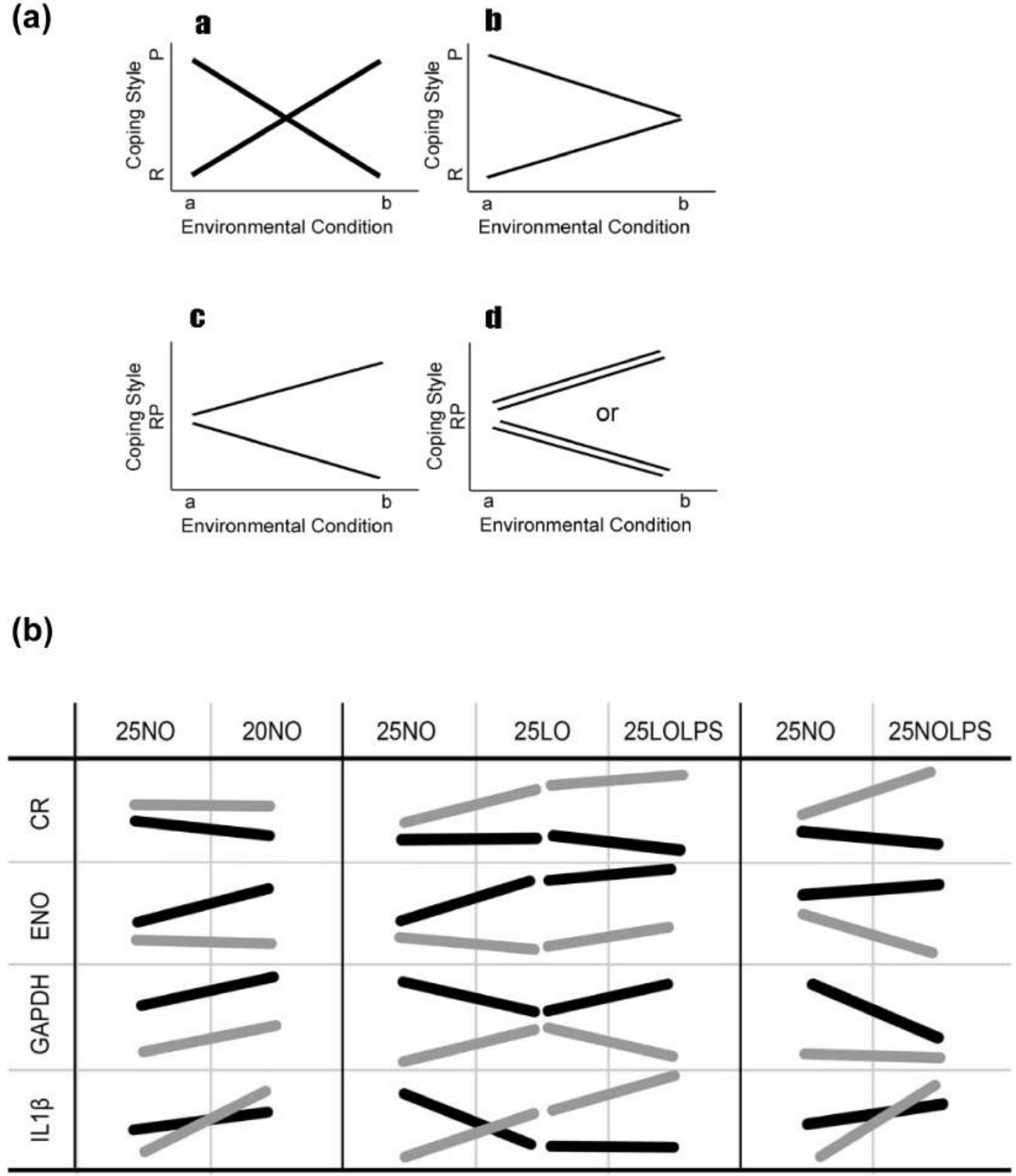
Inter-population Variation..

2010 Goetz *et al.* A genetic basis for the phenotypic differentiation between siscowet and lean lake trout (*Salvelinus namaycush*). *Mol Ecol.* 2010 Mar;19 Suppl 1:176-96.





Differential responses in common carp (*Cyprinus carpio* L.) under environmental challenge highlight the importance of coping style in integrative physiology. Morera *et al*, J Fish Biology 2015 (accepted in press)



Genetic variation (G)
genome variation affects
phenotype

Permanent environment variance
(PE); individual-specific variation
(plasticity) (e.g.early-life conditions)

Animal personality
Behavioural syndrome
Stress coping style
Individual coping style

MATERIAL AND METHODS

Screening for personalities

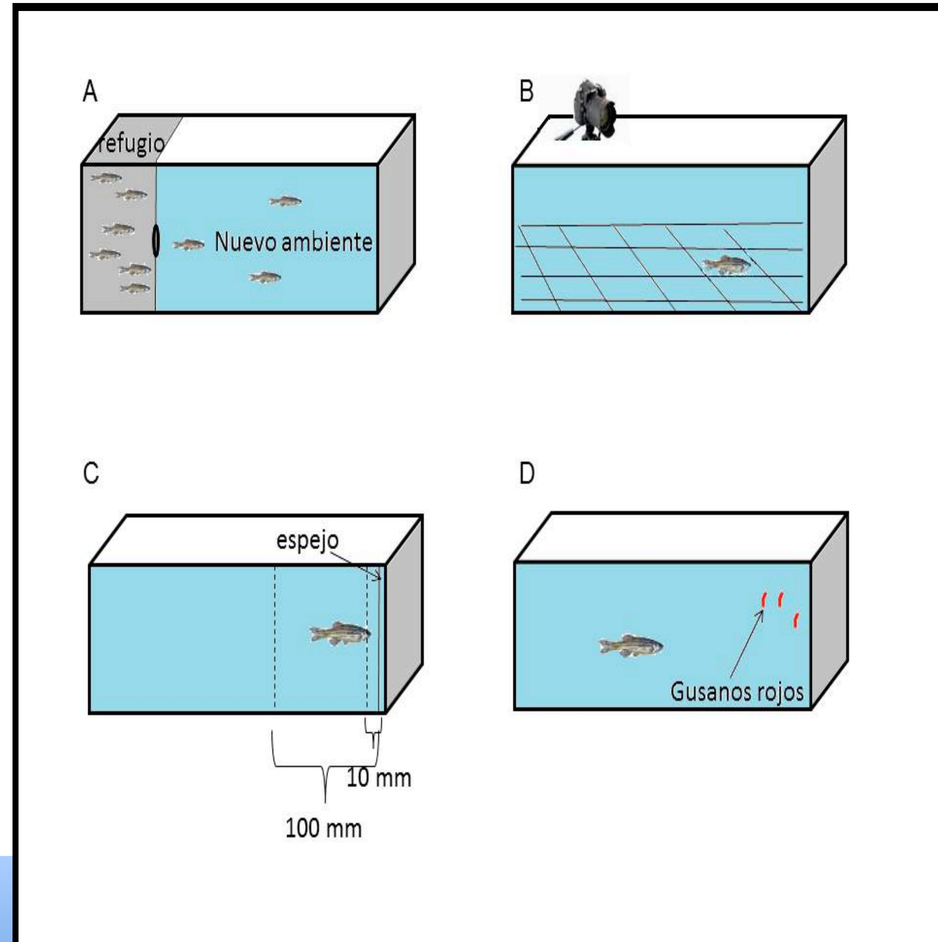
A1. Risk-Taking in groups (RUN1)

A2. Risk-Taking in groups (RUN2- 10 months later)

B. Activity in isolation (novel environment)

C. Agression (Mirror Image Stimulation Test: MIS)

D. DAI Latency or latency to first feeding after a stressful event (confinement: held submerged in a net for 1min)



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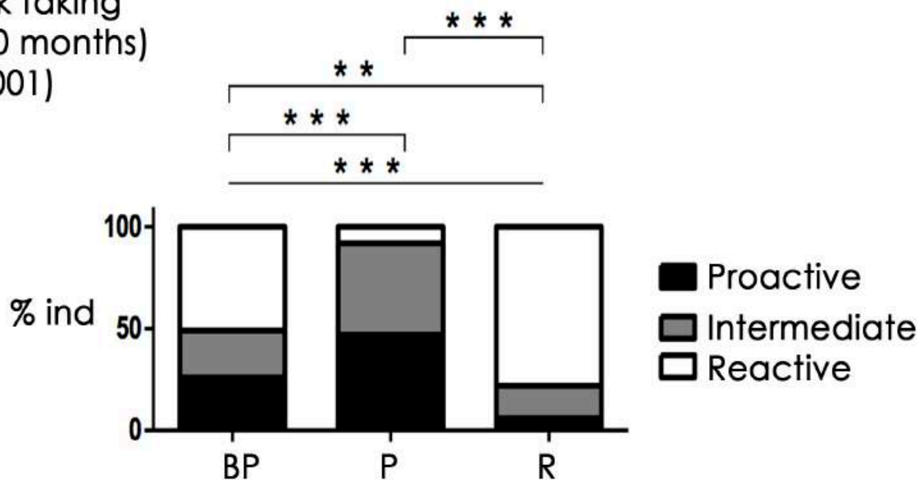
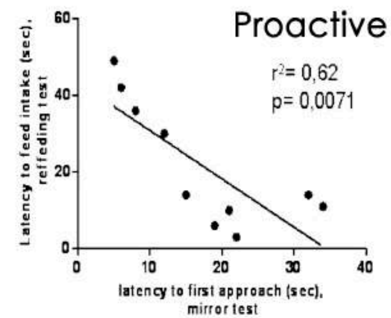
Combining animal personalities with transcriptomics resolves individual variation within a wild-type zebrafish population and identifies underpinning molecular differences in brain function.

(Rey *et al*, 2013, unpublished.)

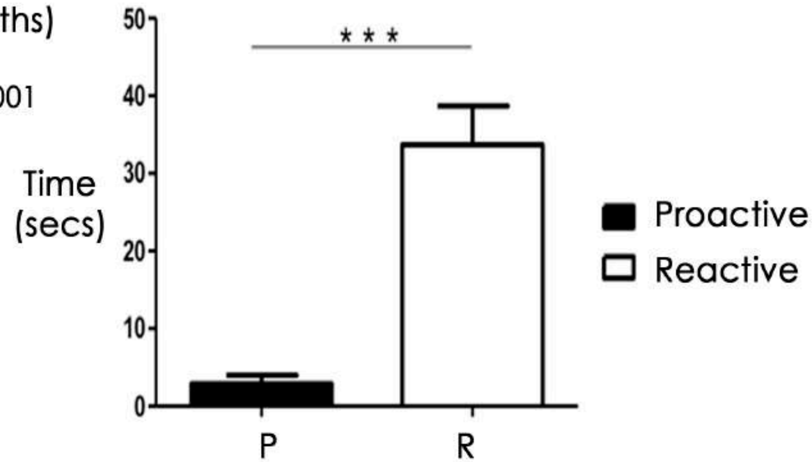
Novel Environment - Risk taking
Consistency over time (10 months)
(**p< 0,01; ***p< 0,001)

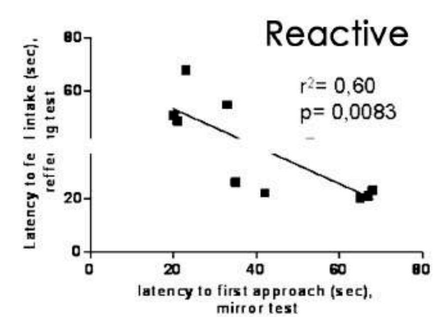


Consistency across contexts
Spearman rank
correlation analysis



Individual freezing response
Consistency over time (10 months)
(***p< 0,001)
Mann Whitney U Test, U= 0,00 p<0,001





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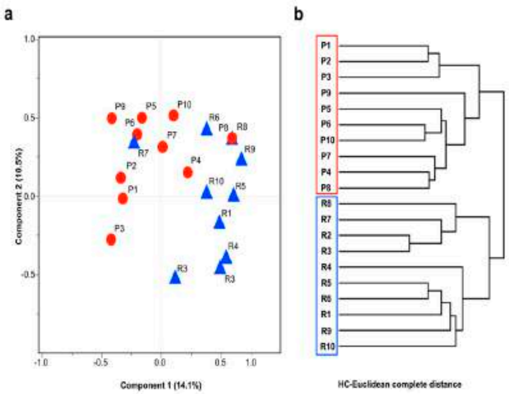
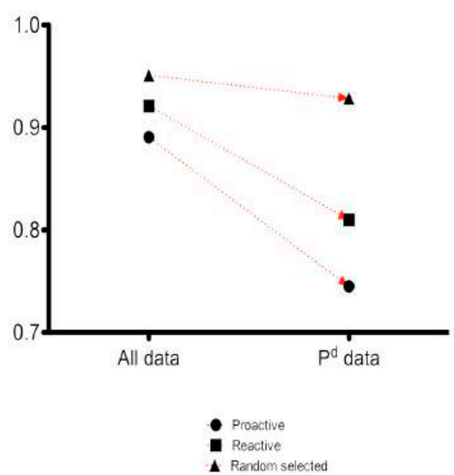


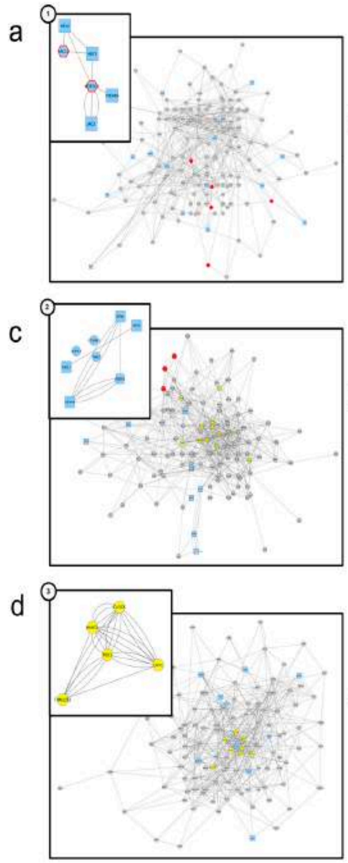
PCA on all data for individual samples



ANCOVA: on adjusted expression values, followed by Tukey test: α=0.05; N=3,027 transcripts at each selection strategy

Interactome analysis P vs R.

Two-way ANOVAs followed by post-hoc Tukey α = 0.05



GO Description	O. Sample	O. Genome	Proactive reg.	Reactive reg.
Notch signaling pathway	7	49	down-regulated	up-regulated
sequence-specific DNA binding	11	217	down-regulated	up-regulated
positive regulation of cell differentiation	12	262	down-regulated	up-regulated
regulation of cell morphogenesis involved in differentiation	7	104	down-regulated	up-regulated
regulation of nervous system development	10	197	up-regulated	down-regulated
negative regulation of transcription from RNA polymerase II promoter	11	267	down-regulated	up-regulated
DNA replication	8	191	down-regulated	up-regulated
DNA strand elongation involved in DNA replication	4	32	down-regulated	up-regulated
DNA strand elongation	4	35	down-regulated	up-regulated
hormone-mediated signaling pathway	4	27	down-regulated	up-regulated

GO Description	O. Sample	O. Genome	Proactive reg.	Reactive reg.
negative regulation of cell projection organization	4	33	up-regulated	down-regulated
negative regulation of cell differentiation	8	212	up-regulated	down-regulated
cell cycle checkpoint	9	235	down-regulated	up-regulated
G1/S transition of mitotic cell cycle	7	169	down-regulated	up-regulated
M/G1 transition of mitotic cell cycle	5	79	down-regulated	up-regulated
regulation of axonogenesis	5	50	up-regulated	down-regulated
ephrin receptor activity	3	14	down-regulated	up-regulated

GO Description	O. Sample	O. Genome	Proactive reg.	Reactive reg.
sequence-specific DNA binding	13	217	down-regulated	up-regulated
cell fate specification	4	27	down-regulated	up-regulated
rhythmic process	5	58	up-regulated	down-regulated
circadian rhythm	5	30	up-regulated	down-regulated
negative regulation of transcription from RNA polymerase II promoter	11	267	down-regulated	up-regulated
Notch signaling pathway	5	49	down-regulated	up-regulated
E-box binding	4	27	down-regulated	up-regulated
positive regulation of cell differentiation	9	262	down-regulated	up-regulated
transcription regulatory region sequence-specific DNA binding	5	62	down-regulated	up-regulated
central nervous system development	9	283	up-regulated	down-regulated

up-regulated down-regulated

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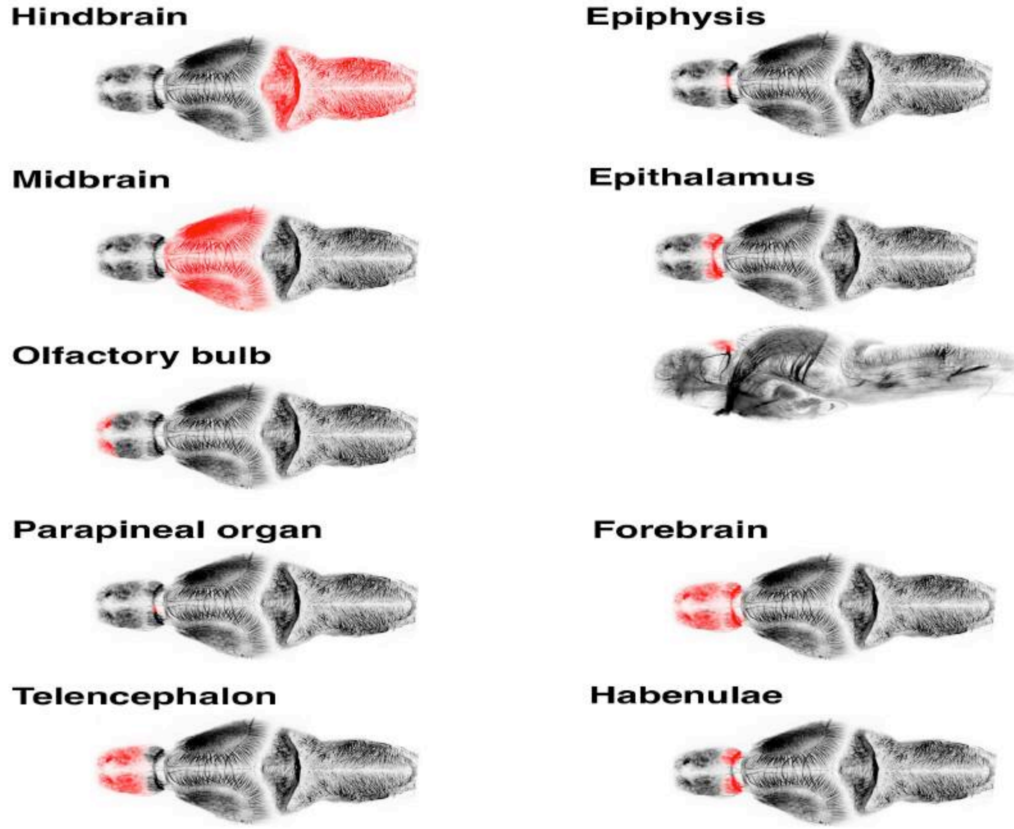
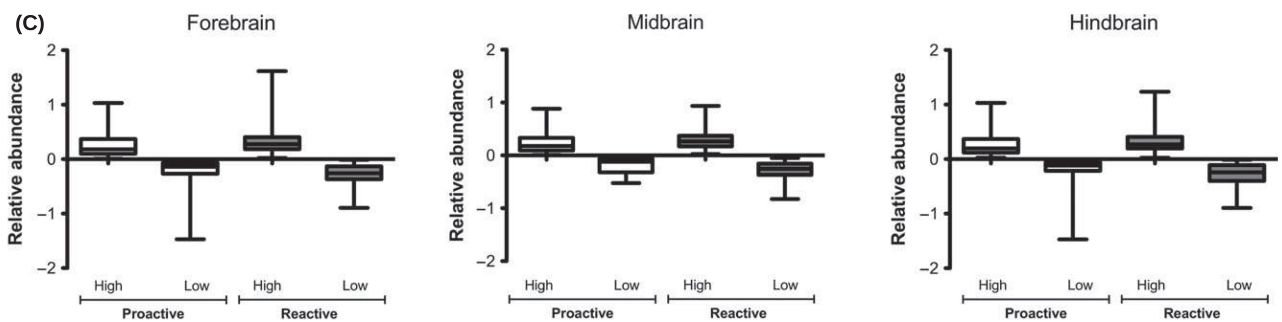
Zebrafish Brain:





Same specific set of transcripts up or down regulated differentially in each brain region depending on personality types. This suggests there is a personality-depending enrichment of function in distinct brain regions.

Social environment is associated with gene regulatory variation in the rhesus macaque immune system.

(Tung *et al*, 2012, PNAS, April 24 vol.109; 6490-6495.)

Fig. 2. Rank–gene expression associations among inflammation-related immune genes. Low-ranking females tend to overexpress inflammation-related genes: (A) PTGS2 (P = 0.004); (B) IL8RB (P = 0.003); and (C) NFATC1 (P < 10–3).

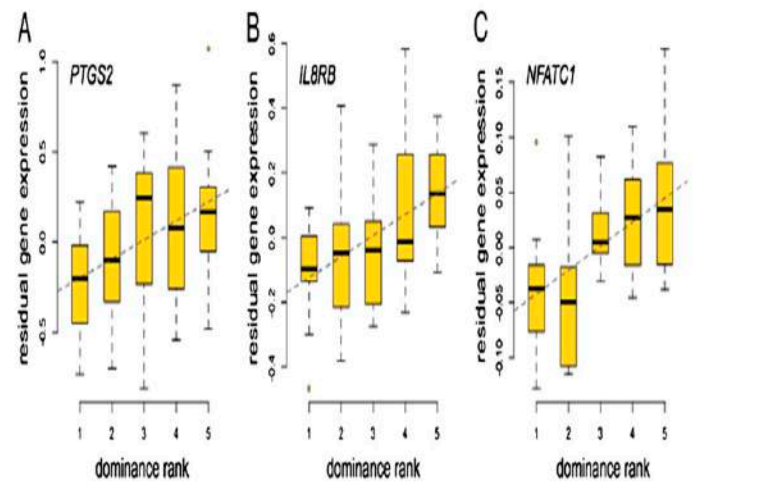
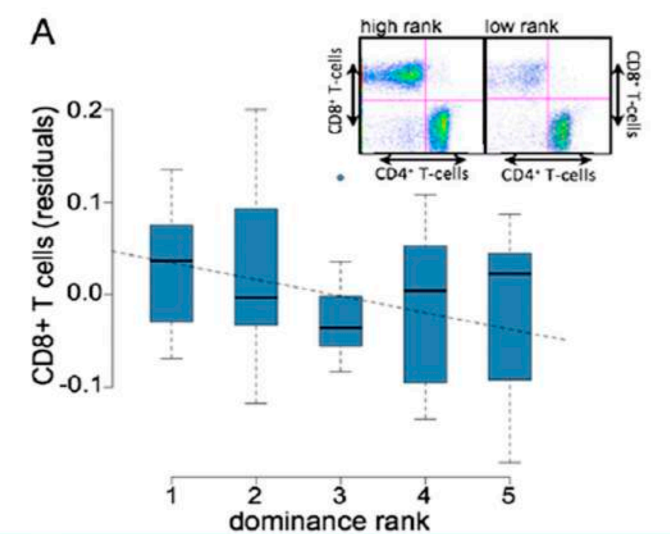


Fig. 2. Rank-gene expression associations among inflammation-related immune genes. Low-ranking females tend to overexpress inflammation-related genes: (A) *PTGS2* ($P = 0.004$); (B) *IL8RB* ($P = 0.003$); and (C) *NFATC1* ($P < 10^{-3}$).

Fig.4.(A) Low-ranking individuals exhibit lower proportions of CD8+ T cells in PBMCs (P = 0.047, n = 39; y axis shows the residuals of T-cell proportions after controlling for social group). (Inset) Example data for a rank 1 female and a rank 5 female.



Our results motivate efforts to develop a nuanced understanding of social effects on gene regulation, with the aim of both exploring its evolutionary and ecological consequences and addressing its effects on human health (Conclusions; Tung *et al*, 2012, PNAS).

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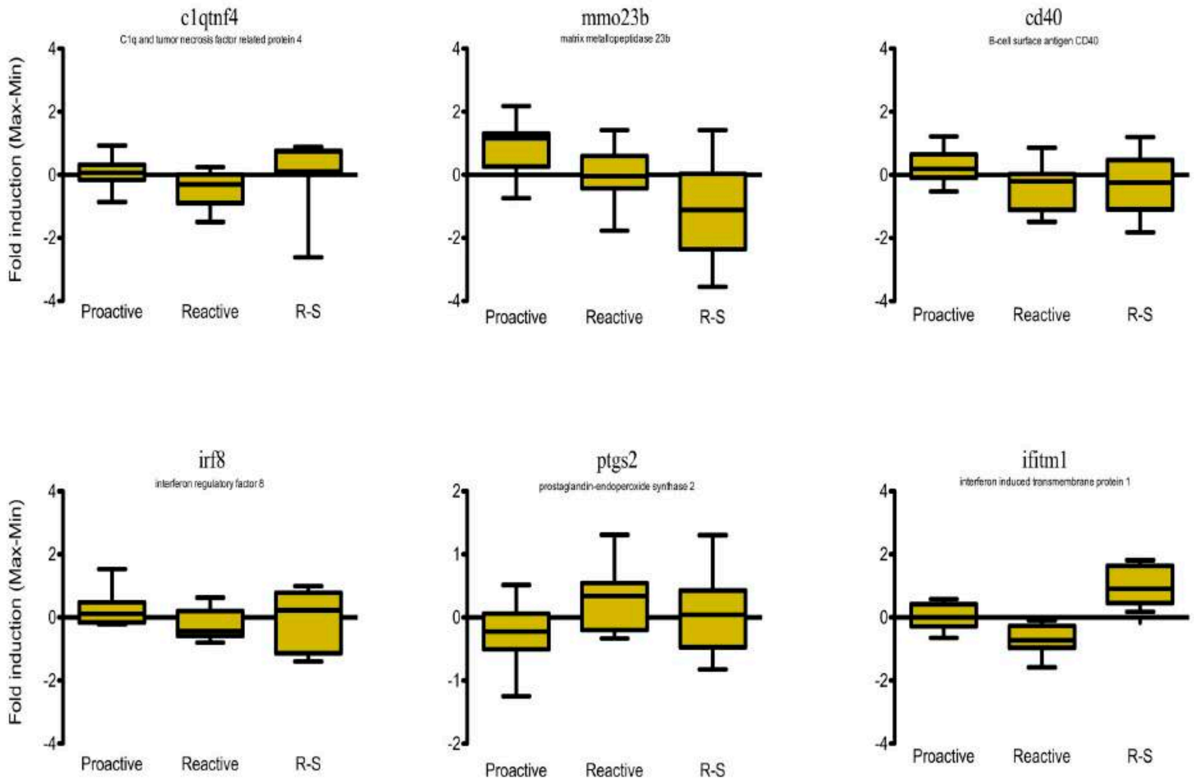
Personality and gene regulatory variation in the fish immune system.



Fish were screened for personality traits (Rey et al, 2013 unpublished).

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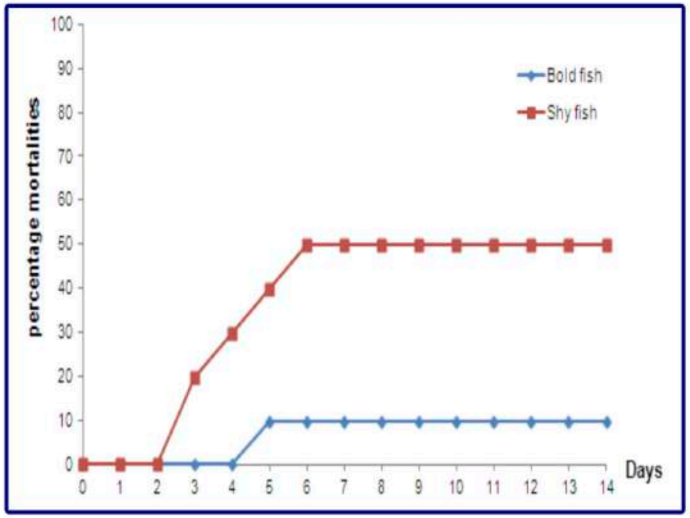
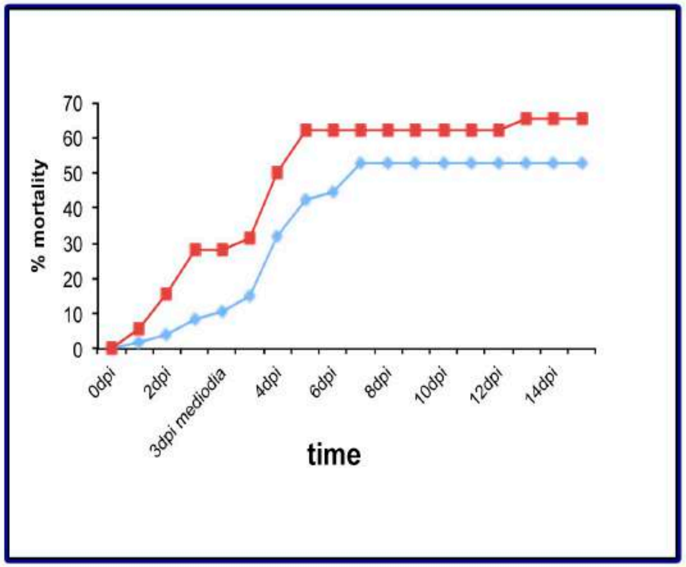


Cumulative % mortality in bold and shy Tilapia i.p. challenged with S agalactiae (10^7CFU/ml) over a 14 day period.PhD thesis; D Wongsathein, University of Stirling.

Fish were screened using social group as attractant.

Adult zebrafish screened for risk-taking in groups
SVCV concentration: 10^3TCID50/ml,
injection of 10µl/fish at 28°C.
(Rey & Novoa, unpublished data)



THERMAL *PREFERENDUM* TO ASSESS ANIMAL PERSONALITY AND INFECTION SUSCEPTIBILITY IN NILE TILAPIA *OREOCHROMIS NILOTICUS*

Marco Cerqueira[a]

Sonia Rey[b]

Zoe Featherstone[b]

Margaret Crumlish[b]

Bryan McAndrew[b]

Simon MacKenzie[b]

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Naturwissenschaften (2010) 97:981–985
DOI 10.1007/s00114-010-0714-7

ORIGINAL PAPER

Migratory and resident blue tits *Cyanistes caeruleus* differ in their reaction to a novel object

Anna L. K. Nilsson · Jan-Åke Nilsson · Thomas Alerstam · Johan Bäckman

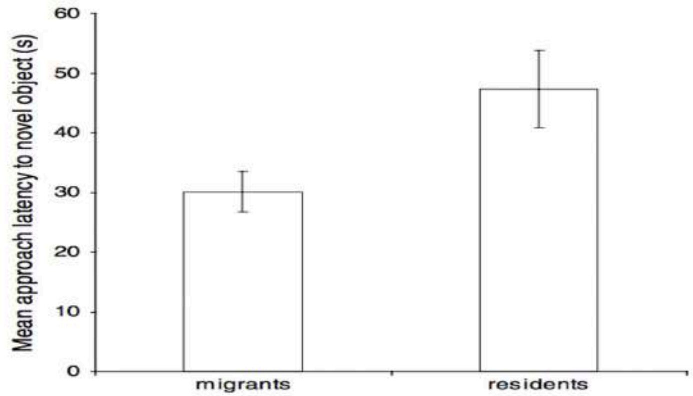

Fig. 2 Mean (±SE) approach latency to a novel object among migrant and resident blue tits. Sample size: residents=54; migrants=81. Maximum approach time was set at 2 min. Eight residents and five migrants failed to approach the novel object within this time and were given the approach time 120 s

"Contrary to our hypothesis, migratory blue tits approached novel objects faster than residents did."

Chapman, B. B., Hulthen, K., Blomqvist, D. R., et al. (2011c).
To boldly go: individual differences in boldness influence migratory tendency.
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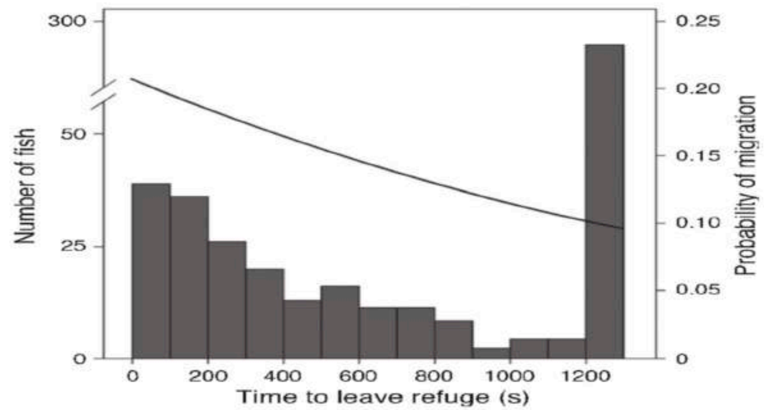

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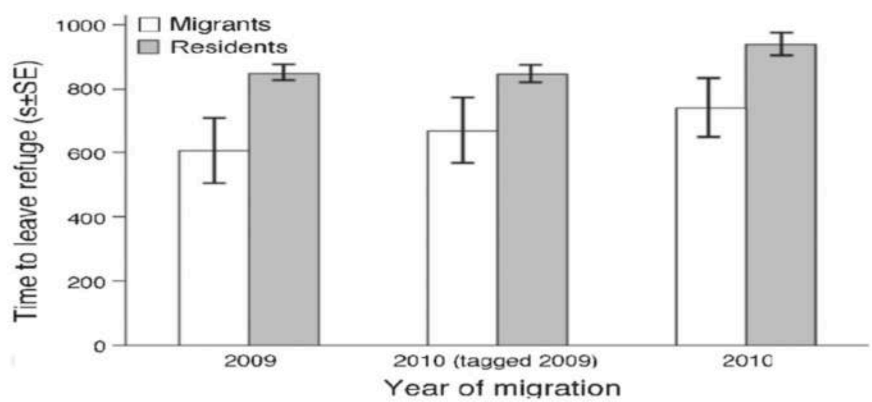

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PROCEEDINGS OF THE ROYAL SOCIETY B

Proc. R. Soc. B (2011) **278**, 1670–1678
doi:10.1098/rspb.2010.1892
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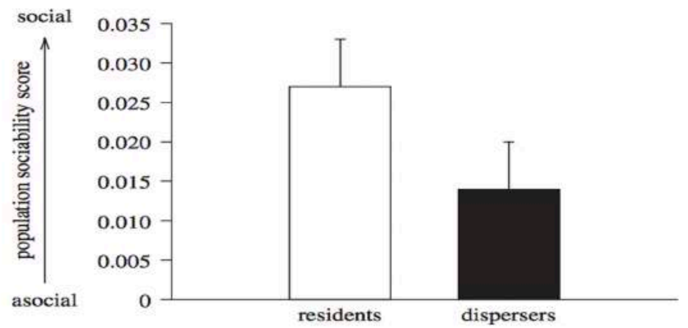
Personality-dependent dispersal in the invasive mosquitofish: group composition matters

Julien Cote*, Sean Fogarty, Tomas Brodin, Kelly Weinersmith and Andrew Sih

Department of Environmental Science and Policy, University of California, Davis, CA, USA



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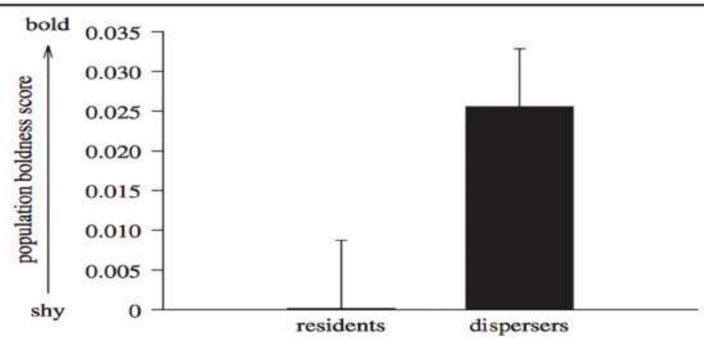

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The journey toward the brain and temperature

S.MacKenzie.
Marine Biotechnology,
Institute of Aquaculture,
University of Stirling, UK.

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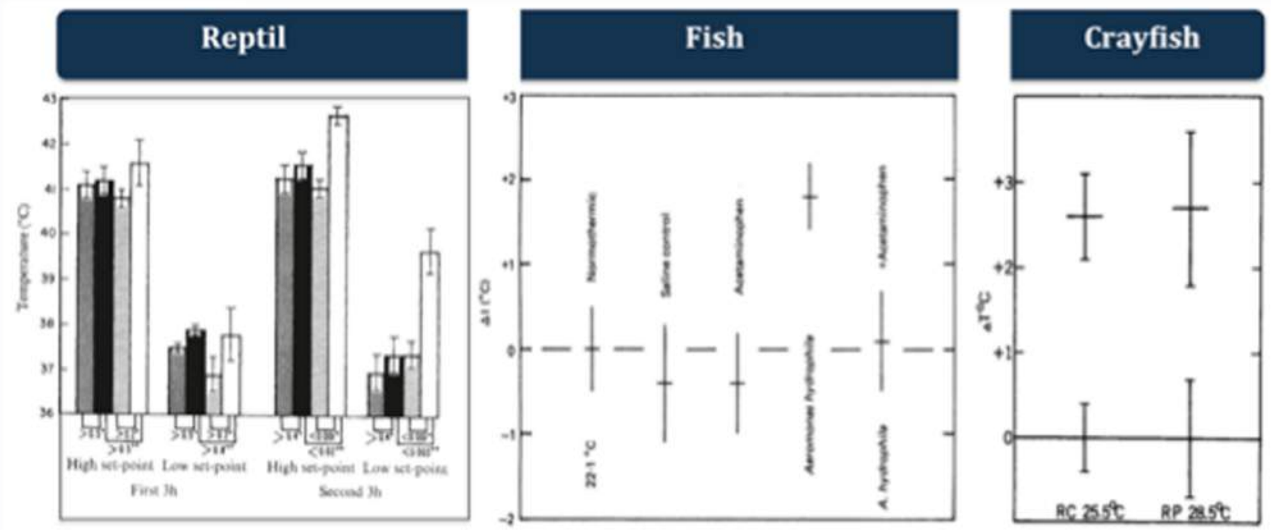
The vast majority of animal species are ectothermic thus can only manipulate their body temperature by choice of an appropriate environmental temperature and so may be adjusted in response to fluctuations at local and habitat scales.



Vaughn *et al*, 1974 Nature

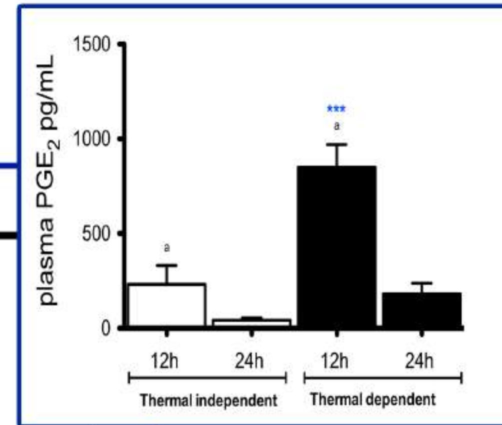
Reynolds *et al*, 1976 Nature

Casterlin and Reynolds, 1979 *Life Sci*

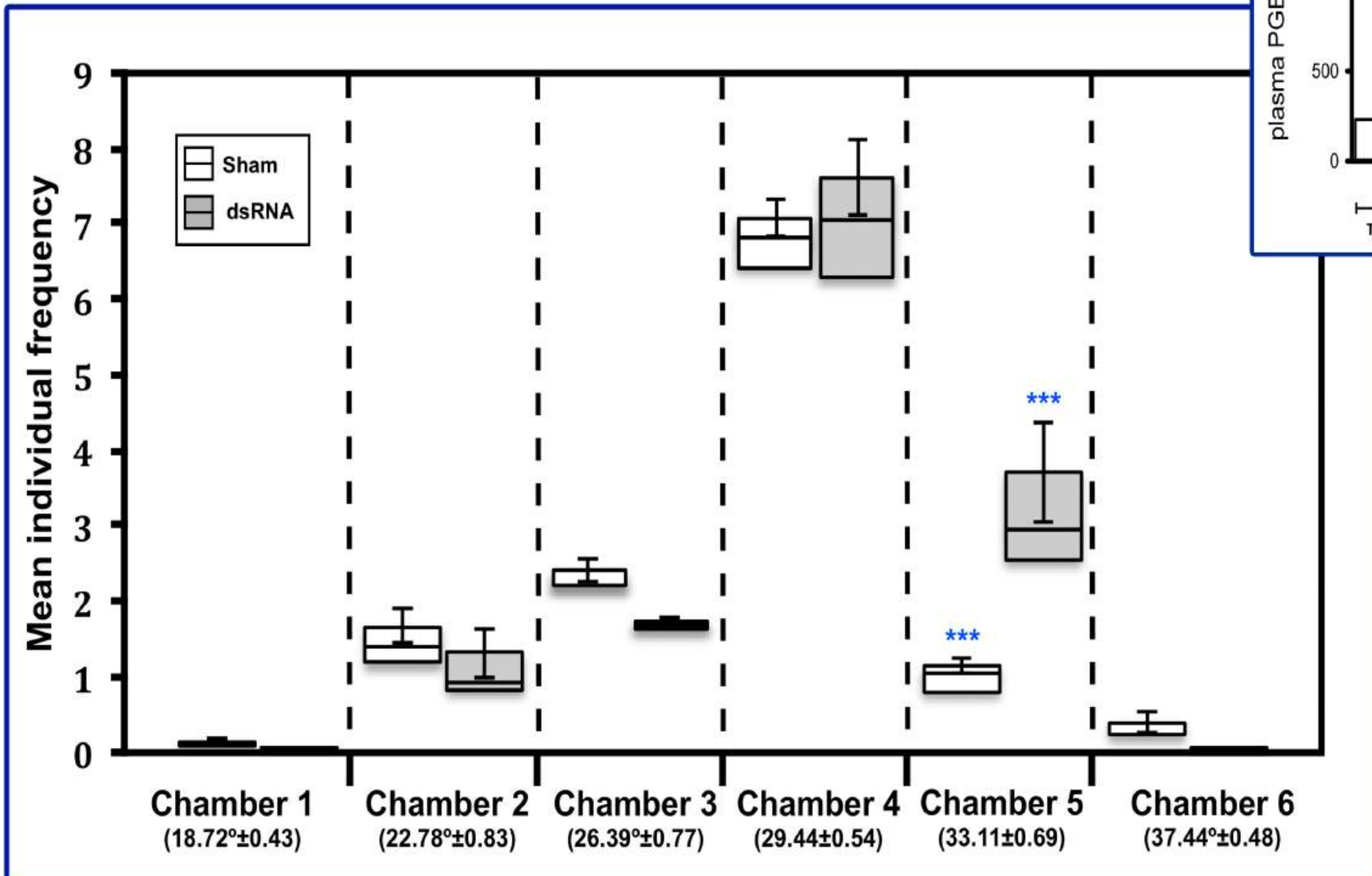
It has been suggested, but so far not confirmed, that such changes in thermal regime modify metabolic rate, favouring the immune response and thus promote survival (*Kluger et al 1975, Covert,1977, Elliot et al. 2002, 2005)*

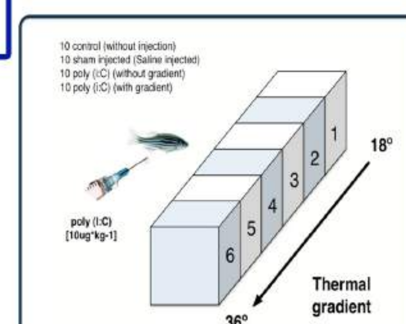
Behavioural fever in dsRNA challenged adult zebrafish

Frequency (15min intervals) of chamber occupation in individual adult zebrafish (group =10 individuals) challenged with dsRNA in a thermal gradient (Boltana *et al, P ROY SOC B-BIOL SCI*, 2013 in press.)



Plasma concentrations of PGE2 (pg/ml)





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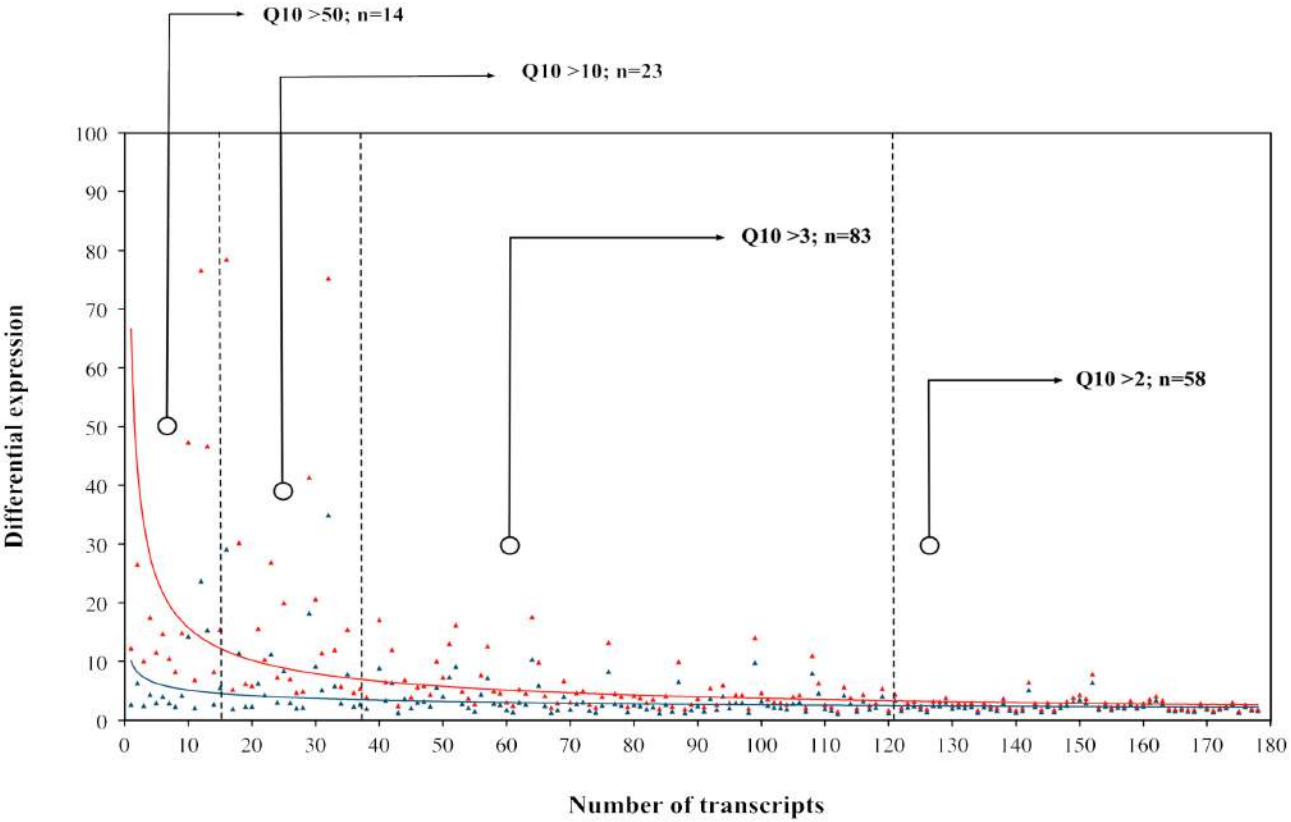
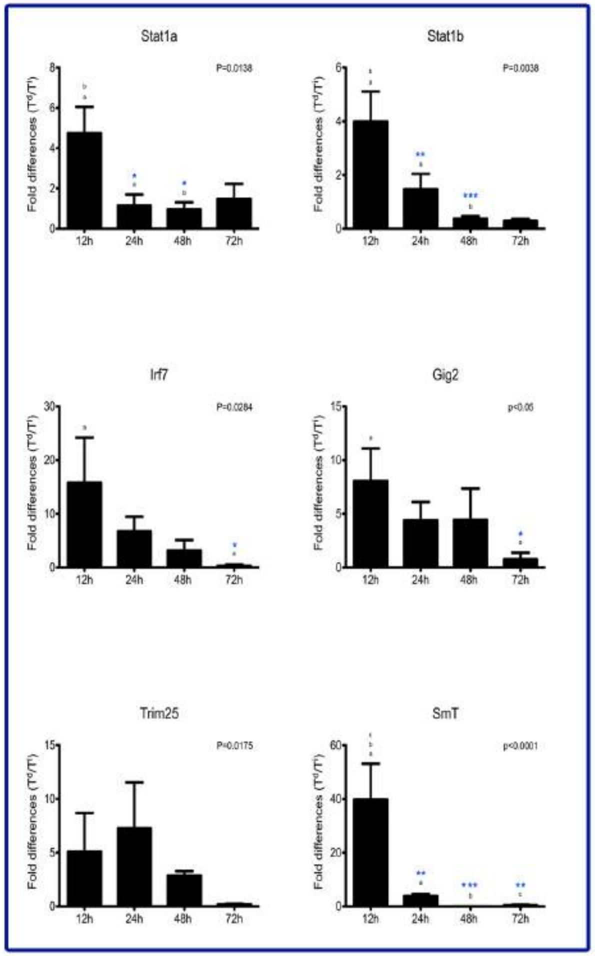
Behavioural fever in dsRNA challenged adult zebrafish

Gene-environment interaction during dsRNA-induced behavioural fever
Differential expression levels of 156 (fold change >2) dsRNA-induced transcripts common to both constant conditions (Ti) or in a thermal gradient (Td).
Q10 values were calculated and shown in 4 groupings relative to intensity.
(Boltana *et al*, *P ROY SOC B-BIOL SCI*, 2013 in press.)





Q10 temperature coefficient is the rate of change in a biological system (temperature dependence)

$$Q_{10} = \left(\frac{R_2}{R_1}\right)^{\left(\frac{10}{T_2 - T_1}\right)}$$

The majority of Q10>10 mRNAs are related to the anti-viral response. All transcripts show an increased abundance over T_{ind} fish and the response is time independent.

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Behavioural fever in dsRNA challenged adult zebrafish

SVCV infection, clinical symptoms and virus recovery

Representative photographs of individual zebrafish infected with SVCV 7dpi at 22°C, 28°C (Ti) and 28°Cd (Td)

(Boltana *et al*, *P ROY SOC B-BIOL SCI*, 2013 in press.)

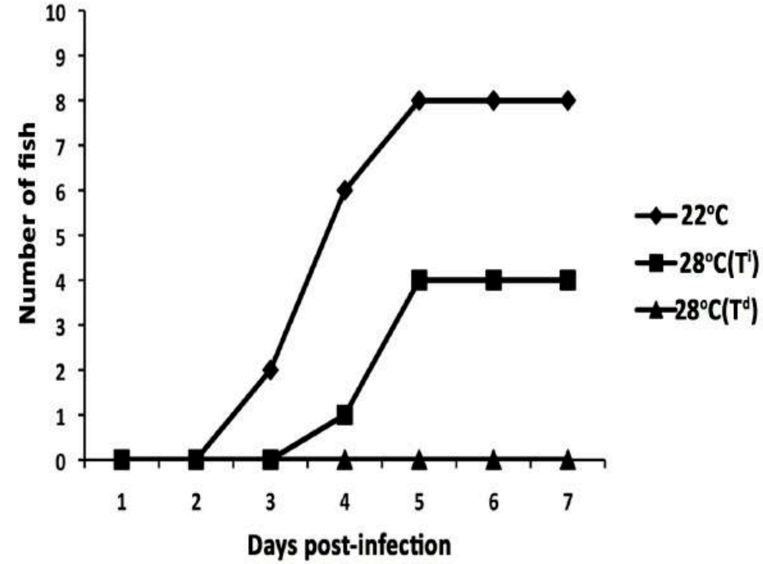
Representative photographs of individual zebrafish infected with SVCV 7dpi at 22°C, 28°C (Ti) and 28oCd (Td),

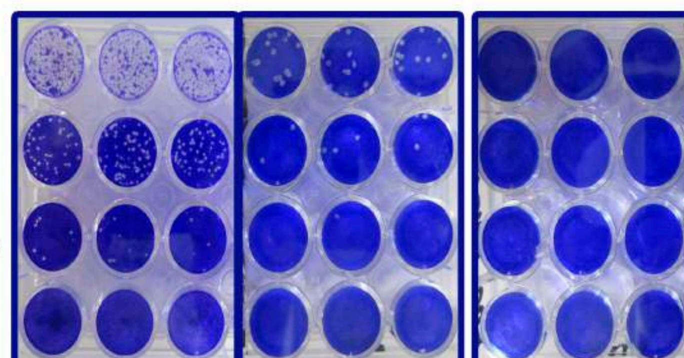
22⁰C

28⁰C Tⁱ

28⁰C Tᵈ

Appearance of clinical signs of skin haemorrhaging in SVCV-infected fish (n=10) 1-7dpi in each experimental group





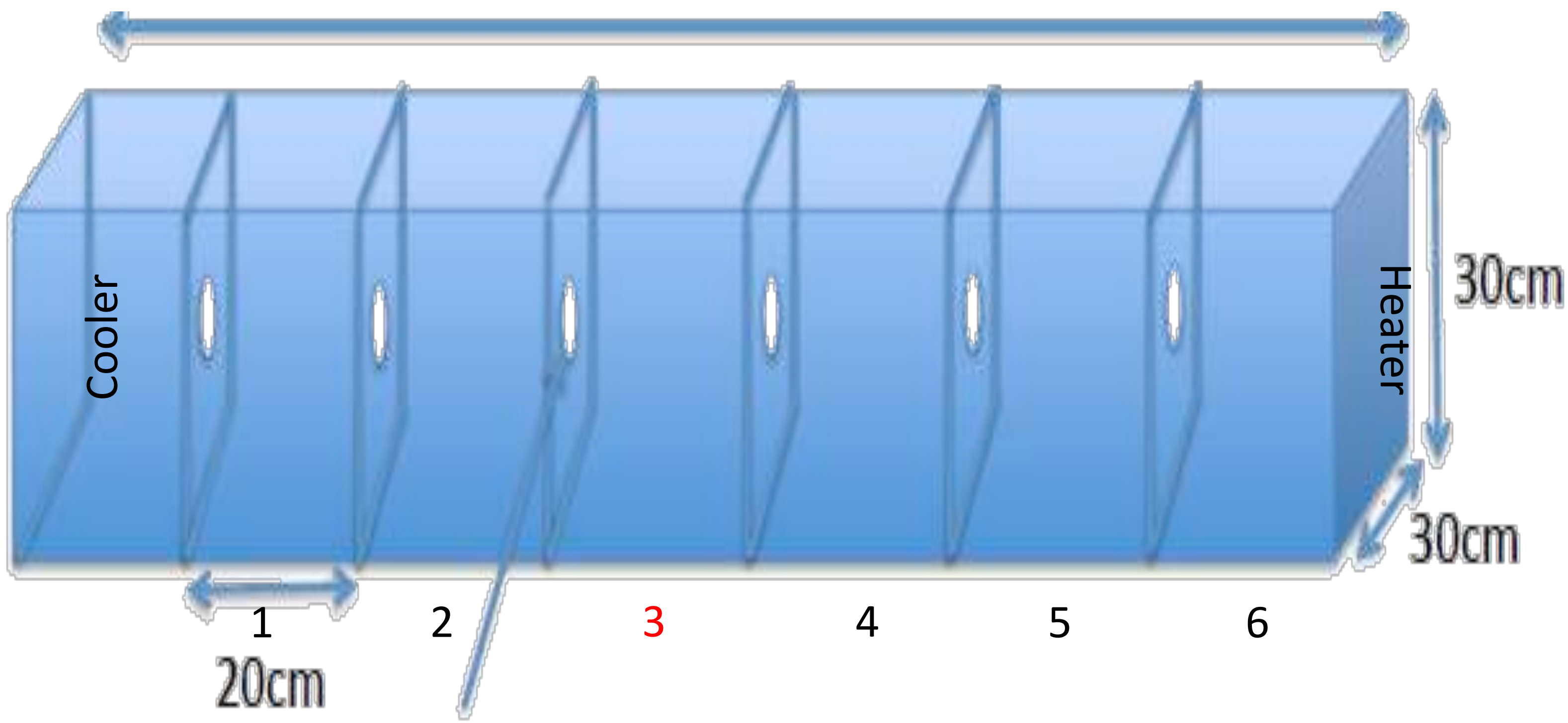
Plaque formation in EPC cell monolayers after infection with viral particles recovered from surviving SVCV-challenged fish 7dpi (n=4) at 22°C, 28°C (Ti) and 28°Cd (Td).
Estepa and Garcia-Valtanen, UMH

Animal personality is related to thermal preference in fish

Institute of Aquaculture UNIVERSITY OF STIRLING

The temperature gradient tank

Boltana, Rey et al. 2013 Proc R Soc-B



3 groups per personality and 3 groups of naïve non-screened fish per treatment.

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Thermal preference expt

- 100 animals screened for personality using risk taking in groups.
- Two treatments, constant (T_R at 28ºC) and gradient temperature (T_{Ch} from 21 to 35ºC).
- First hour after placing the animals continuous recording of activity (latencies to move to the next chamber and number of chamber transitions).
- Overnight acclimation (min 12h) and recordings every 15min for 8 h (for fish distribution).

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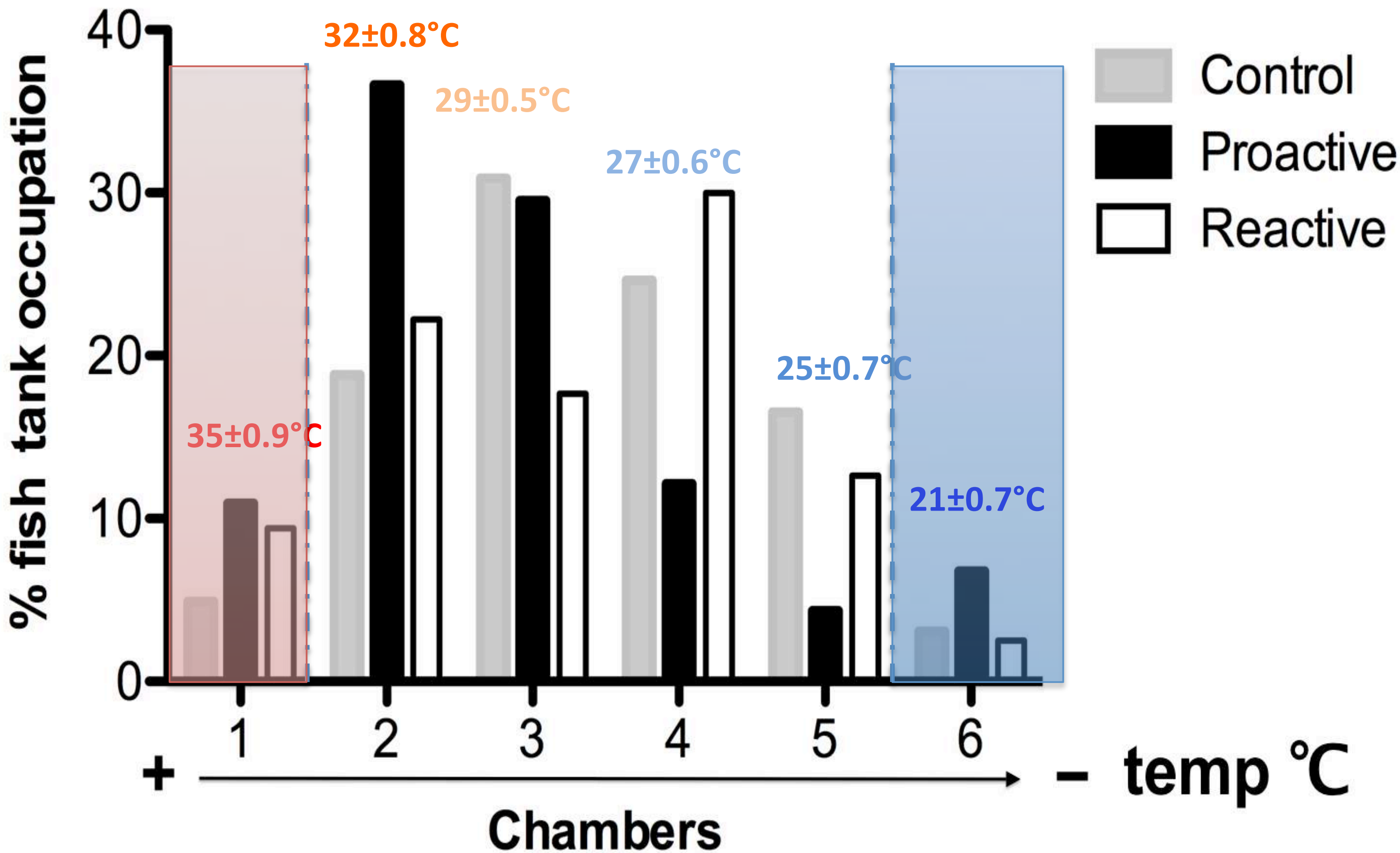
Results



Repeated measures ANOVA; $F_{(10,\ 1125)}$=24.168, $p<0.001$; Plotted as percentage of chamber occupation per fish by each personality type for a clear illustration

Fish can show emotional fever: stress-induced hyperthermia in zebrafish
Rey et al. 2015 Proc Roy.Soc.B 2nd review

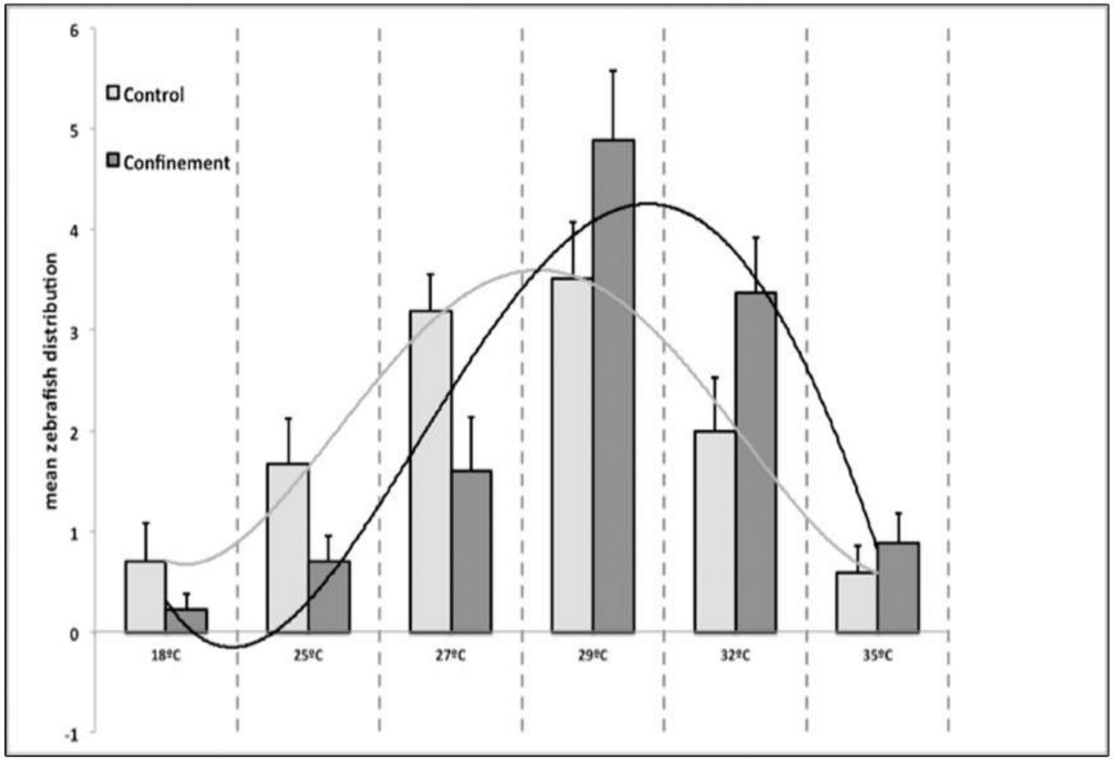


Figure 1. Stress induces hyperthermia in zebrafish under confinement stress.
Mean distribution for individual adult zebrafish after a confinement stress treatment (group=12 individuals) under the temperature gradient tank vs control non stressed zebrafish.
Repeated measures ANOVA ($F_{40,192}=1.889$; $p<0.001$). White bar represent control, grey bar represent animals under confinement stress.

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Animal Personality Relates to Thermal Preference in Wild-Type Zebrafish, *Danio rerio*. Rey S, Digka N, MacKenzie S. *Zebrafish*. 2015 Jun;12(3):243-9.

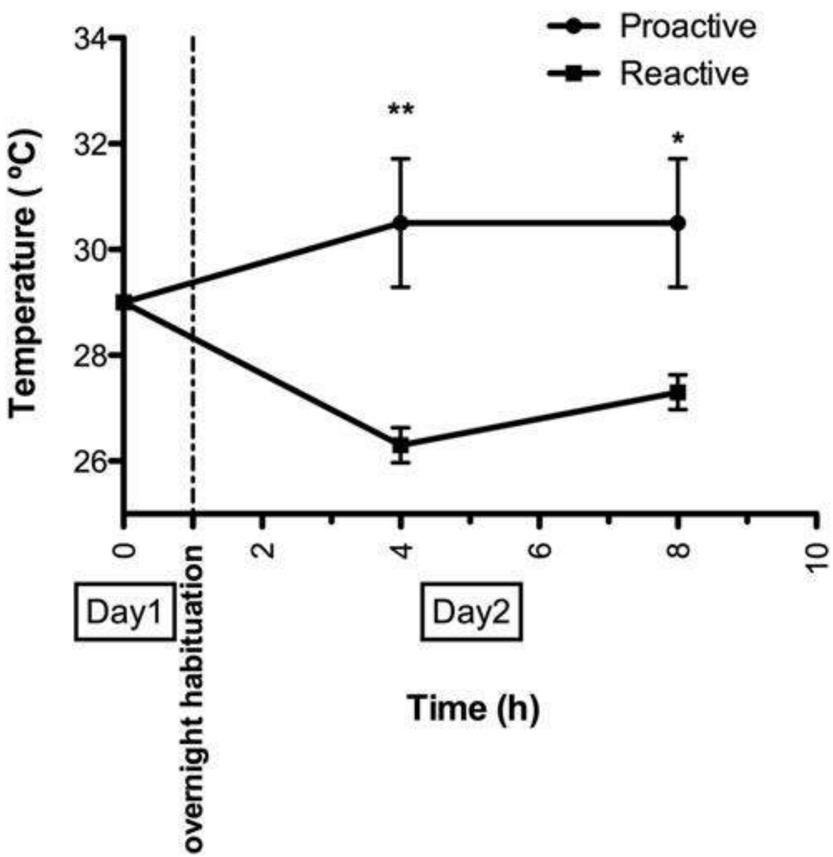

FIG. 5. Mean temperature at experimental middle (4h) and end time (8h) points for proactive and reactive fish groups after overnight habituation (minimum 12 h). Differences were mainly due to personality and not due to time or the interaction
(two-way ANOVA $F_{(1, 27.38)} = 17.35$; post hoc: *$p < 0.05$, **$p < 0.01$).

Conclusions for thermal choice

- Our results highlight the importance of environmental temperature choice on experimental laboratory setups.
- Temperature choice in the context of different animal personality strategies, at any of their developmental stages, may provide an important insight into individual variation within populations. *see also behavioral fever on ZF larvae poster by Moiche el al.

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- Our results have implications for research into adaptation to environmental challenge (Wingfield, 2003) including climate change (Somero, 2012) where thermal choice has been poorly explored.

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Consequences of personalities for ecology and evolution:

+Survival of endangered populations or fragile ecosystems (coral reefs, mountain rivers, etc) under environmental changes (temperature, Ph, catastrophes, anthropogenic pollution, etc).

+Reintroduction programs for endangered species.

+Predicting expansion and management of invasive species (invasiveness syndrome similar to bold personality in animal behavior).

+Differential disease susceptibility, fitness and selection pressures for different personalities within the same species.

http://www.collective-behavior.com/ASABWinterMeeting/)

Migratory animals spend different seasons in often geographically distinct areas, and so the question of whether personality traits are consistent at these kinds of geographical and temporal scales is of interest to students of both animal personality and migration biology.

Consistency across contexts.

Bold juvenile bluegill sunfishes, *Lepomis macrochirus*, moved in longer and faster bursts of swimming than did shy individuals (Wilson and Godin 2010).
Thus, in all three of the phases composing the dispersal process, fast-exploring and/or bold individuals seem to behave in a way promoting long dispersal distances.

Migratory animals spend different seasons in often geographically distinct areas, and so the question of whether personality traits are consistent at **(p.95)** these kinds of geographical and temporal scales is of interest to students of both animal personality and migration biology. Do migratory animals show consistency in behaviour or do they adopt location-specific behaviours? A study following the migratory behaviour of individually marked common cranes, *Grus grus*, showed that birds that hatched in undisturbed habitats in Finland choose undisturbed stopover sites in Hungary (Vegvari et al. 2011). Four of five disturbance tolerance variables (which included proximity to road and human population density) were highly repeatable within and between years for individual cranes. Hence, for this species behavioural sensitivity to disturbance can be considered a personality trait that is consistent over large temporal and geographical scales. This fascinating analysis also highlights important questions—why did birds from undisturbed natal habitats choose undisturbed roosting sites? Was this due to early experience and imprinting, or learning from parents? Or alternatively, does habitat preference have a strong genetic component? It is in this way that migratory systems can be used for asking critical questions about the development and evolution of personality variation in animals.

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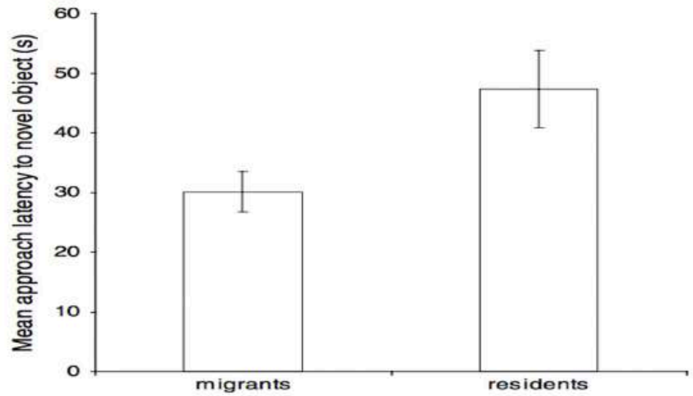
Thomas Alerstam · Johan Bäckman



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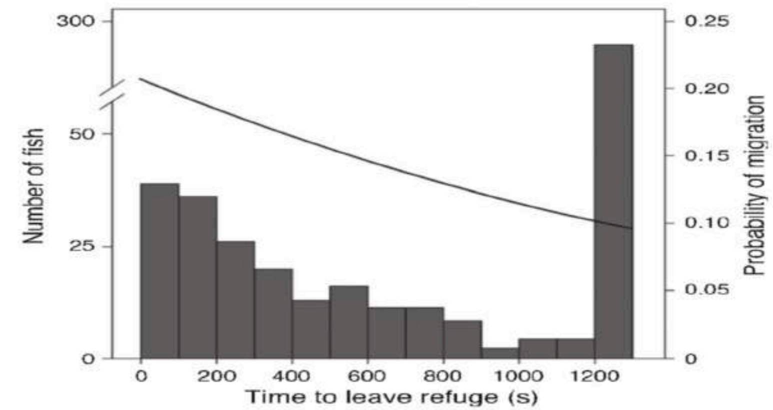

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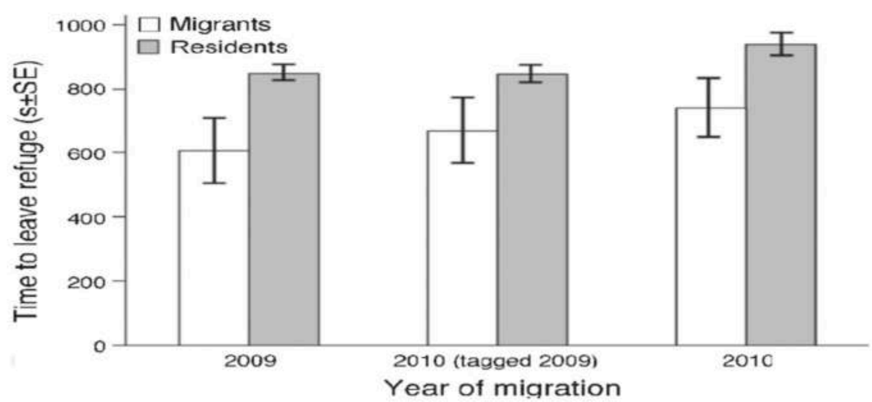

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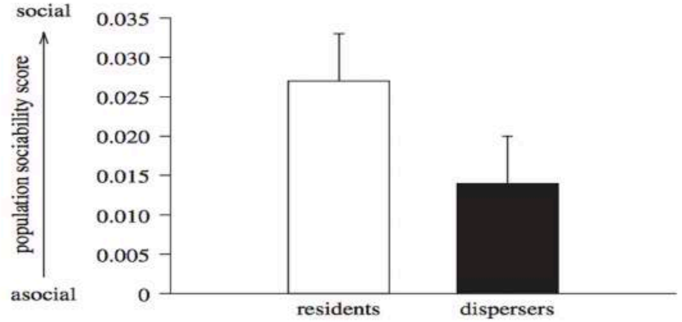
Department of Environmental Science and Policy, University of California, Davis, CA, USA



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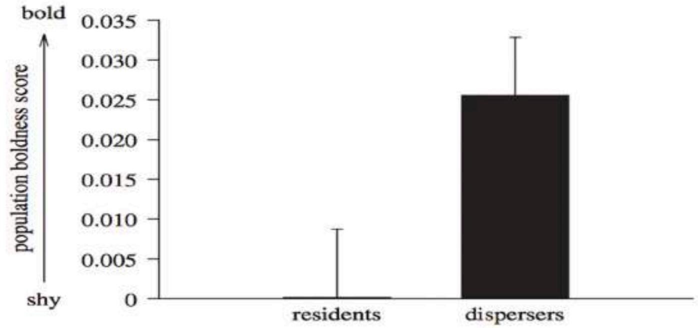

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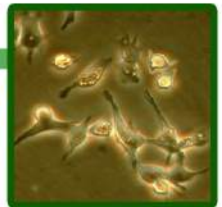
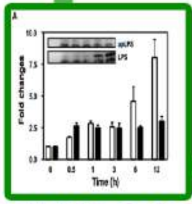
Group of Immunity and Evolution

CELL CULTURE

MACROPHAGE BIOLOGY
PAMP-PRR INTERACTION

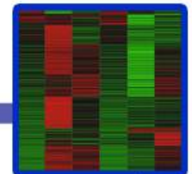




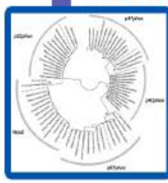
ENDOTOXIN

PEPTIDOGLYCANS

Host Pathogen



TRANSCRIPTOMICS
RNA-Seq, oligoARRAY



RNA-Seq

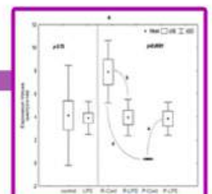
Oligoarrays

Pathogen Challenge

IMMUNO-MODULATION

Formulation

Fever



BEHAVIOUR AND IMMUNITY

Stress Coping Styles

evolutionary immunology

ibb

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Dr Sonia Rey(FP7)		Behaviour
Dr Felipe Reyes(FondeCyt)		Transcriptomics
Dr Sebastain Boltaña(C;lider)		PAMP-PRRs
Dr Mariana Teles(JdC fellow)		Immunity
Phd students		
Agnes Callol	UAB-UV	Host-Pathogen
Eva Vallejos	UAB	IS diets
Reynaldo Vargas	Panama	Behaviour
Angels Ruyra	UAB	Nanovaccines
Deborah	Chile	PAMP-immunity

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