ANTI-PREDATOR RESPONSE OF *HALIOTIS TUBERCULATA* IS MODIFIED AFTER ONE GENERATION OF DOMESTICATION

Sabine ROUSSEL, Thomas BISCH, Sébastien LACHAMBRE, Pierre, BOUDRY, Jean-Lou GERVOIS, Christophe LAMBERT, Sylvain HUCHETTE, Rob DAY

UNION EUROPÉENNE

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A RECENT DOMESTICATION OF *HALIOTIS TUBERCULATA*

Distribution of *Haliotis tuberculata* : the North Atlantic area (from Canary islands to the English Channel) and Mediterranean Sea

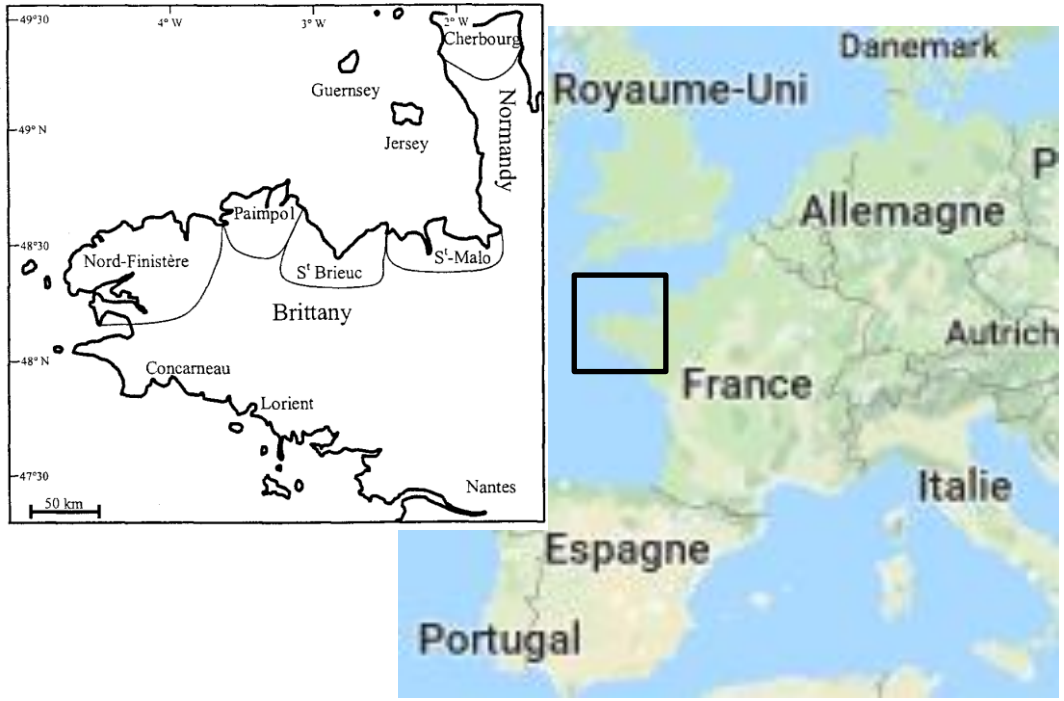


Figure 1 : Fishing zones of the French ormer fishery since 1994 (Huchette and Clavier, 2004)

DEFINITION OF DOMESTICATION

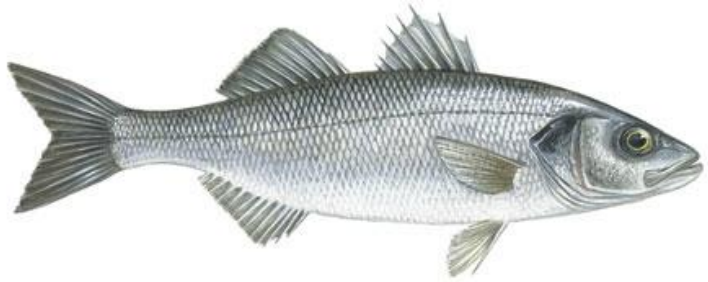
« the process by which a population of animals becomes **adapted to man** and to the **captive environment** by **genetic changes** occurring over generations and **environmentally induced developmental events** reoccurring during each generation" (Price, 1984)

MECHANISM

- **Developmental mechanism** : modification of the expression of phenotypic traits for a given genotype
- **Genetic mechanism** : selection (conscious or unconscious), inbreeding, drift or genetic engineering

MODIFICATIONS DUE TO DOMESTICATION

A shift from **resource conservation**, **foraging** and **predator avoidance** functions toward **growth** and **reproduction**



In fish: foraging and anti-predator behaviour reduced in complexity and effectiveness after few generations of domestication (Huntingford & Adams, 2005)

In abalone: wild abalone responded more to touching the foot and moved more in a tank in basal situation compared to farmed abalone (Lachambre et al., 2017)

In molluscs, behavioural consequences are far less known.
Developmental or genetic effects ?

OBJECTIVE OF THE EXPERIMENT

Study the consequences of a **selection program** to improve growth, on the **behaviour** and the **morphology** of the selected progeny

⇨ Progeny born from **3 different broodstock origins**, corresponding to **3 different levels of domestication**, exposed to a **common environment**

Table 1 : Teletchea and Fontaine (2014) domestication level

0	Capture fisheries
1	First trials of acclimatization
2	Part of the life cycle completed in captivity but bottlenecks for some stages
3	Entire life cycle closed in captivity but with wild inputs
4	Entire life cycle in captivity without wild inputs but no selective breeding
5	Selective breeding program based on specific goals

BROODSTOCK REPRODUCTION

WILD

10 ♀ x 10 ♂
Brittany and Normandy

SELECTED

15 ♀ x 15 ♂
5% selection on **weight**

RANDOMLY SAMPLED

15 ♀ x 15 ♂
randomly sampled

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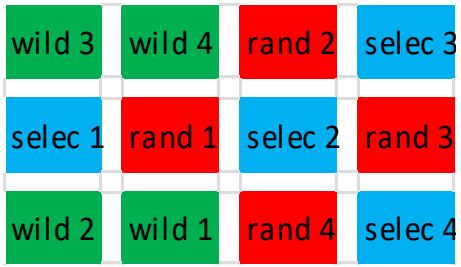
4 REPETITIONS
(4 spawning periods)

JUVENILE REARING

NURSERY 1
(10 months)

No control of density



JUVENILE REARING

NURSERY 1
(10 months)

NURSERY 2
(6 months)

No control of density

wild 3	wild 4	rand 2	selec 3
selec 1	rand 1	selec 2	rand 3
wild 2	wild 1	rand 4	selec 4

Control of density and food

One tank per treatment and per spawning

JUVENILE REARING

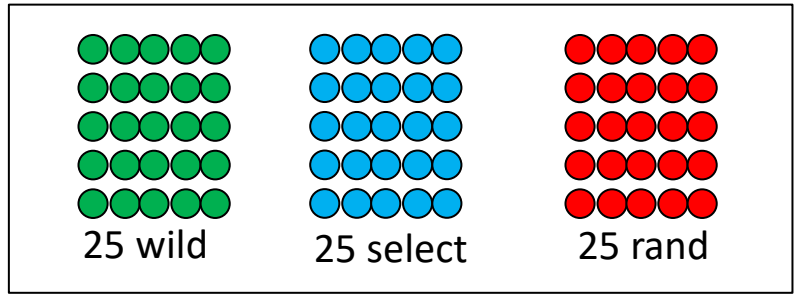
NURSERY 1 (10 months)	NURSERY 2 (6 months)	SEA-REARING PERIOD (18 months)

No control of density

wild 3	wild 4	rand 2	selec 3
selec 1	rand 1	selec 2	rand 3
wild 2	wild 1	rand 4	selec 4

Control of density and food

Offspring in the same density and rearing environment



One tank per treatment and per spawning

- *4 period of spawning, replicated 3 times*
- *n = 12 cages in total*

LABORATORY MEASURES at 34 months of age

GROWTH

Length
- *10 months*
- *16 months*
- *34 months*

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IMMUNE STATUS AFTER A STRESS

- *phagocytosis efficiency*
- *number of beads engulfed / cell*

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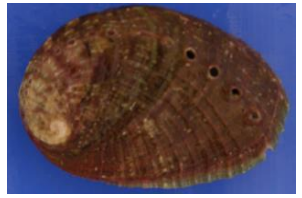
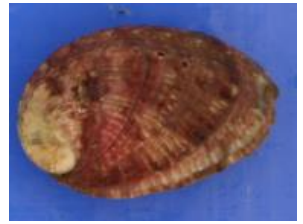
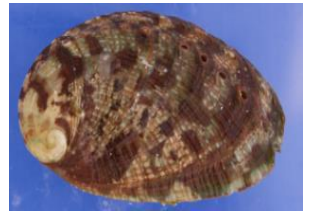
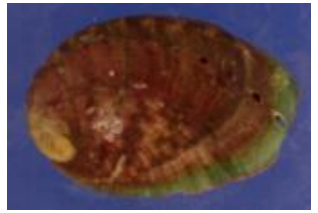
SHELL PATTERN AND COLOR







Shell pattern
- *homogenous*
- *discoloration in one part*
- *stripes in at least 1/3*



Shell color
- *Brown /green*
- *Orange /red*

LABORATORY MEASURES at 34 months of age

CIRCADIAN RHYTHM and FEEDING BEHAVIOUR

- Quantity of algae ingested per gram of abalone
- % time hiding
- % time spent moving

LABORATORY MEASURES at 34 months of age

CIRCADIAN RHYTHM and FEEDING BEHAVIOUR

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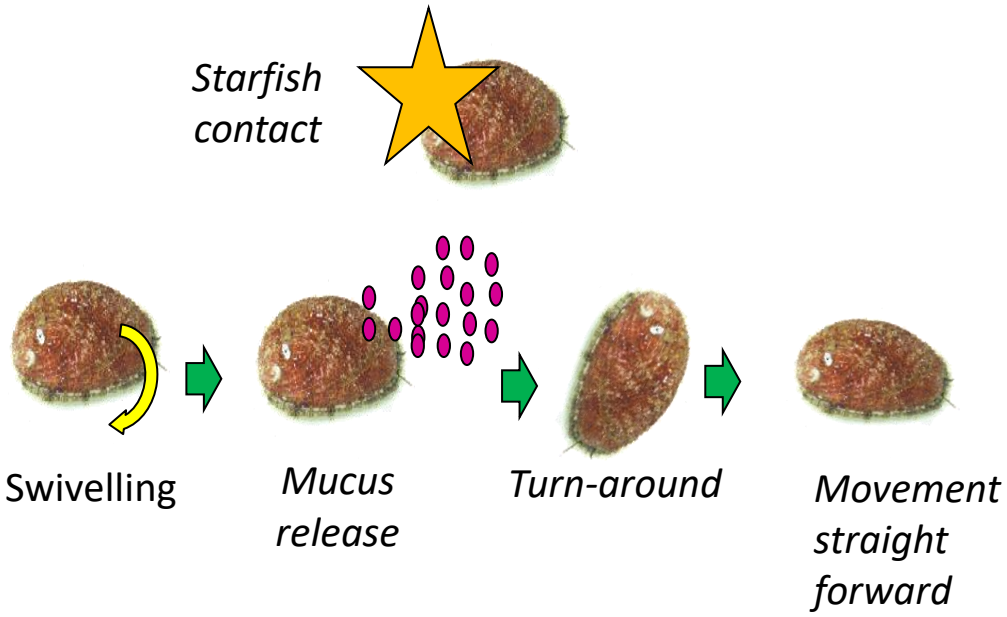
RIGHTING TEST

- Righting latency

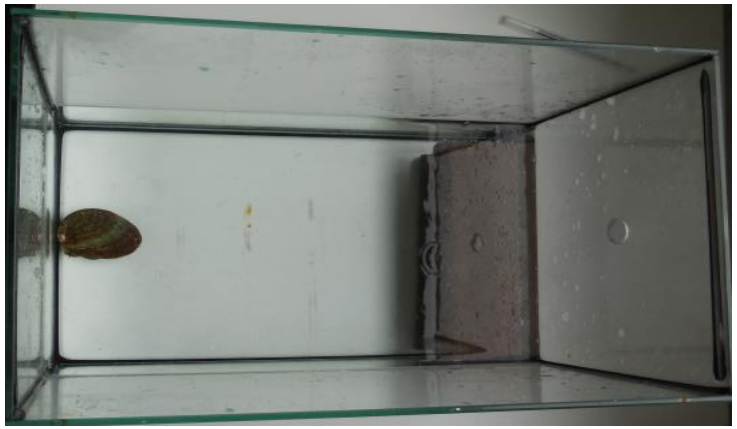
LABORATORY MEASURES at 34 months of age

PREDATOR TEST



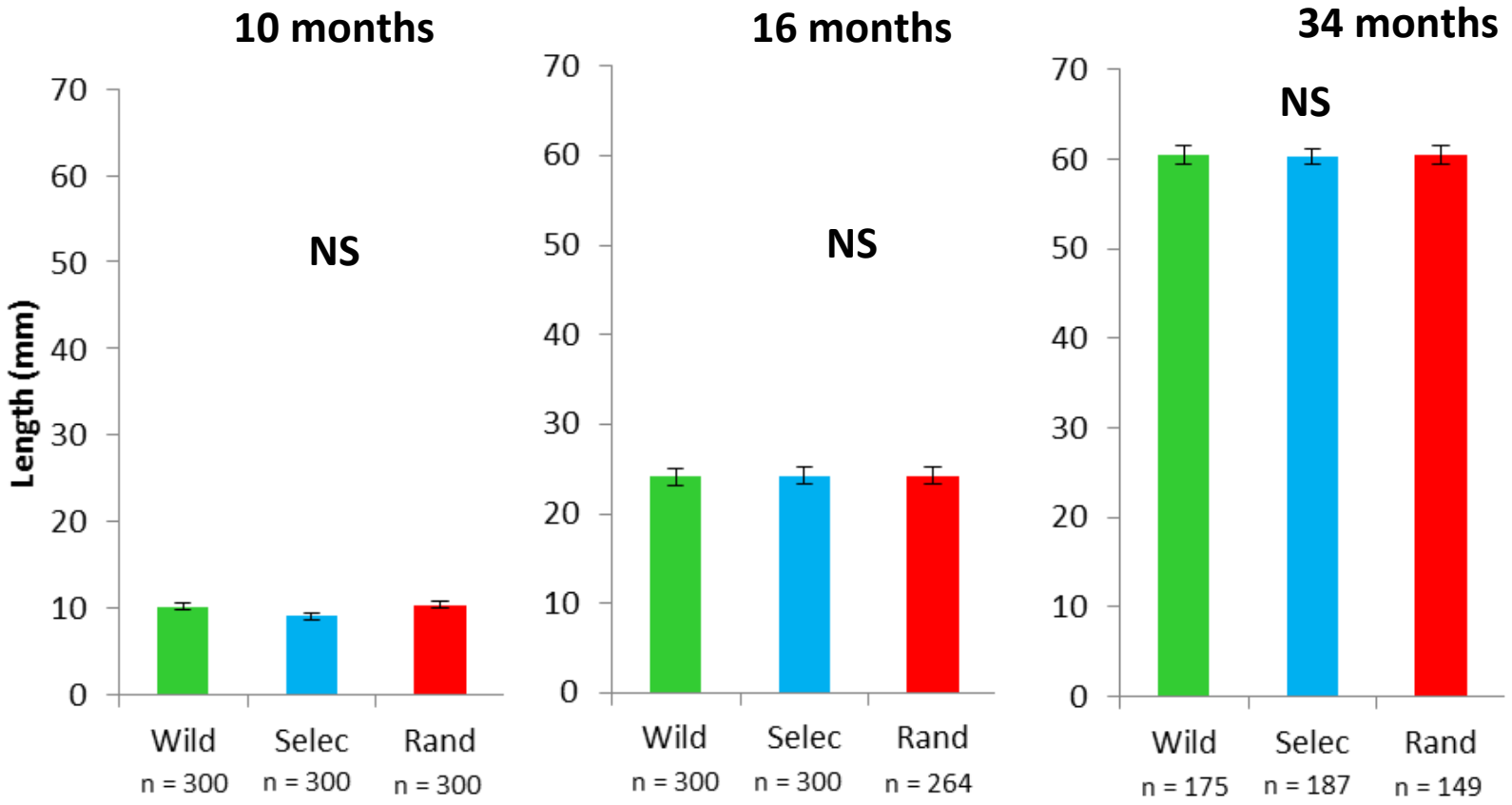
- Number of abalone that performed the 4 escape behaviours
- Number of mucus release

HIDING TEST



- Latency to reach the hiding place

No effects of broodstock origin on **length** and **weight** at 10, 16 and 34 months of age



Growth of *H. tuberculata* is heritable *(Lachambre et al., 2017).*

⇨ However the impact of the environment during ontogeny does not allow the expression of the genetic potential

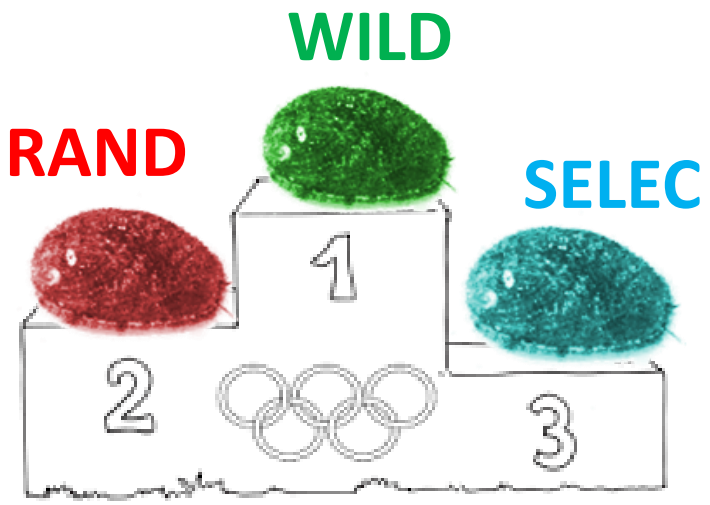
No effects of broodstock origin on **immune status** after a stress and **survival**

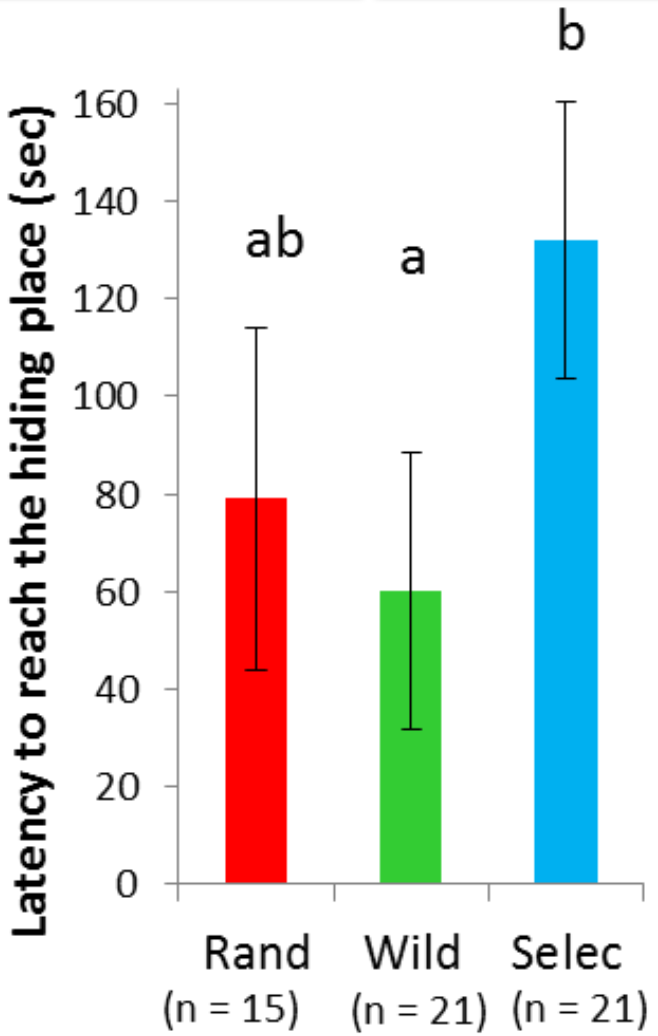
Parental origin	**WILD**	**SELEC**	**RAND**	**Origin effect F / H**	**P**
Phagocytosis efficiency (%)	13.3 ± 1.15	14.2 ± 1.21	14.3 ± 1.56	0.17	NS
Survival rate from 16 to 34 months (%)	80.7 ± 4.62	83.6 ± 4.62	75.0 ± 4.62	0.92	NS

⇨ selection pressure probably does not lead to rapid modification of genes associated with these functions

No effects on **feeding behaviour**, **righting behaviour** and **circadian rhythm**

BUT a reduced **hiding behaviour** in selected offspring

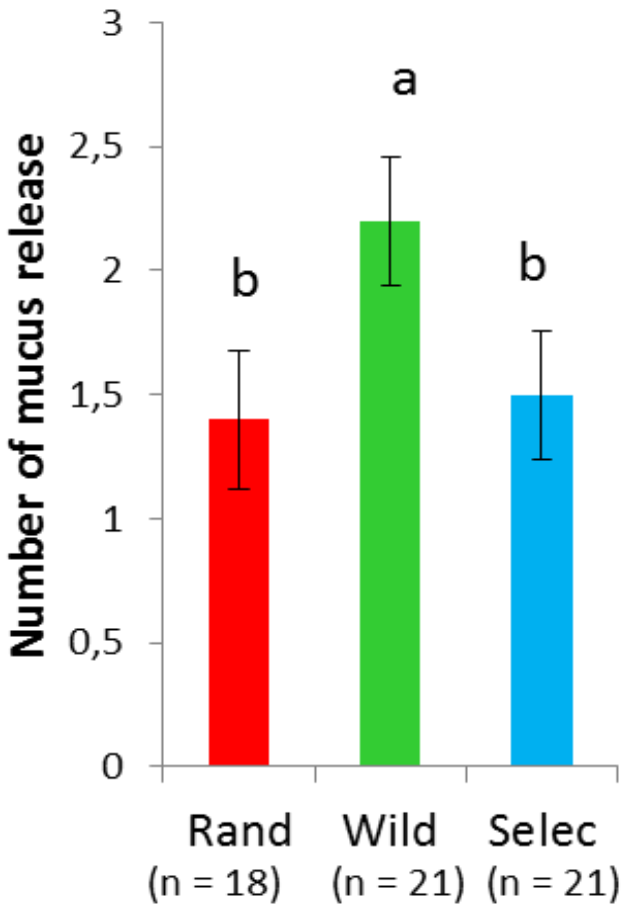




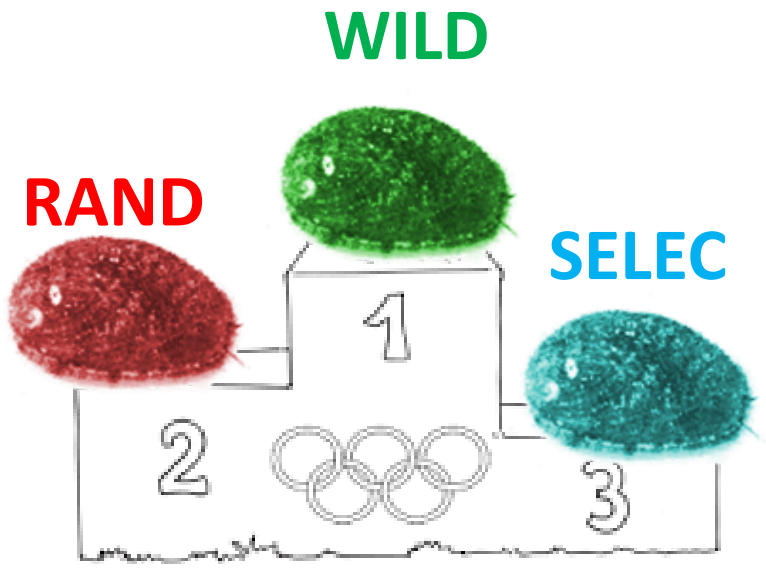
H. tuberculata : strong photophobic species

⇨ Change of the stimulus threshold required to trigger an escape response or receptive cells of the retina ?

A reduction of **escape behaviour** in selected offspring

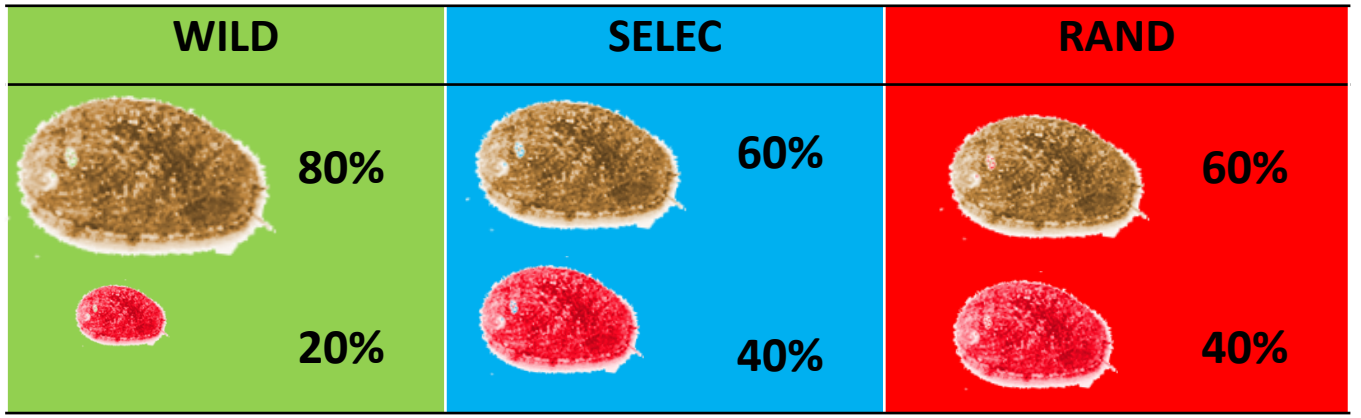


Parental origin	RAND	WILD	SELEC
Number performing the 4 escape behaviour	6 out of 18 [ab]	12 out of 21 [a]	5 out of 21 [b]

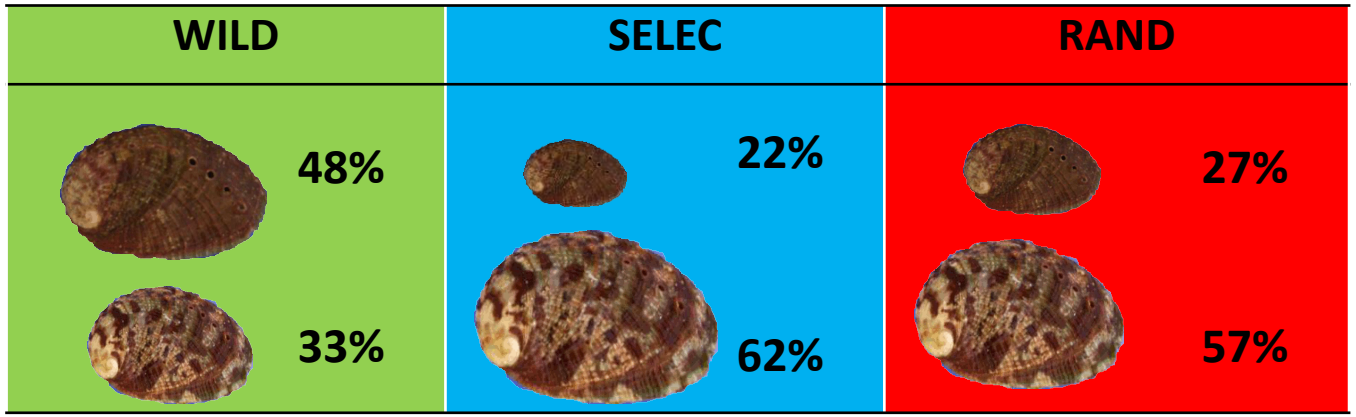


Alteration responses to a predator, both in quantity and quality
⇨ reduction in the production of mucus glands or increased stimulation threshold required to trigger escape response ?

Shell color : more orange-red shell in selected and randomly sampled abalone ($p < 0.05$)



Shell pattern : more shell with stripe in selected abalone ($p < 0.05$)

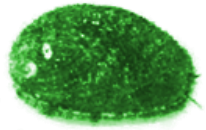


The color differentiation : a genetic origin (Williams 2017, Lachambre et al. 2017)

⇨ Relaxed natural selection AND unconscious selection for shells with a brighter color and nicer looking pattern ?

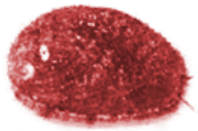
Domestication : a complex process with several mechanisms implicated in the transition from wild to farmed animals

WILD



- natural selection absent (relaxed selection),
- inadvertent selection due to the farm environment

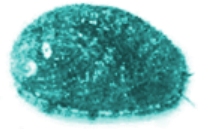
RAND



Modification of shell pattern and color, and small differences in responses to a predator

- + Unconscious selection

SELEC



No effect on length, but modification of shell pattern and color, responses to a predator and hiding behaviour

- + Conscious selection

Results => need to be confirmed on **younger abalone**, used for sea-enhancement program
(discuss with Pierre Chauvaud in front of his poster !)

The use of wild broodstock = clearly encouraged for marine stock enhancement programs based on **genetic** considerations, but they should also be used for **behavioural reasons**.

ACKNOWLEDGEMENTS

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GENORMEAU

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Moderate to high heritability of most traits

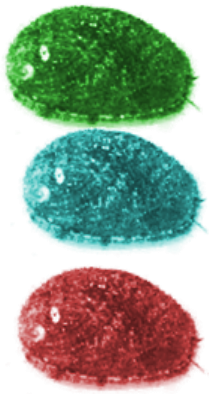
Traits	h^2	Mean	CV
Weight at harvest (g)	**0.54±0.17**	28	0.27
Length at harvest (mm)	**0.49±0.16**	58	0.1
Bleed Meat Weight (g)	**0.42±0.12**	2.41	0.48
Bleed Meat Yield (%)	**0.36±0.11**	31	0.09
Shell color (A score)	**0.71±0.14**	2.12	1
Foot color (B score)	**0.31±0.1**	0.41	0.3
Gonad Weight (g)	0.16±0.07	0.5	0.78
Gonad Yield (%)	0.09±0.06	5	0.45
Phagocytocis (%)	0.15±0.08	18	0.48
Glycogen content mg.g (%)	0.16±0.08	1.1	1.1
Individual duration of consumption over night (h)	0.13±0.07	1.4	0.9

Results: Genetic correlations

A trade off identified: A positive genetic correlation between growth and gonad investment

Interesting genetic correlation: Selection on growth will benefit on the color and on the bled meet yield

	Foot color	Bled meet yield	Gonad yield	Shell color	Phagocytosis	Glycogen content	Duration of nutrition over night
L32	0.37±0.19	0.30±0.21	0.72±0.23	0.23±0.21	0.19±0.30	0.23±0.27	0.15±0.30
P32	0.34±0.21	0.30±0.21	0.83±0.19	0.14±0.22	0.18±0.29	0.34±0.26	0.15±0.30



WILD

SELEC

RAND