Domestication modifies behaviour of first generation of domesticated abalone

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INTRODUCTION

The **domestication** of *Haliotis tuberculata* began recently. During this domestication process, abalone may acquire behavioural and physiological traits to become more adapted to their captive environment. These modifications could be the result of intentional selection on production traits, or of unintentional selection due to specific conditions experienced in the farm environment.

The objective of this experiment was to study the **effect of domestication process** on **growth, physiology and behaviour of progenies** of 3 different broodstock : **wild, farmed selected and farmed non-selected broodstock**

Table 1 : Teletchea and Fontaine (2014) domestication level

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 programme on specific goals

BROODSTOCK

4 REPETITIONS (4 spawning periods)

WILD	SELECTED	UNSELECTED
 Photo : France Haliotis	 Photo : France Haliotis	 Photo : France Haliotis
10 ♀ x 10 ♂ Brittany and Normandy	15 ♀ x 15 ♂ 5% selection on **weight**	15 ♀ x 15 ♂ randomly selected
LEVEL 3	*LEVEL 5*	*LEVEL 4*

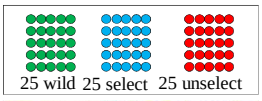
Domestication level of the offspring

REARING PROCEDURE

NURSERY PERIOD 1	NURSERY PERIOD 2	SEA-REARING PERIOD	LABORATORY
No control of density **10 months**	*Control of density and food* **16 months**	*Offspring in the same density and rearing environment*	**34 months**

⇨ One tank per treatment and per spawning


Photo : Gervois J.L.



⇨ In a cage, 3 treatments from the same spawning period


Photo : Gervois J.L.

⇨ 4 period of spawning, replicated 3 times
⇨ N = 12 cages in total

MEASURES
⇨ **Growth**
⇨ **Behaviour** (circadian rhythm and feeding behaviour, return test, predator test, hiding test)
⇨ **Immunity status** (phagocytosis and THC)

RESULTS AND DISCUSSION

NURSERY PERIOD 1 & 2

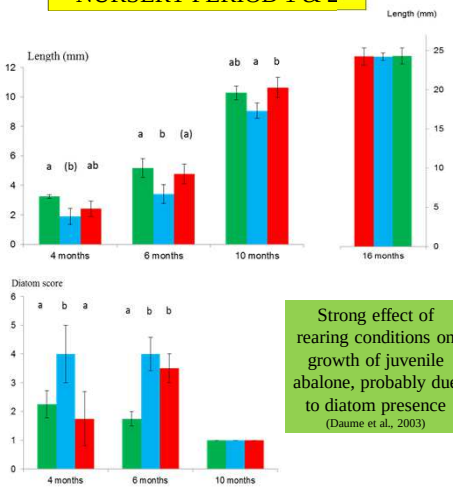


Figure 1 : Abalone length, at 4, 6, 10 and 16 months, and diatom score of rearing plates of abalone born from wild , selected on weight , and unselected broodstock

Strong effect of rearing conditions on growth of juvenile abalone, probably due to diatom presence (Daume et al., 2003)

GROWTH
⇨ Offspring of **selected broodstock smaller** than offspring of wild and unselected broodstock during the first nursery period (Fig.1)
⇨ No **difference** anymore at **16 months of age**

ENVIRONMENT EFFECT
⇨ Same *Ulvella* cover, but a higher quantity of diatoms for the selected juveniles

Statistical model : mixed model with treatment and period as fixed effects, and the tank as random factor (var-cov matrice : AR1)

34 MONTH OF AGE

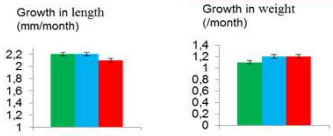


Figure 2 : Growth in length and weight juveniles born from wild , selected on weight and unselected broodstock

GROWTH
⇨ No effect of broodstock origin on offspring length and weight growth at 34 months of age (Fig. 2)

Growth is heritable (Lachambre et al., 2017).
However the impact of the environment during ontogeny does not allow the expression of the genetic potential


Photo : Bisch T.


Photo : Coheleach M.

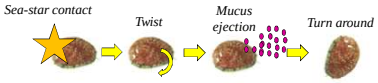


Figure 3 : Circadian rhythm apparatus, hiding test device and behavioural response to sea-star contact

HIDING TEST
⇨ Abalone born from **selected broodstock** took **longer to do the first movement** and to **reach the hiding place** compared to abalone born from **wild broodstock** (Table 2)

PREDATOR TEST
⇨ Abalone from **selected broodstock** showed a lower **escape behaviour** compared to abalone born from **wild broodstock**

PHYSIOLOGICAL RESPONSE AFTER A SHAKING STRESS
⇨ No modification of pagocytosis rate
⇨ Higher THC response of selected offspring compared to unselected offspring

CIRCADIAN RHYTHM and FEEDING BEHAVIOUR
⇨ No effect on circadian rhythm during a two days 24h observation
⇨ No effect on feeding behaviour during a 1-month supervision

Table 2 : Behavioural responses during a hiding and predator tests of offspring from 3 different broodstock origin (wild, farmed selected on weight and farmed randomly selected broodstock, n = 19 abalone minimum per treatment) (Lsmean ±s.e.m)

	Wild (n=22)	Selected (n=22)	Unselected (n=22)	F / χ2	P
Hiding test					
Latency of the first movement (s) *	$30^{a} \pm 5.0$	$48^{b} \pm 5.0$	$39^{ab} \pm 6.1$	4.02	*
Latency to reach the hiding place (s) **	$60^{a} \pm 28.3$	$132^{b} \pm 28.5$	$79^{ab} \pm 35.0$	6.53	*
Predator test					
Latency of the first movement (s)	11.8 ± 2.29	14.3 ± 2.31	14.9 ± 2.50	2.58	NS
Number of mucus ejection	$2.2^{a} \pm 0.26$	$1.5^{b} \pm 0.26$	$1.4^{b} \pm 0.28$	4.10	*
Number of abalone having performed the 3 escape behaviours ***	12 out of 21 [a]	5 out of 21 [b]	6 out of 18 [ab]	5.20	°

** log transformation **Kruskal Wallis test *** Khi-square test*

Statistical model : mixed model with treatment and spawning as fixed effects, and the cage as random factor

Offspring from selected broodstock showed lower escape behaviours compared to offspring from wild broodstock, unselected progenies being intermediate
⇨ Response to predator highly heritable (Sinn et al., 2006)
⇨ The selection on growth traits had an unintentional effect on behaviour

CONCLUSION

These results suggest that the first stages of selection of *H. tuberculata* did not induce a significant modification of growth and physiology. This was linked to preponderant environment effect during nursery period. The behavioural observations suggest that selected progenies might be less adapted to wild environment. Domestication trade off was observed right from the first generation. These results are essential for stock enhancement programs and also suggest that under-optimal conditions in early rearing environment may compromise the selection efforts for growth.