Boldness in fishes: A selection tool for aquaculture or a personality type with no apparent return?

Associate Professor
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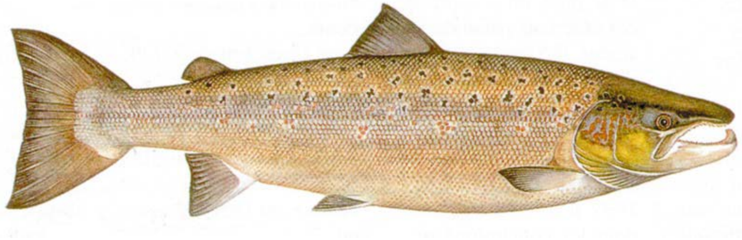
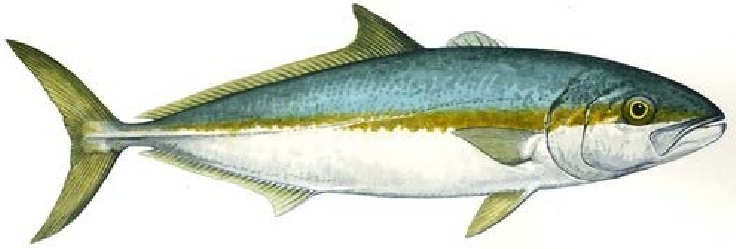
Danish aquaculture production

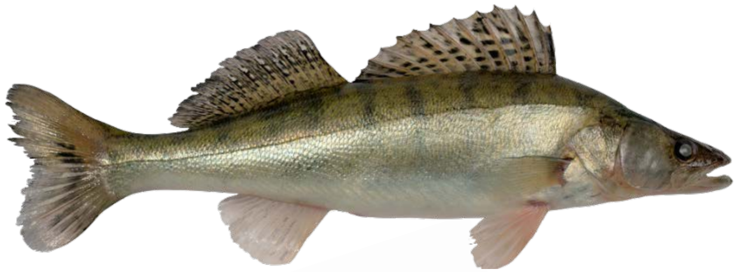
Species



Atlantic salmon (*Salmo salar*)
Danish Salmon (1200 t/yr)
Atlantic sapphire (2000 t/yr)



Kingfish (*Seriola lalandi*)
Sashimi Royal (1200 t/yr)



Pike perch (*Sander lucioperca*)
AquaPri (1500 t/yr)

Eel (*Anguilla anguilla*)
~500 t/yr

Organic Rainbow trout (*Oncorhynchus mykiss*)
(1100 t/yr)

- ✓ GMO free
- ✓ No colouring
- ✓ No chemical therapeutants
- ✓ Traceability
- ✓ Extensive (25 kg m^{-3})
- ✓ Good O_2
- ✓ Added value
- ✓ Less medicine use

Promoting organic trout production

Project RobustFish

1. Is it possible to select robust fry early in the production process?
2. How do non-marine lipids in the diet influence stress tolerance and disease resistance?
3. Is there an market for larger production volumes of organic RBT and might conventional farmers convert?

Stress coping style

ELSEVIER
ANIMAL BEHAVIOUR, 2008, 75, 309–318
doi:10.1016/j.anbehav.2007.05.026
Available online at www.sciencedirect.com
ScienceDirect

Temperament, risk assessment and habituation to novelty in eastern chipmunks, *Tamias striatus*

JULIEN G. A. MARTIN & DENIS RÉALE
Université du Québec à Montréal

ethology
international journal of behavioural biology
Explore this journal >

Consistency in Context-specific Measures of Shyness and Boldness in Rainbow Trout, *Oncorhynchus mykiss*

Alexander D. M. Wilson, E. D. Stevens

Contents lists available at SciVerse ScienceDirect
Animal Behaviour
journal homepage: www.elsevier.com/locate/anbehav
ELSEVIER

Personality traits across ontogeny in firebugs, *Pyrrhocoris apterus*

Enikő Gyuris[a,*], Orsolya Feró[a,b], Zoltán Barta[a]

Contents lists available at SciVerse ScienceDirect
Animal Behaviour
journal homepage: www.elsevier.com/locate/anbehav
ELSEVIER

Boldness, trappability and sampling bias in wild lizards

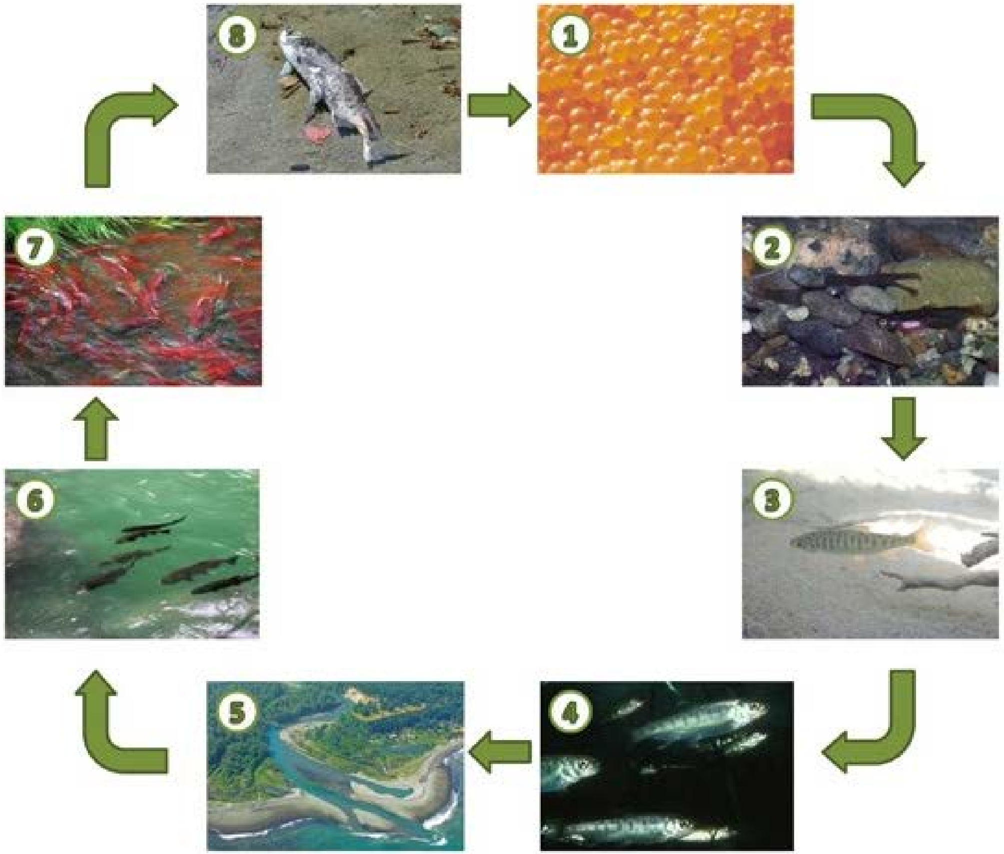
Alecia J. Carter[a,b,*], Robert Heinsohn[a], Anne W. Goldizen[c], Peter A. Biro[d]

ELSEVIER
ANIMAL BEHAVIOUR, 2008, 75, 433–442
doi:10.1016/j.anbehav.2007.05.008
Available online at www.sciencedirect.com
ScienceDirect

Development of shy/bold behaviour in squid: context-specific phenotypes associated with developmental plasticity

DAVID L. SINN*†, SAMUEL D. GOSLING‡ & NATALIE A. MOLTSCHANIWSKYJ*

Fry swim-up



Hatching, emergence time, and personality..

Early emergers have first access to feed and territorial space, but suffer under high predation pressure.

	Predator introduced after emergence					
	Exp 1			Exp 2		
	N initial	N end	% survival	N initial	N end	% survival
I	39	30	76.9	25	8	32.0
II	88	45	51.1	98	12	12.2
III	51	15	29.4	62	5	8.1

Data from Brännäs (1995)

Emergence time correlates with

- ✓Access to territory
- ✓First feeding
- Dominance and boldness

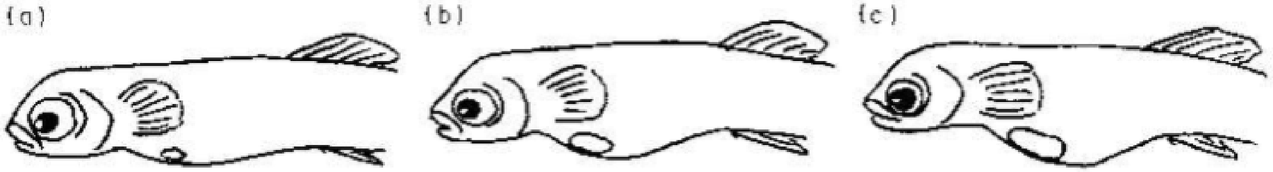


FIG. 1. Diagrammatic representation of the extent of yolk sac remaining at the time of classifying fish into (a) Early, (b) Intermediate and (c) Late feeding groups.

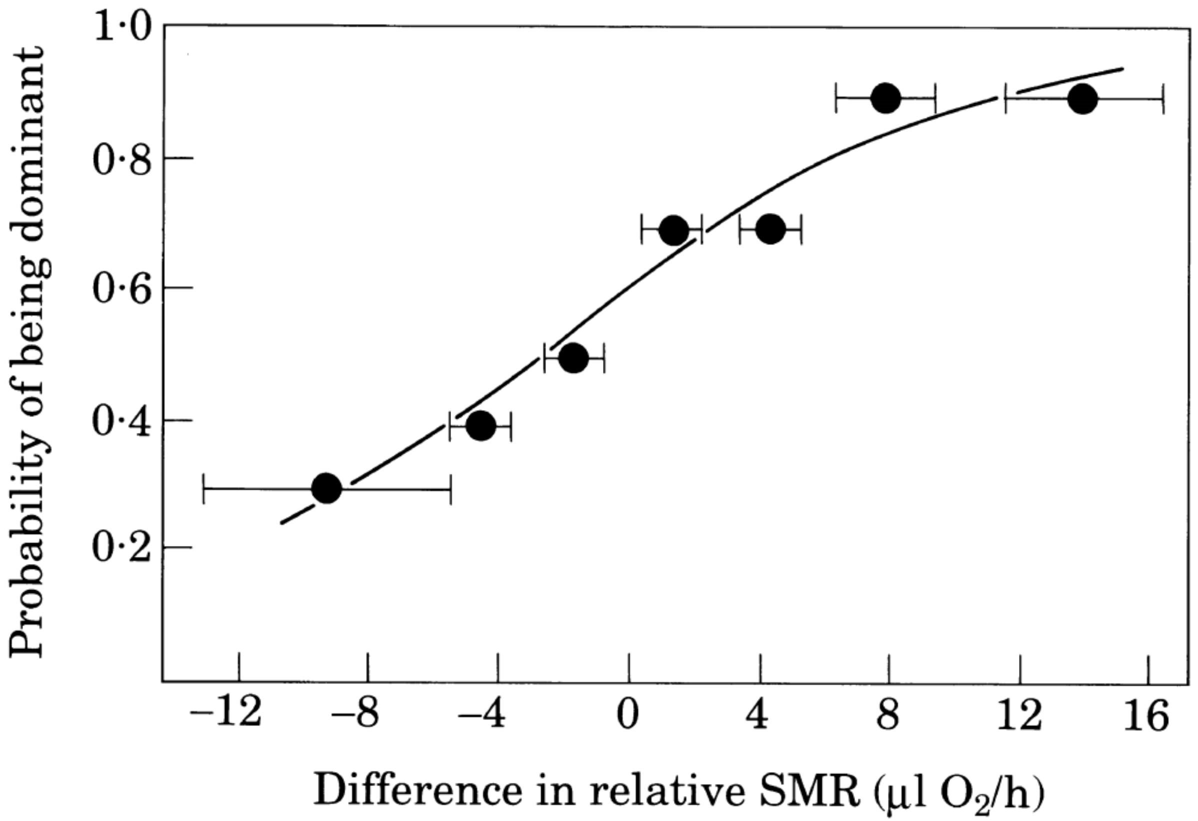
Early predictors of life-history events: the link between first feeding date, dominance and seaward migration in Atlantic salmon, *Salmo salar* L.

N. B. METCALFE AND J. E. THORPE*

Journal of Fish Biology (1992) **41** (Supplement B), 93–99

TABLE I. Breakdown of the characteristics of the dominant fish in 113 pairs of sibling Atlantic salmon fry, tested for dominance within 2 weeks of first feeding. See text for definitions and statistical analysis

		n
Dominant fish was:	earlier to begin feeding and larger	52
	earlier to begin feeding and smaller	24
	later to begin feeding and larger	20
	later to begin feeding and smaller	17



Metabolic rate, social status and life-history strategies in Atlantic salmon

NEIL B. METCALFE*, ALAN C. TAYLOR* & JOHN E. THORPE†

10000 fertilized all-female eggs were obtained from Seven Springs Hatchery in Ireland and incubated in a triplicate system of hatching trays. Hatching began after 365 degree days.

Swim-up began 1 week later. A total of ~9000 fry were recovered according to their time of emergence in 20% fractions.

The early, middle and late emerging fractions were retained and reared in triplicate tank systems on commercial diets.

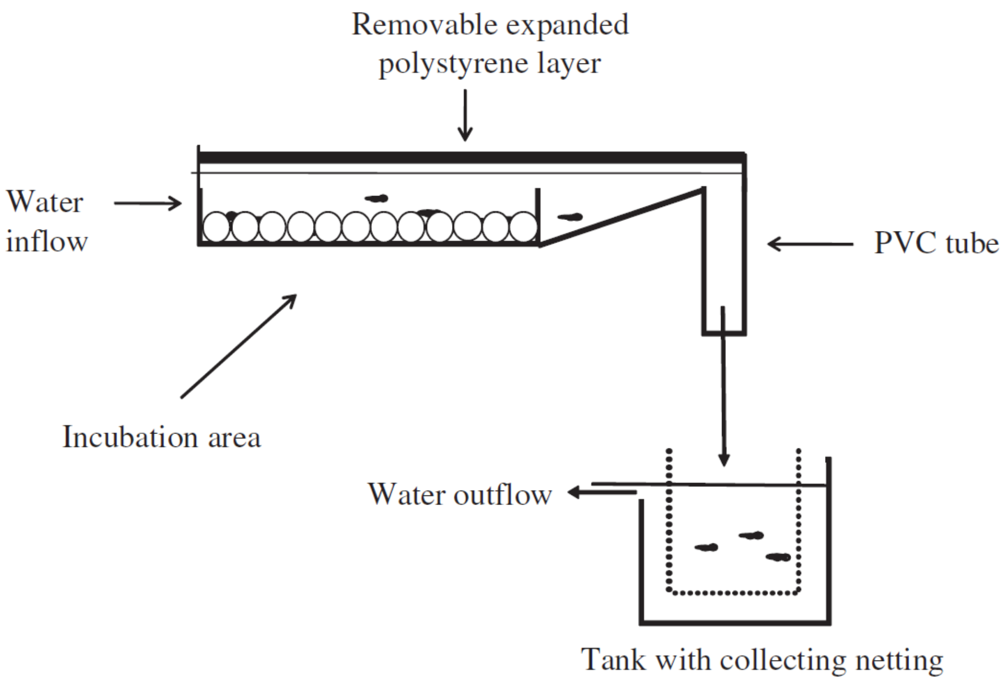


Fig. 1. Principal drawing of an incubator for sorting of Atlantic salmon larvae with respect to time to emerge from the artificial redds, in this case golf balls. Larvae were flushed downstream to a collecting tank when they emerged from the incubator.

Juvenile growth

Prior to any physiological or behavioural experiments, the growth of juveniles was followed from a size of 10 g to 50 g.

	Early	Middle	Late	p
Initial mass (g)	14.2 ± 1.1	11.6 ± 0.5	12.1 ± 0.7	0.125
Final mass (g)	54.3 ± 2.2	48.0 ± 1.2	49.5 ± 1.6	0.092
Weight gain (g)	40.2 ± 1.1	36.5 ± 0.7	37.4 ± 1.0	0.075
FCR (g feed g^{-1})	0.80 ± 0.01	0.80 ± 0.00	0.80 ± 0.01	0.879
SGR (% day^{-1})	2.28 ± 0.11	2.50 ± 0.05	2.45 ± 0.07	0.196

No indication that any fraction have better growth or feed utilization during juvenile growth.

Screening

Behaviour

Dropping an object into their arena and leaving it hanging (startle response and novel object): Fish seek shelter and measures are time to reappear, time to emerge, time spent exposed, approach or proximity to novel object.

Respiratory physio

Chase protocol: Standard metabolic rates, oxygen debt, maximum oxygen uptake rates, recovery times

Stress physio

Resting cortisol levels followed by low water stress challenge: Magnitude of the cortisol response and glucose mobilisation

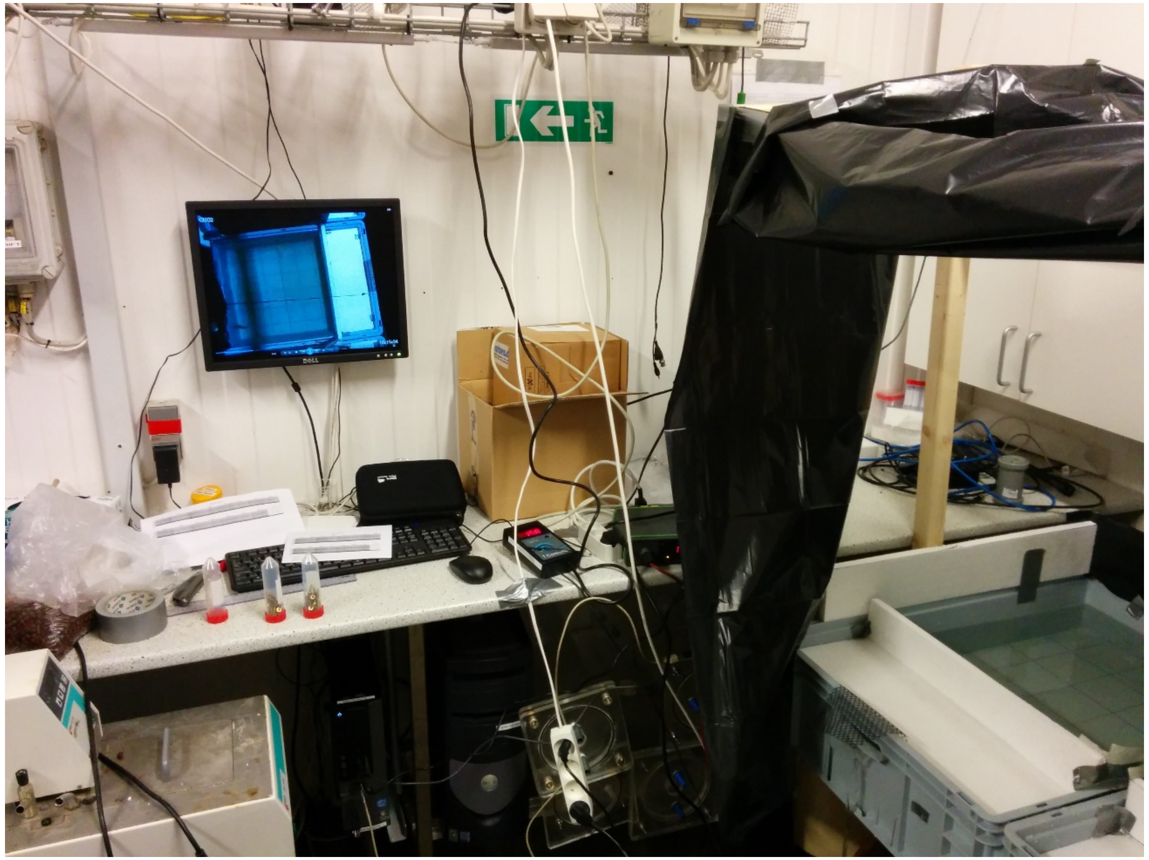
Production

Starvation and growth

Weight loss in individuals subjected to starvation for 10 days, weight gain following ad lib feeding for 7 days.

Weight loss during co-habitation with other fractions, competitive advantages in a restrictive feeding regime

Behaviour

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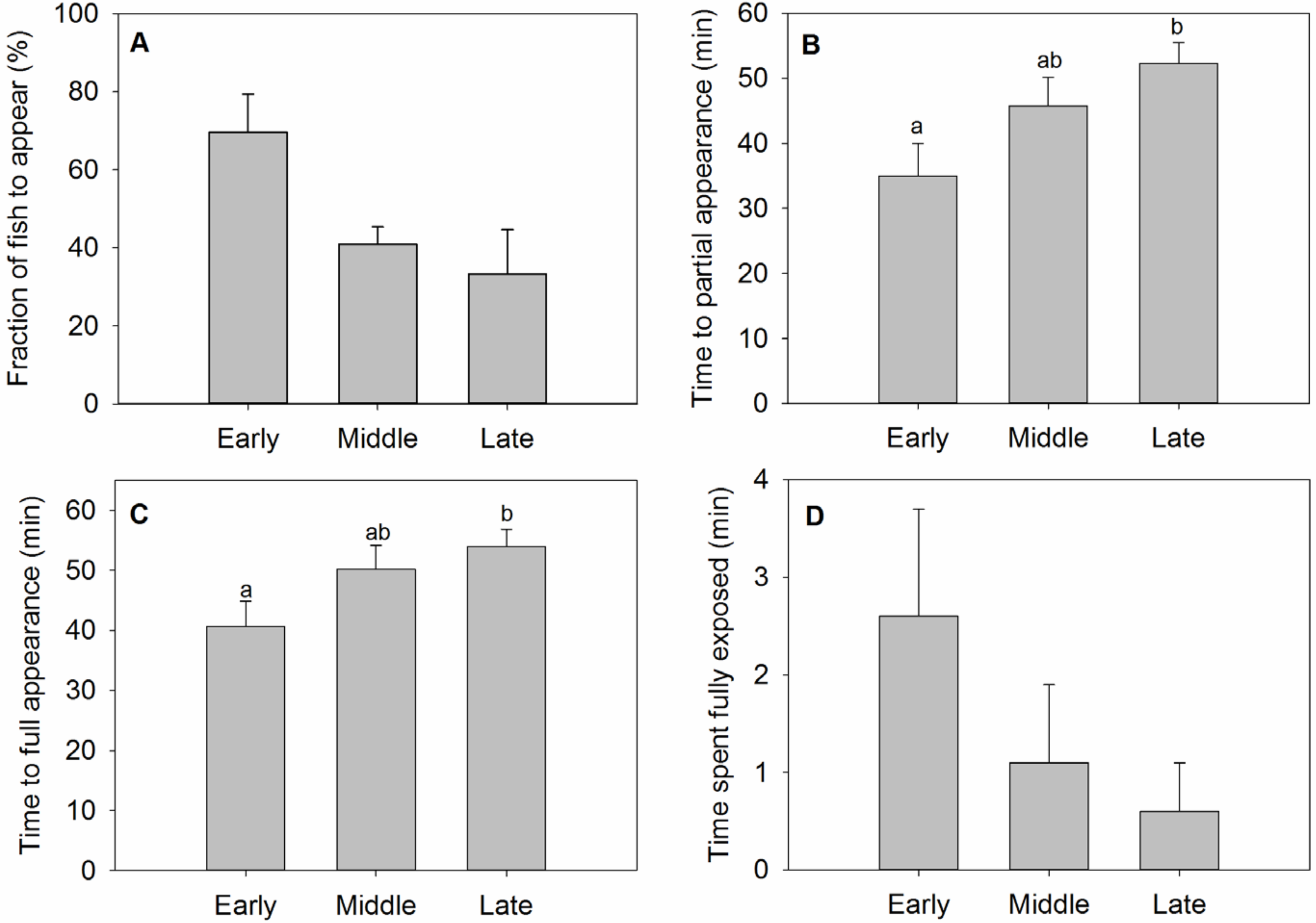
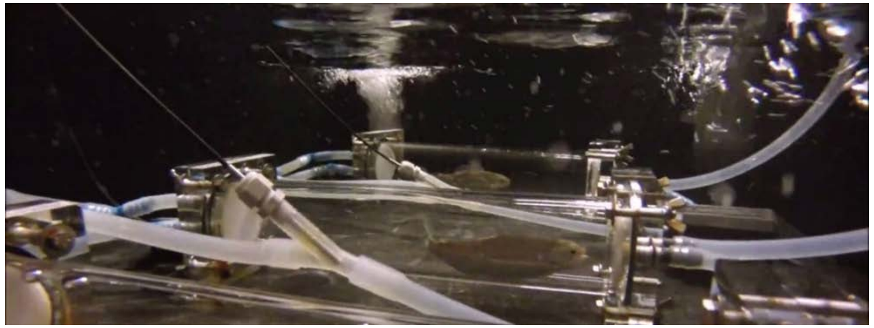
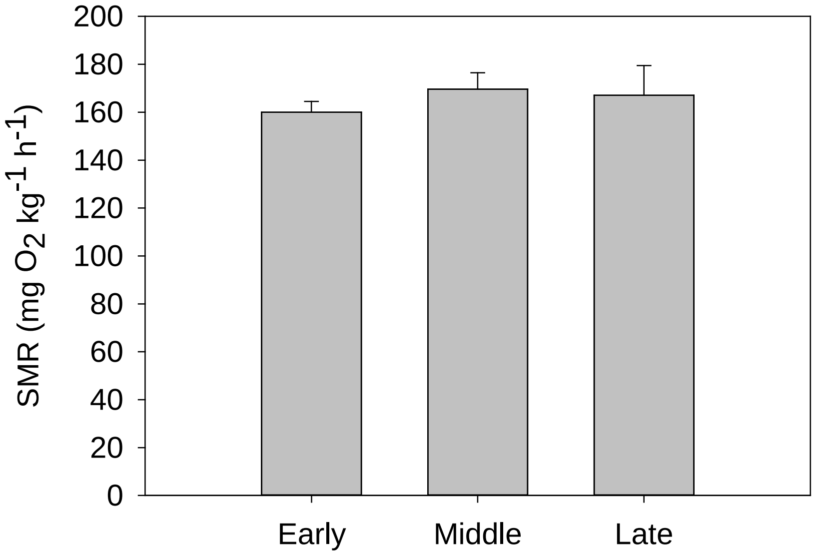
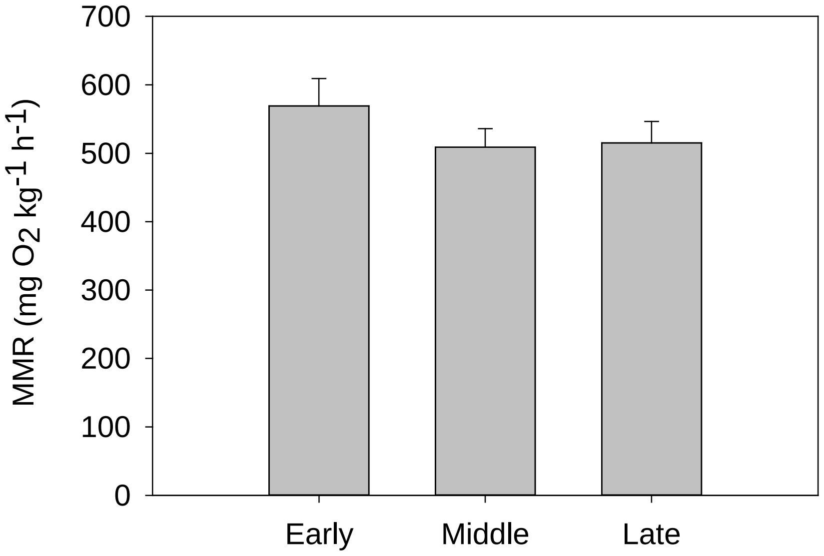
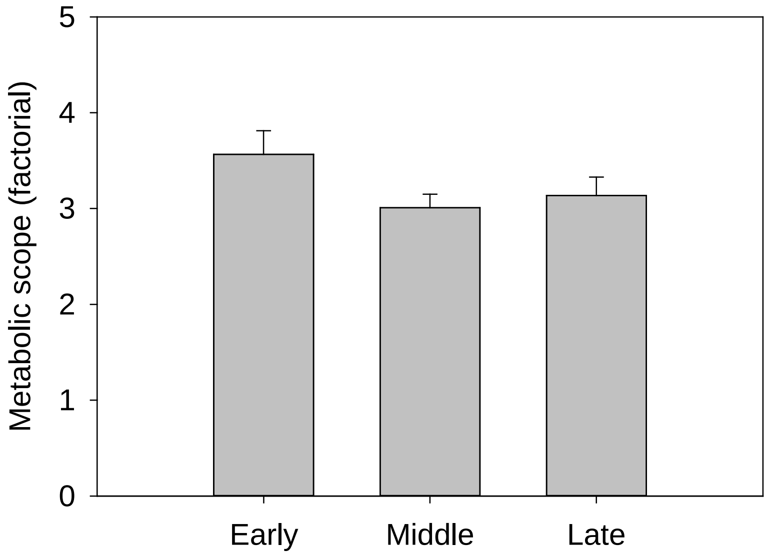

A
Fraction of fish to appear (%)
100
80
60
40
20
0
Early
Middle
Late
B
Time to partial appearance (min)
60
50
40
30
20
10
0
a
ab
b
Early
Middle
Late
C
Time to full appearance (min)
60
50
40
30
20
10
0
a
ab
b
Early
Middle
Late
D
Time spent fully exposed (min)
4
3
2
1
0
Early
Middle
Late

Metabolic rates

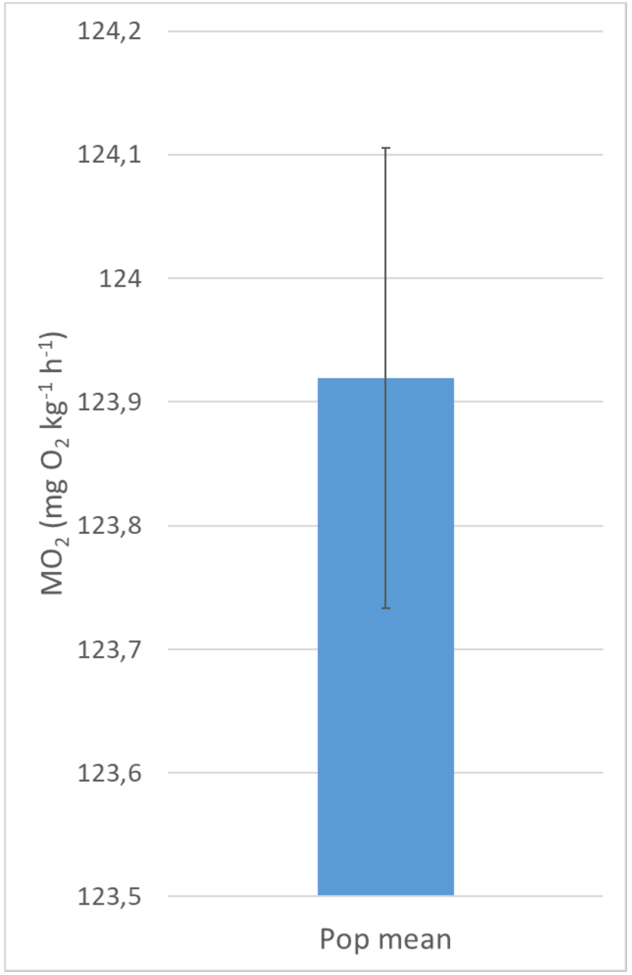


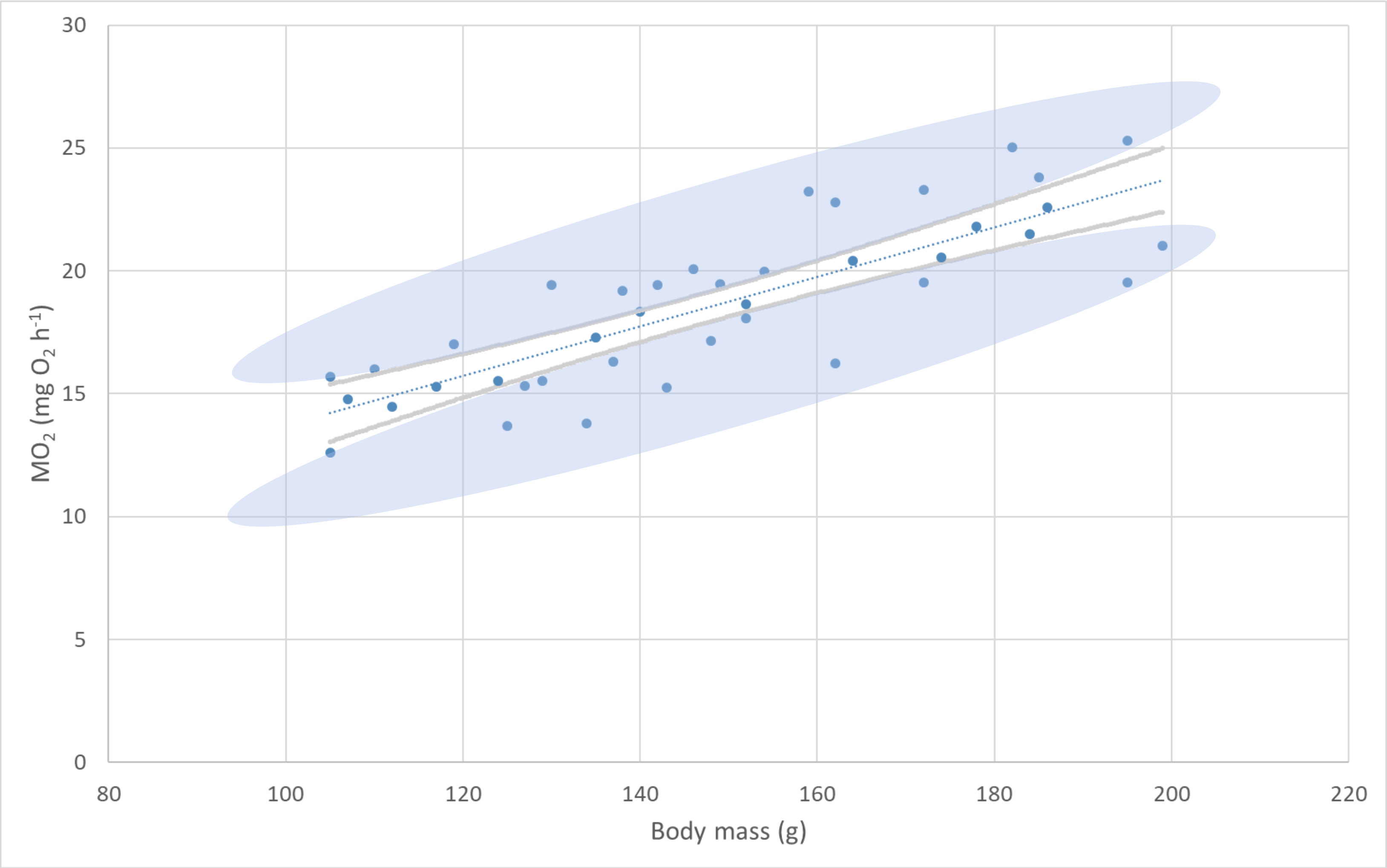




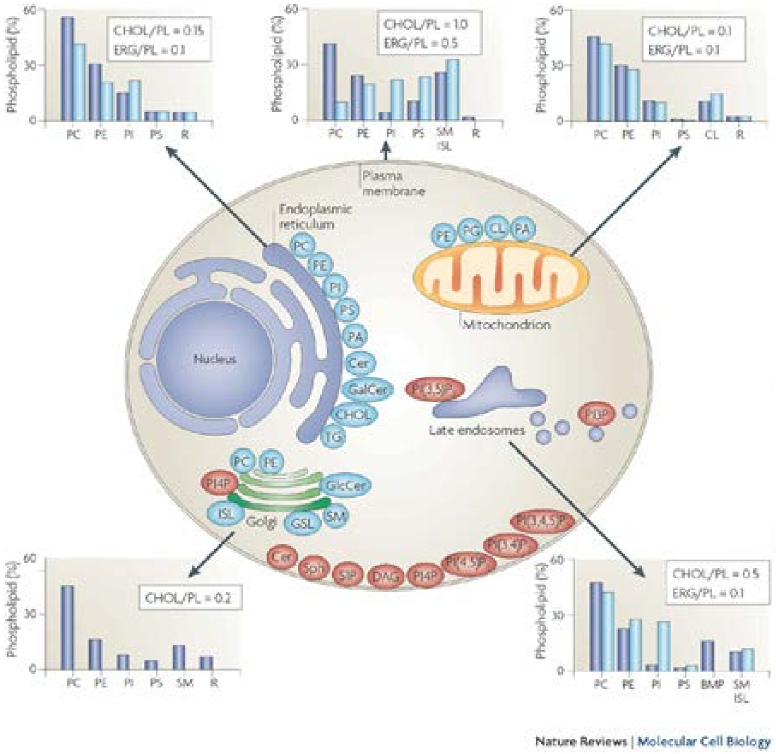


Metabolic rate as an indicator



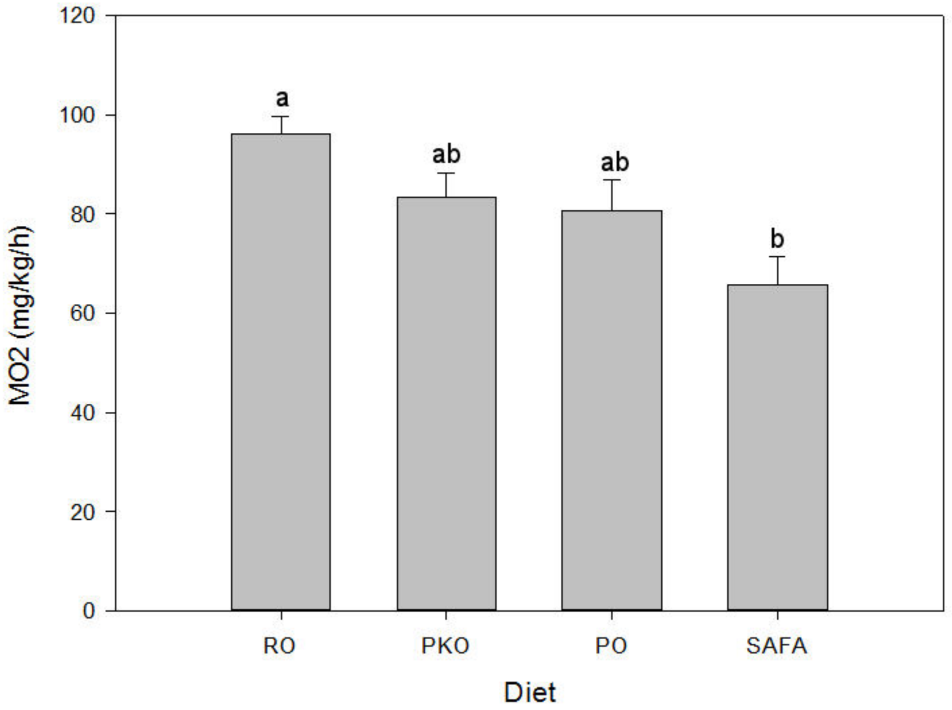


Low and high SMR phenotypes



OPM database

Van Meer et al., 2008



Standard metabolic rate in rainbow trout fed diets with lipid from rapeseed oil (RO), palm kernel oil (PKO), palm oil (PO), or South Atlantic fish oil (SAFO).

Skov, unpublished

Standard metabolic rate is the sum of parts (and parts may vary)

FISHERIES SCIENCE 2003; **69**: 687–694

Relationship between summated tissue respiration and body size in a marine teleost, the porgy *Pagrus major*

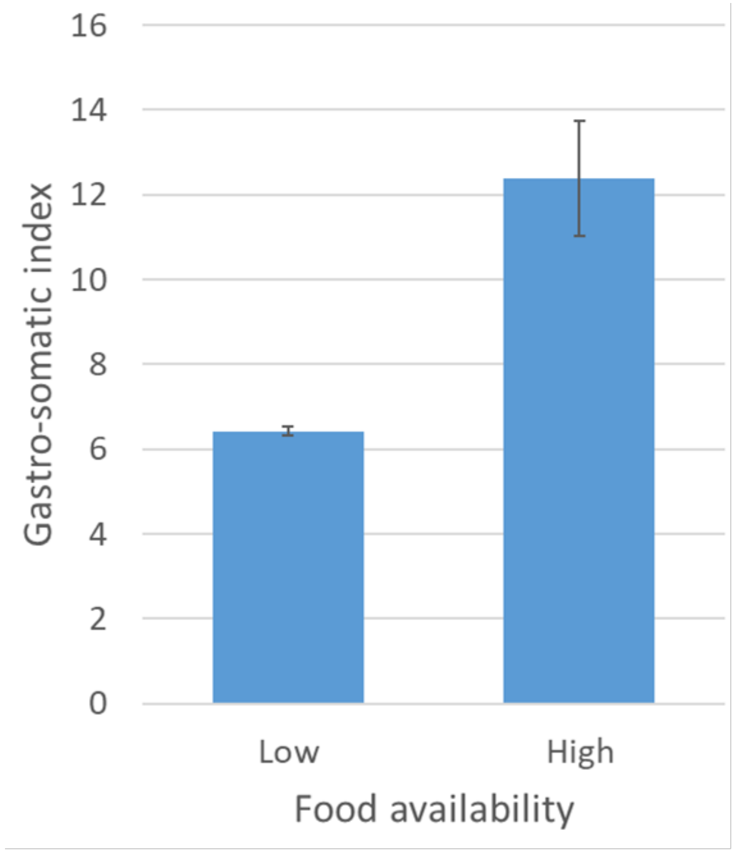
SHIN OIKAWA*[a] AND YASUO ITAZAWA[b]

Organ or part	$QO_2 = cW^d$ c	d
Juvenile and adolesc		
Head	5.63	−0.233
Trunk	1.42	−0.133
Fins	14.81	−0.025
Viscera[‡]	18.99	−0.027
Adolescent and later		
Head		
Brain		
Brain	31.58	−0.052
Brain		
Gill filaments	47.54	−0.071
Gill filaments		
Trunk		
Trunk		
White muscle	0.80	−0.035
Scales[†] of trunk	9.54	−0.248
Skin of trunk	3.56	−0.009
Stomach	22.45	−0.064
Pyloric ceca	27.54	−0.005
Intestine	20.70	−0.051
Hepatopancreas	13.39	−0.130
Spleen	47.63	−0.202
Spleen		
Head kidney	32.68	−0.088
Body kidney	70.69	−0.109
Atrium	14.22[¶]	ND
Ventricle	13.34[¶]	ND
Arterial bulb	8.30[¶]	ND
Gonads	7.47[¶]	ND
Fins		
Pectoral fins	20.54	−0.153
Ventral fins		
Dorsal fin	13.96	−0.177
Anal fin		
Caudal fin	20.04	−0.215

Table 2 Change in relative contribution of metabolism of a part, an organ or an organ system to whole metabolism ($M_{in\ vitro}$) with increasing body mass

Part or organ	Relative metabolism (%) at body mass of: 1 g	10 g	100 g	1000 g
Parts				
Head, including brain and gill	37	34	31	29
Trunk	20	25	27	30
Fins	9	7	6	5
Viscera*	29	29	29	29
Organs				
Brain	16	9	4	1
Gill filaments	5	9	13	19
Digestive organs[†]	25	23	22	21
Head kidney and body kidney	4	4	5	5
Cutaneous parts				
Dermis other than fins	6	7	9	11
Scales with epithelium	23	14	8	6
Fins	9	7	6	5

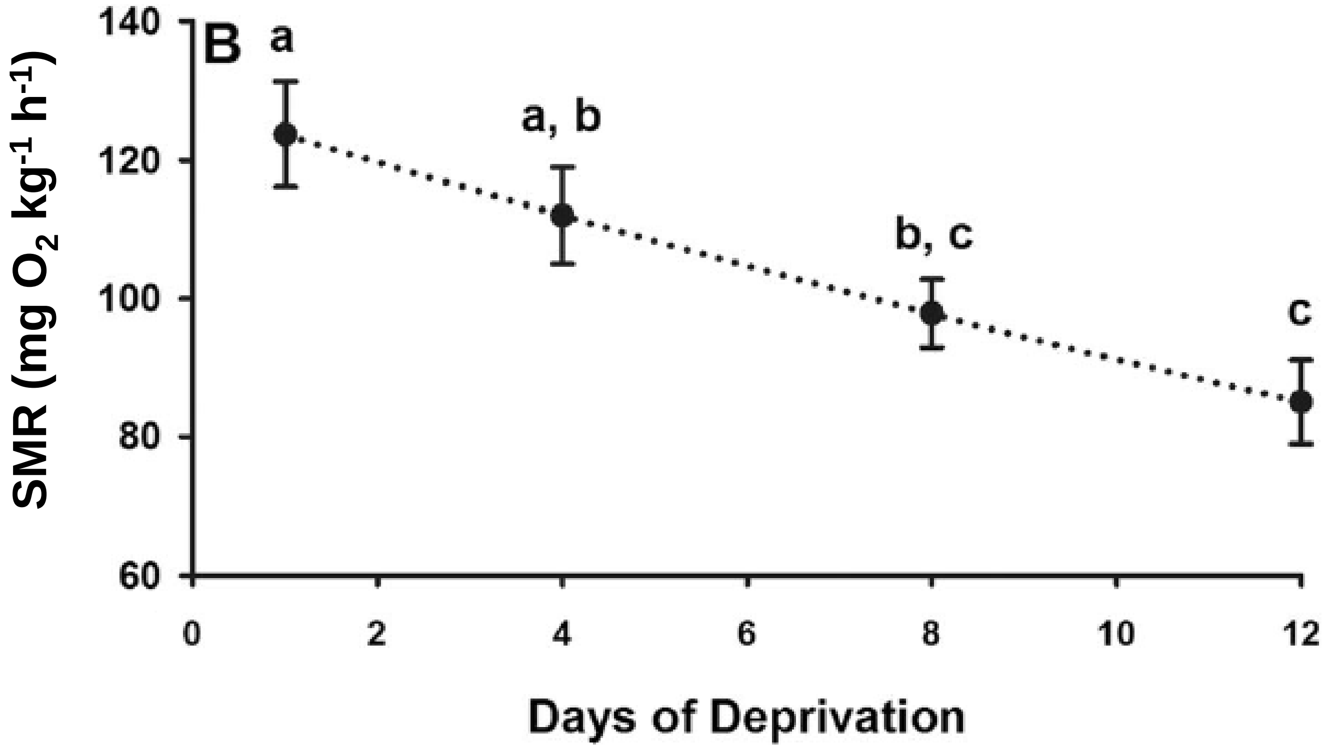
* Stomach, pyloric ceca, intestine, hepatopancreas, spleen, head kidney, body kidney, atrium, ventricle, arterial bulb and gonads.
[†] Stomach, pyloric ceca, intestine and hepatopancreas.



Reba carp, *Cirrhinus reba*

Ramasamy and Rajangam, 2017

SMR drops in response to food deprivation



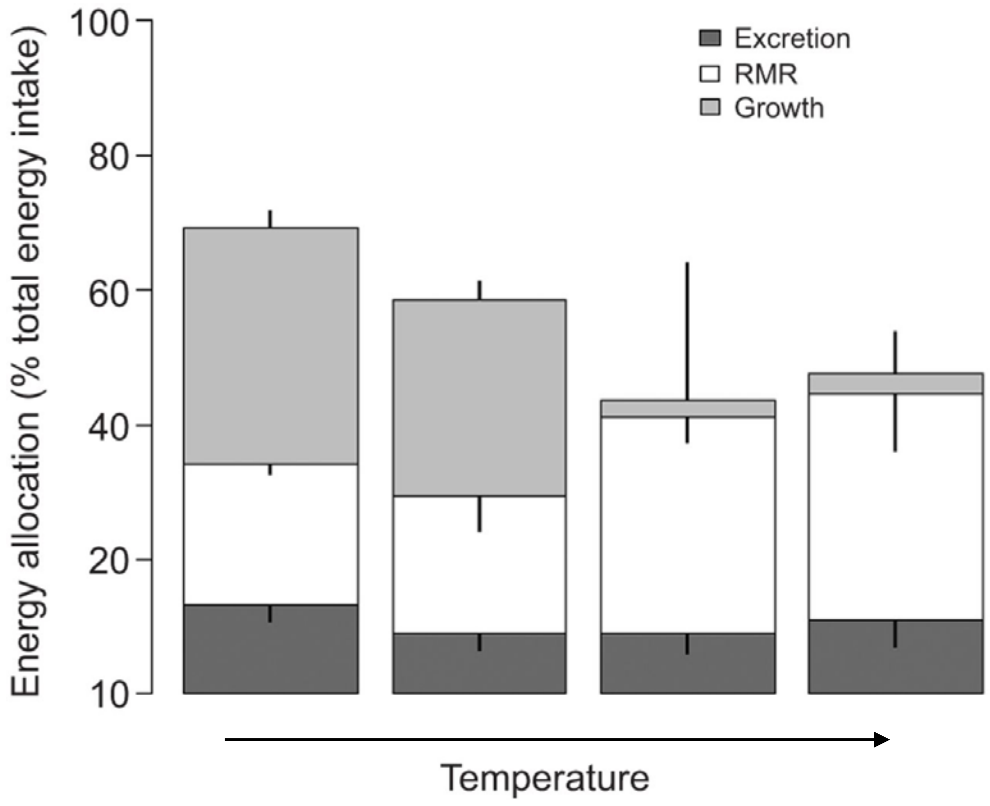
Fish Physiol Biochem
https://doi.org/10.1007/s10695-017-0438-0

Short-term feed and light deprivation reduces voluntary activity but improves swimming performance in rainbow trout *Oncorhynchus mykiss*

J. R. Khan · C. C. Lazado · C. Methling · P. V. Skov

Routine metabolism

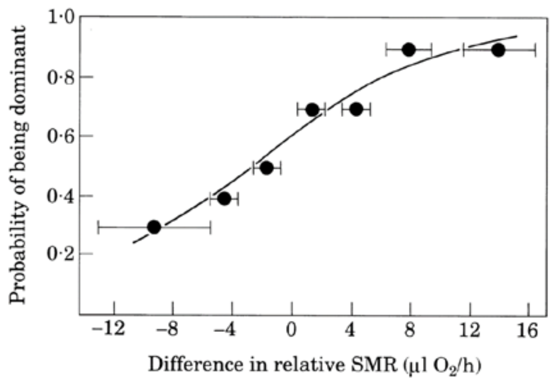
- Inconsistent use of terminology in oxygen use studies.
- Standard, basal, resting, and routine metabolic rate are used interchangeably by many.
- Standard metabolic rate, in energy equivalents, represents <5% of energy intake.
- Routine metabolic rate involves a behavioural component, as such is highly variable and may represent ≥20% of energy intake.



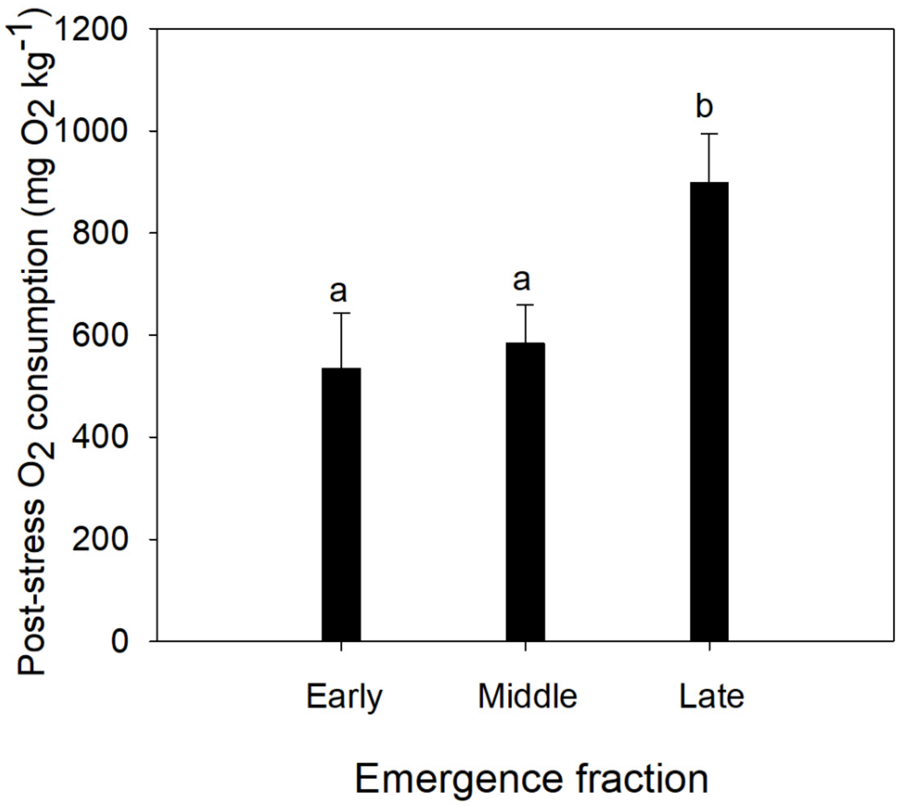
Elevated temperature causes metabolic trade-offs at the whole-organism level in the Antarctic fish *Trematomus bernacchii*

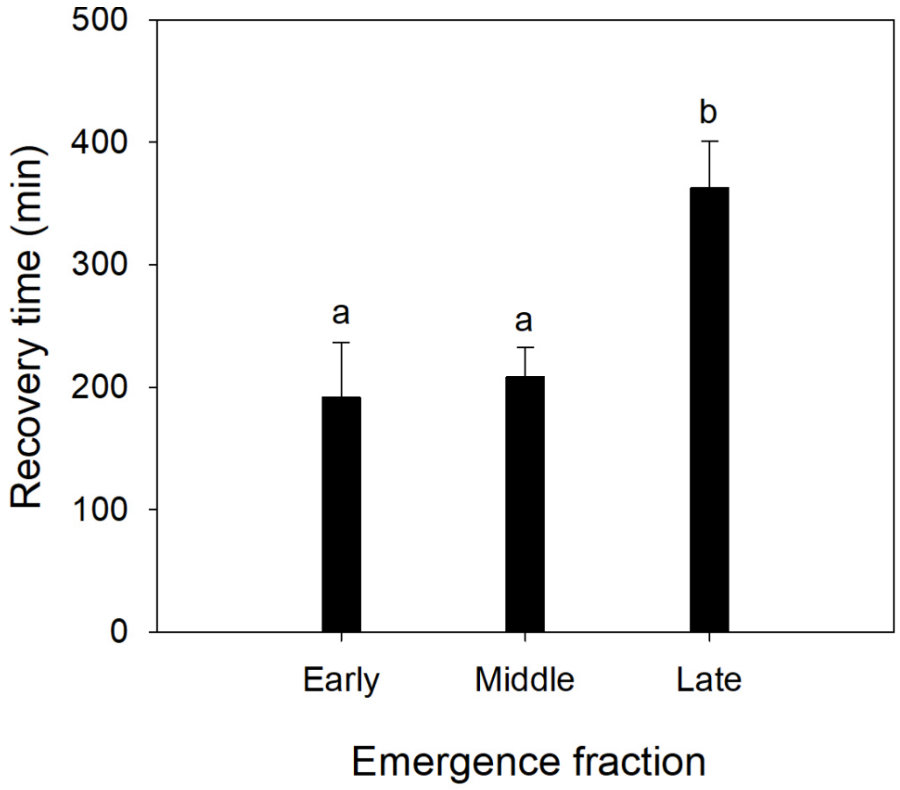
Tina Sandersfeld[1,*], William Davison[2], Miles D. Lamare[3], Rainer Knust[4] and Claudio Richter[1]

The Journal of Experimental Biology (2015) 218, 2373-2381 doi:10.1242/jeb.122804

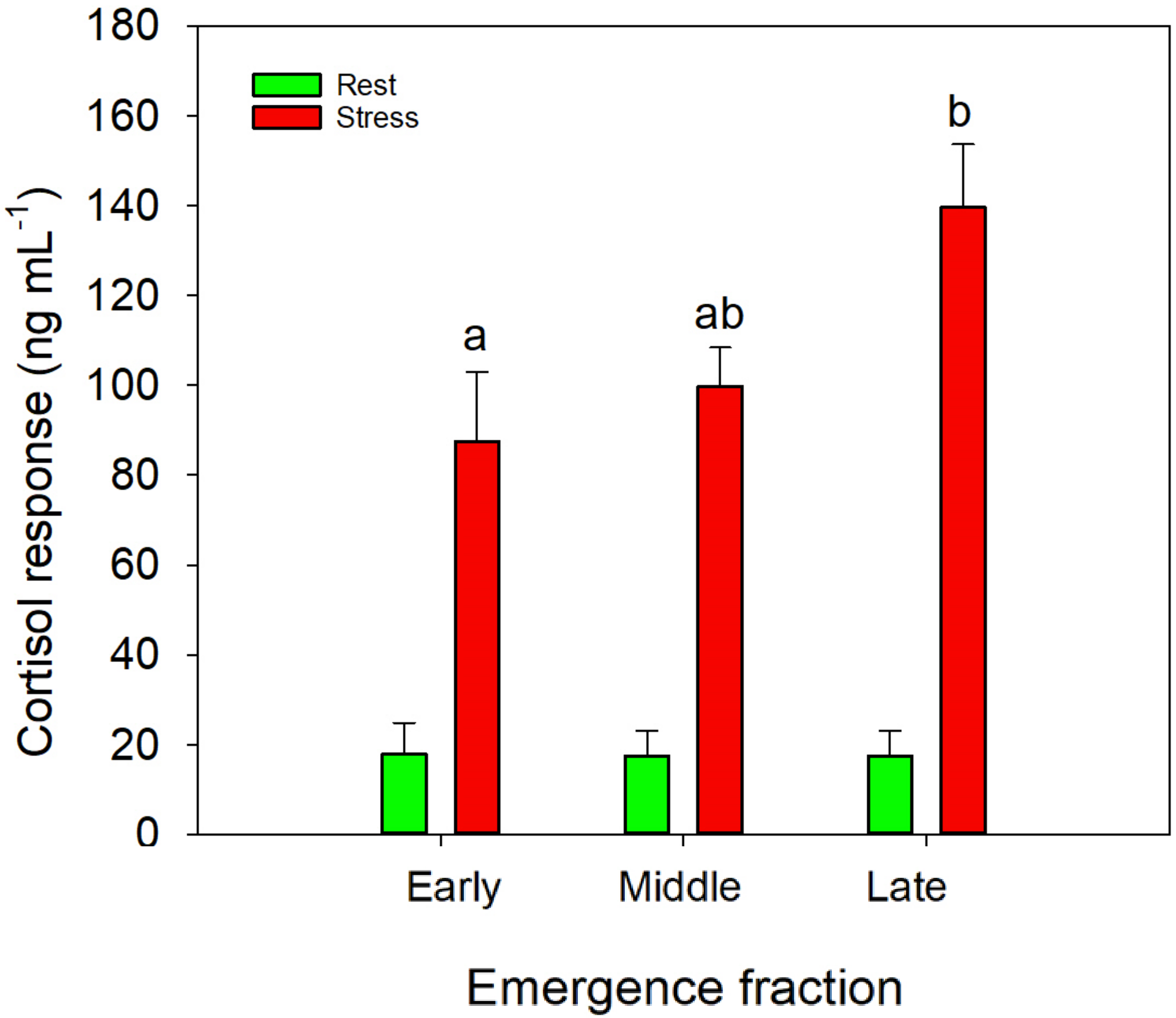


Oxygen debt and recovery





HPI activity and reactivity



Conclusions (I)

Behavioural and physiological results demonstrate that different emergence fractions differ in certain characteristics;

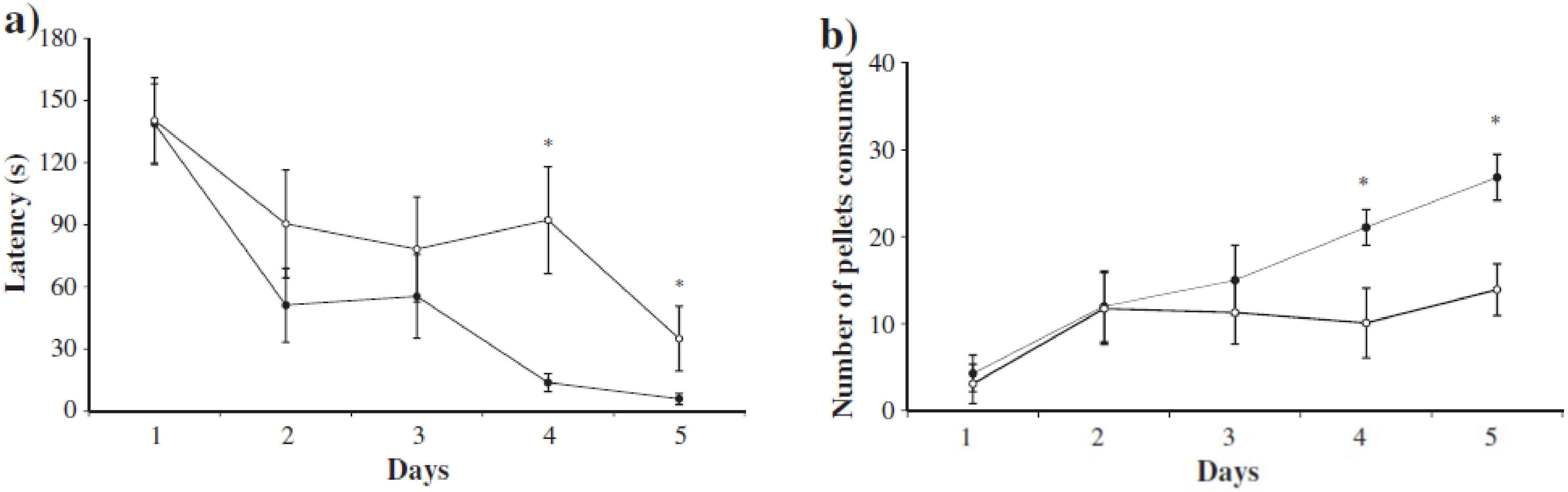
- Early emerging fractions are more bold, they display more exploratory behaviour and recover faster from startling compared to intermediate and late emerging fish.
- There were no differences in SMR, MMR or the metabolic scope of different emergence fractions, however, early emerging fractions had a smaller oxygen debt following chasing, and repaid it quicker.
- Early emerging fractions had a smaller cortisol response following a low water level challenge, but mobilisation of glycogen stores did not differ between fractions.

Feeding

Contents lists available at ScienceDirect
Physiology & Behavior
journal homepage: www.elsevier.com/locate/phb

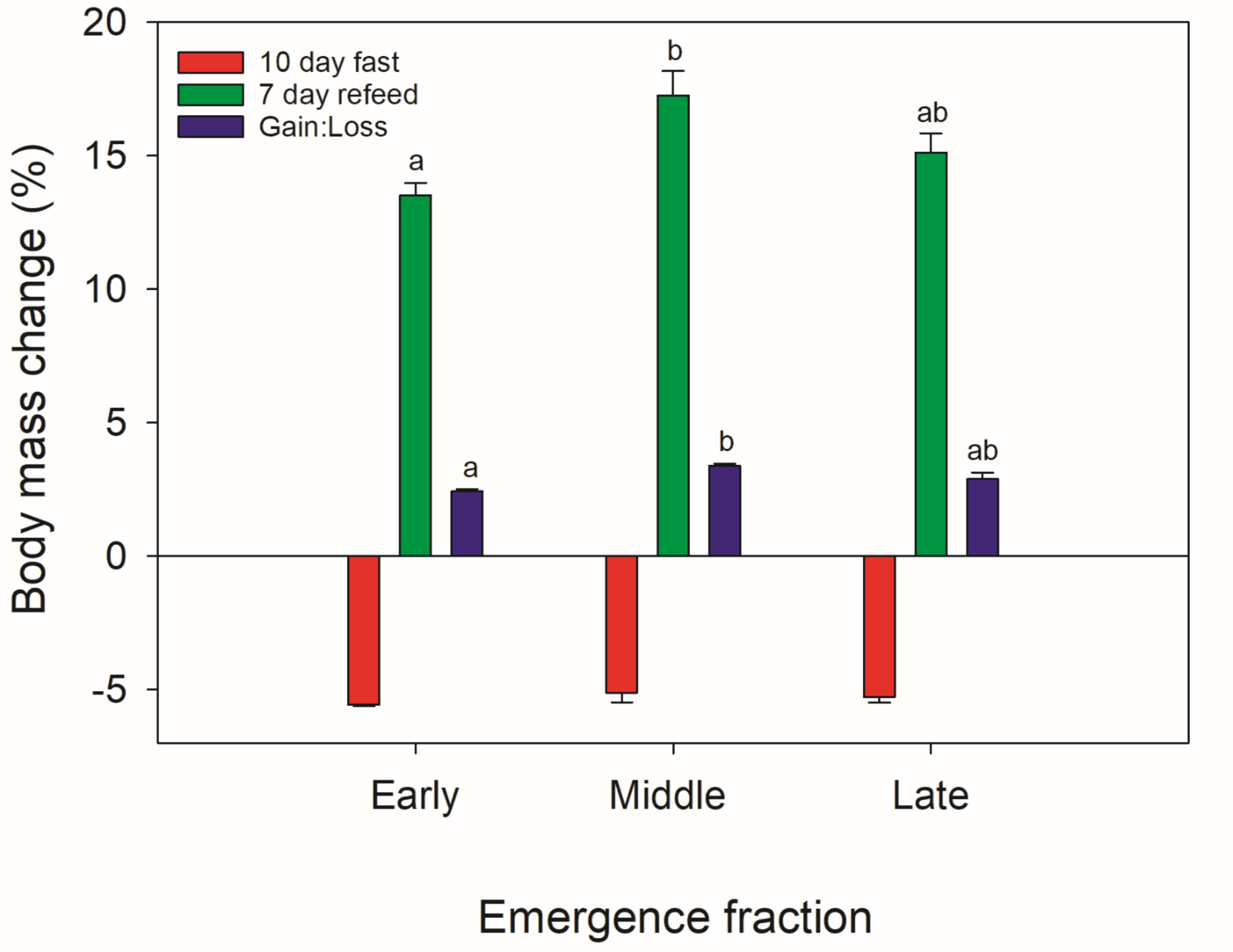
Consistent boldness behaviour in early emerging fry of domesticated Atlantic salmon (*Salmo salar*): Decoupling of behavioural and physiological traits of the proactive stress coping style

J. Vaz-Serrano [a], M.L. Ruiz-Gomez [b], H.M. Gjøen [a], P.V. Skov [c], F.A. Huntingford [c], Ø. Øverli [a], E. Höglund [d,*]



Starvation and refeeding

	Early	Middle	Late	p
BM INIT (g)	53.41 ± 1.67	51.93 ± 1.35	51.63 ± 2.19	0.751
BM FAST (g)	50.21 ± 1.56	49.31 ± 1.26	49.30 ± 2.11	0.908
BM RE-FED (g)	61.29 ± 1.86	64.02 ± 1.94	60.44 ± 2.93	0.524
SGR FAST (% d^{-1})	-0.62 ± 0.04 [a]	-0.52 ± 0.03 [ab]	-0.46 ± 0.04 [b]	0.011
SGR RE-FEED (% d^{-1})	2.00 ± 0.15	2.60 ± 0.14	2.02 ± 0.25	0.050
BM abs loss (g)	3.20 ± 0.23 [a]	2.62 ± 0.15 [ab]	2.33 ± 0.20 [b]	0.013
BM relative loss (%)	5.98 ± 0.35	5.04 ± 0.24	4.53 ± 0.35	0.011
BM abs gain (g)	11.08 ± 0.95	14.71 ± 1.00	11.14 ± 1.52	0.065
BM relative gain (%)	22.19 ± 1.87 [a]	29.80 ± 1.74 [b]	22.71 ± 3.03 [a]	0.048
Gain:Loss abs	3.55 ± 0.33 [a]	5.74 ± 0.44 [b]	4.86 ± 0.56 [ab]	0.008



20
15
10
5
0
-5
Body mass change (%)
10 day fast
7 day refeed
Gain:Loss
a
a
b
b
ab
ab
Early
Middle
Late
Emergence fraction

Conclusions (II)

- Early emerging fractions had a higher rate of weight loss in the face of starvation, probably linked to higher routine activity levels.
- The intermediate group was most starvation tolerant, and gained weight faster during refeeding.
- Co-habitation of different emerging fractions did not reveal a competitive advantage of early emerging fish under a restrictive feeding regime – again, the intermediate group outperformed the others.

Recommendations?

Overall, the intermediate group appears to have the best characteristics for production in an 'optimal' environment.

Some fish farmers are currently using the early emerging fraction to put in sea cages. Production costs slightly more, but is more than met but reduced losses!

Emergence fractions do not always exist.

Thank you for your attention!

Questions?