Control of Metamorphosis in Flatfish

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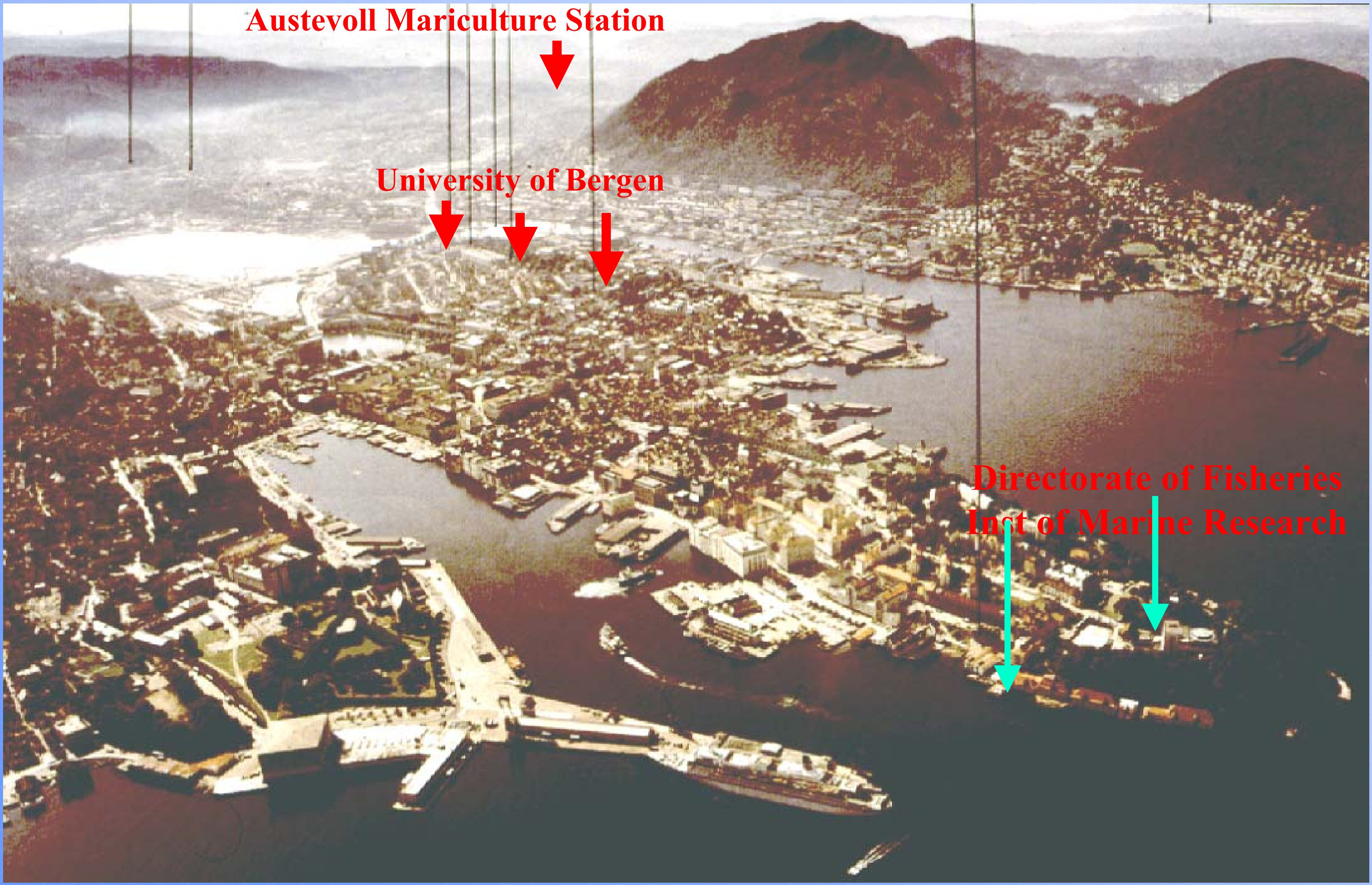
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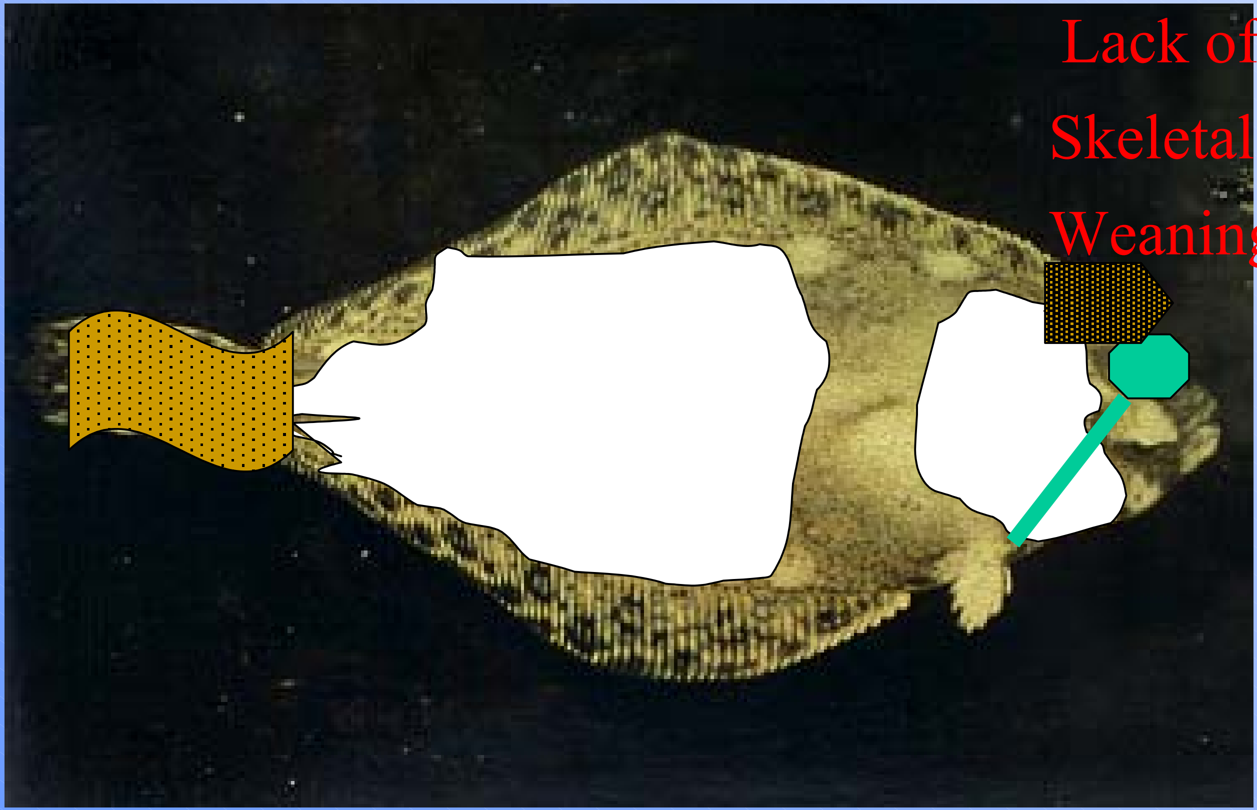
Farmed Flatfish juveniles exhibit:



Pigment abnormalities

Lack of eye migration

Skeletal abnormalities

Weaning mortality

Fundamental common factor?

STAGE

DAYS

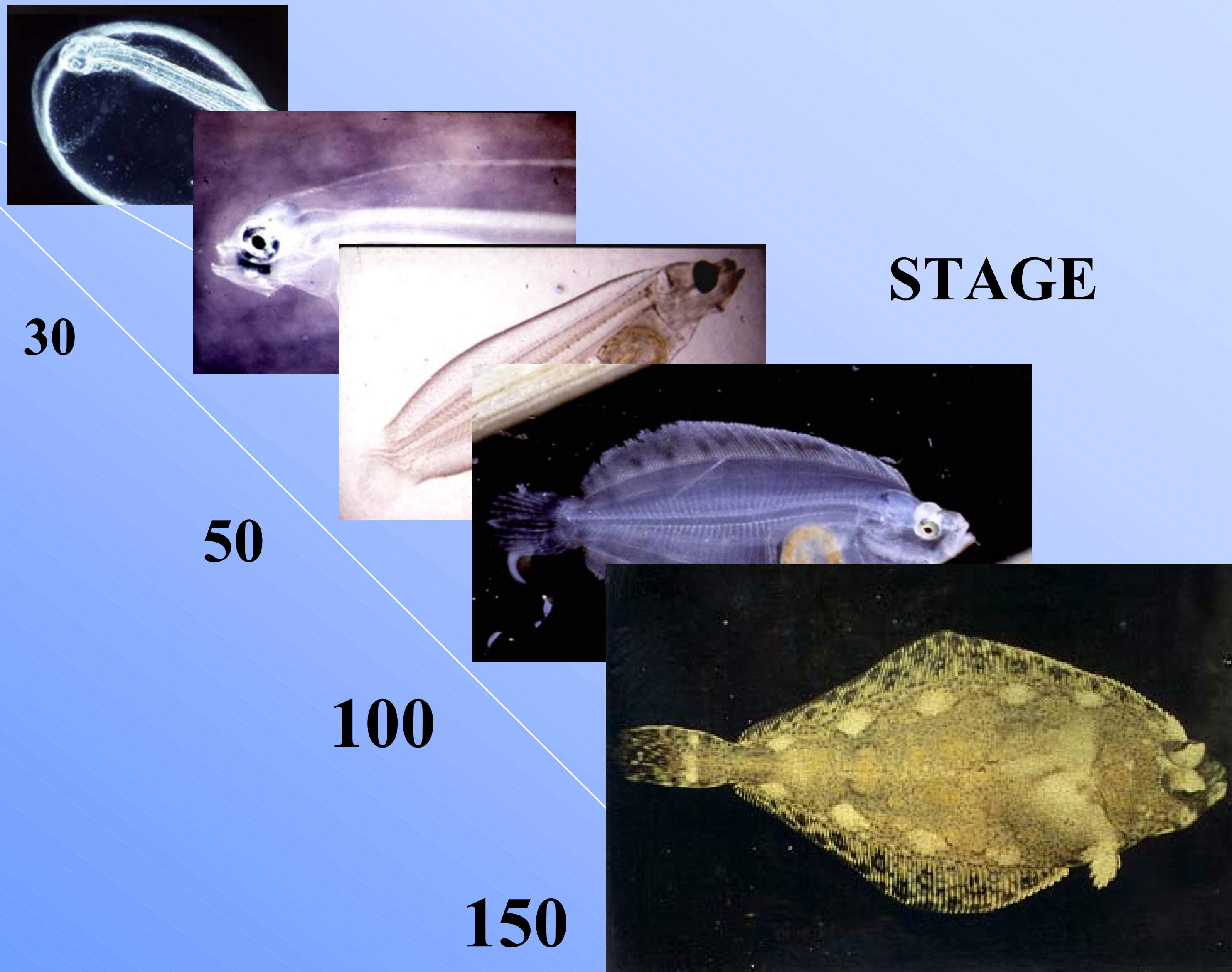
0

30

50

100

150



Control of metamorphosis

= control of juvenile quality

Experiments

1. Natural zooplankton vs standard enriched Artemia

1 egg batch → 4 groups

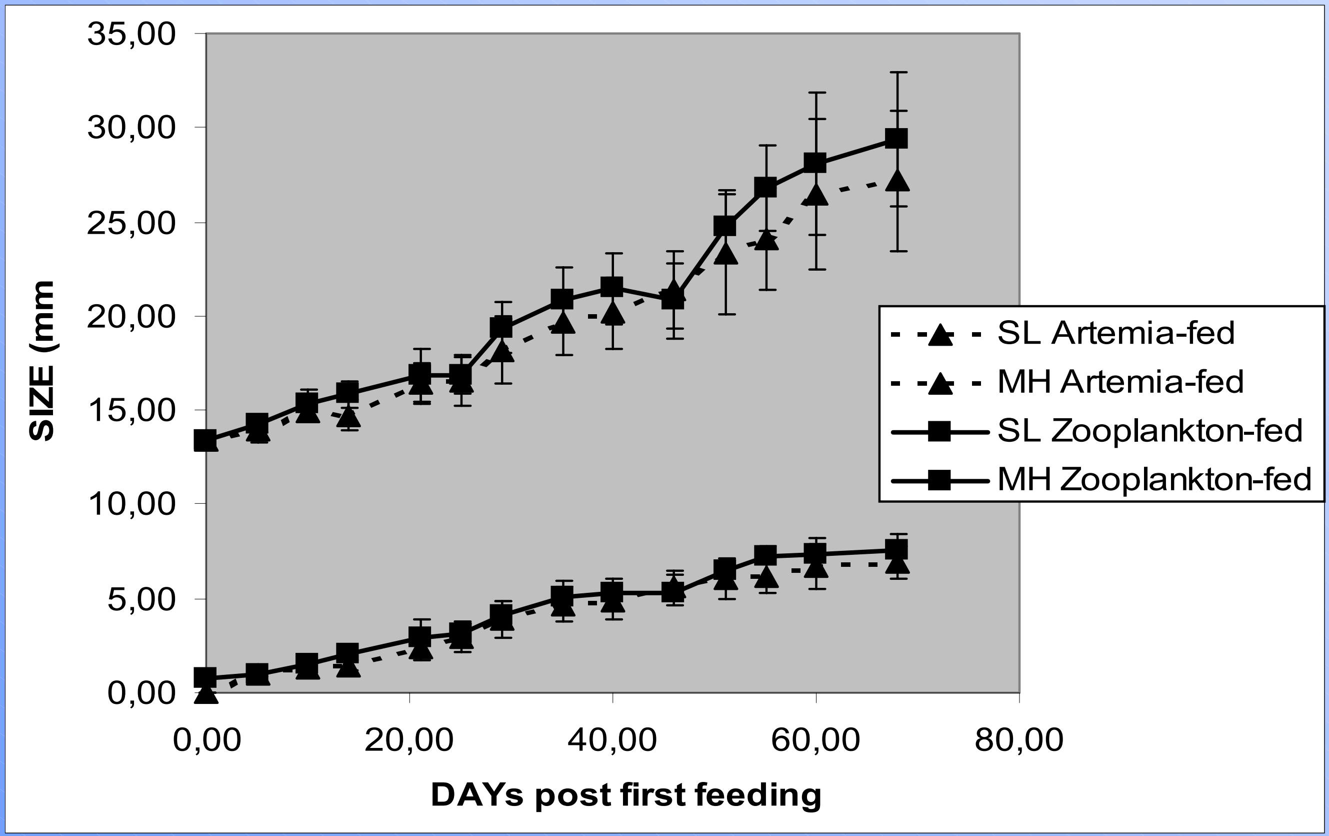
2. Exogenous T4

continuously and at Pre-, Pro, Climax & PC Metam

3. Photoperiod 24 hrs light or 12L:12D

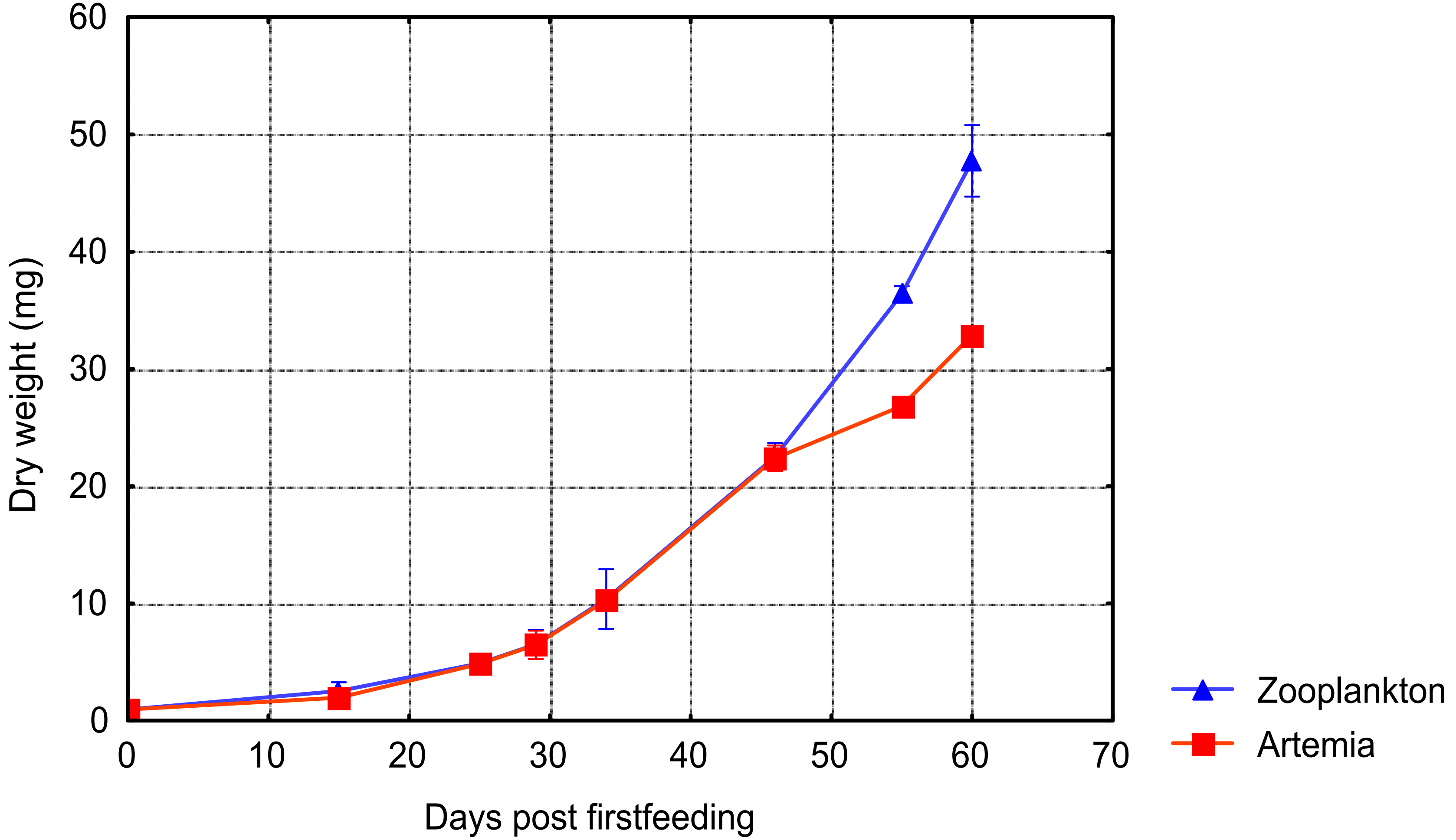
at 22 days and at 12, 21, 30 and 42 DPF

Feeding with Artemia or Zooplankton



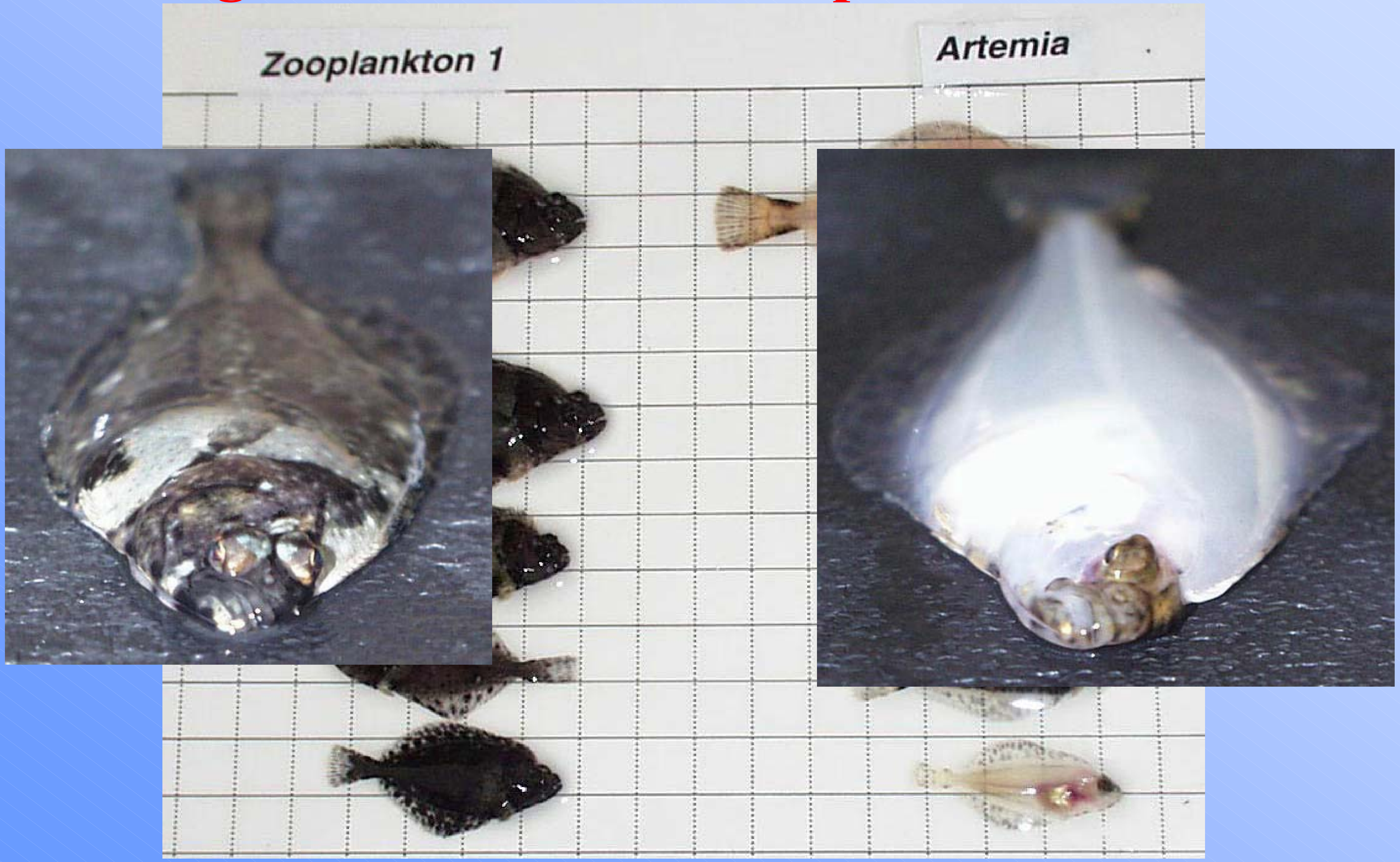
	Artemia	Zooplankton
Malpigmentation:	93%	32%
Lack of Eye migration:	90	12
Dorsal fin “comb”:	82	33

Feeding with Artemia or Zooplankton

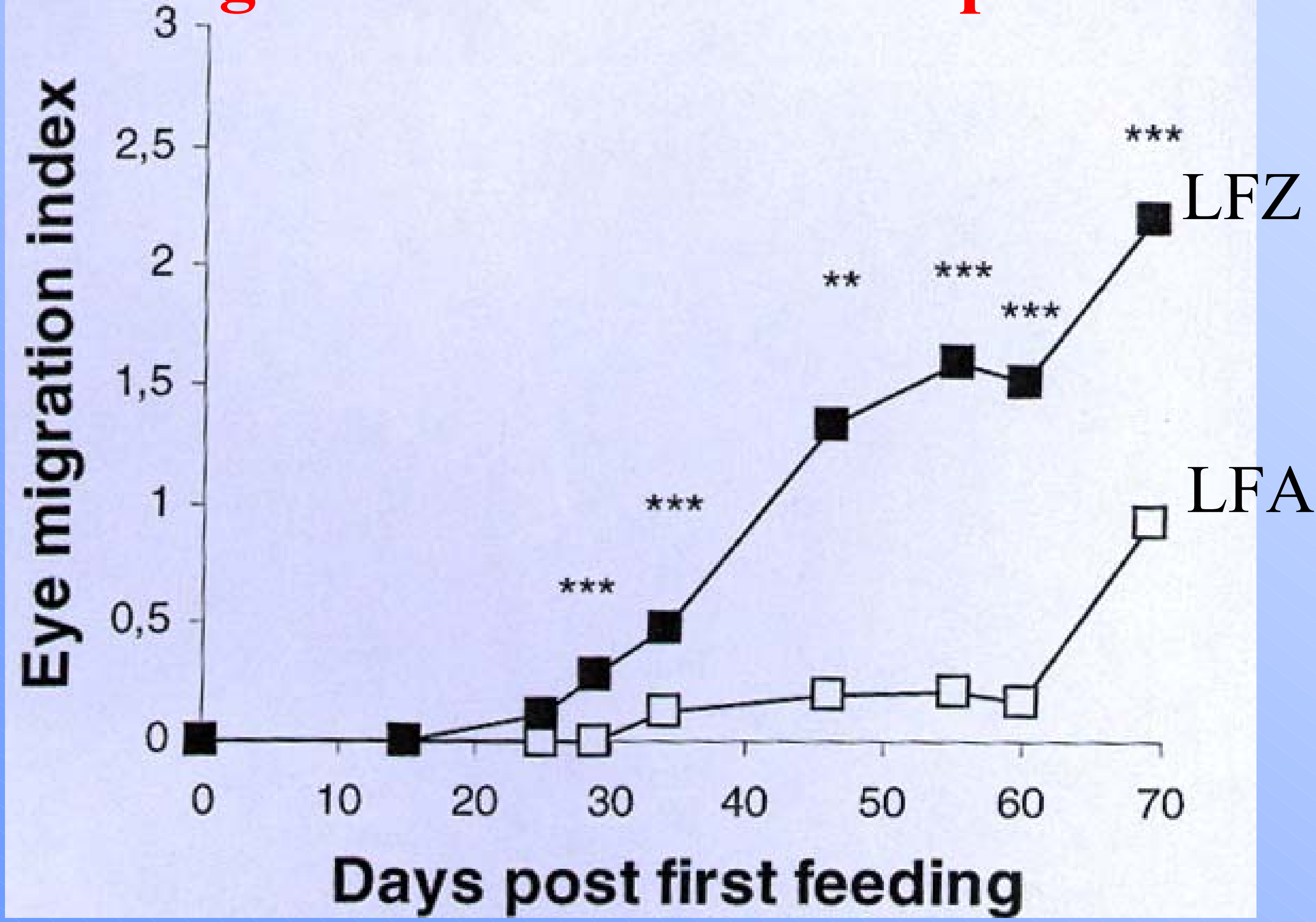


From: Hamre, Opstad, Espe, Solbakken, Hemre & Pittman, submitted

Feeding with Artemia or Zooplankton



Feeding with Artemia or Zooplankton



From Solbakken et al. submitted

FATTY ACIDS IN PREY

	Artemia	Zooplankton
ARA (20:4 n-6)	**2.1±0.1[a]**	**0.7±0.2[b]**
EPA (20:5 n-3)	**4.9±0.3[a]**	**18.6±3.2[b]**
DHA (22:6 n-3)	**6.3±0.9[a]**	**28.5±4.8[b]**
Σ **Saturated**	**21.3±1.2**	**22.5±1.0**
Σ **Monoenes**	**27.3±0.2[a]**	**10.4±4.0[b]**
Σ **n-3**	**34.5±0.4[a]**	**55.9±4.8[b]**
Σ **n-6**	**8.1±0.4**	**4.3±3.3**
DHA/EPA	**1.3±0.1**	**1.6±0.4**
EPA/ARA	**2.3±0.0[a]**	**29±10 [b]**

Feeding with Artemia or Zooplankton

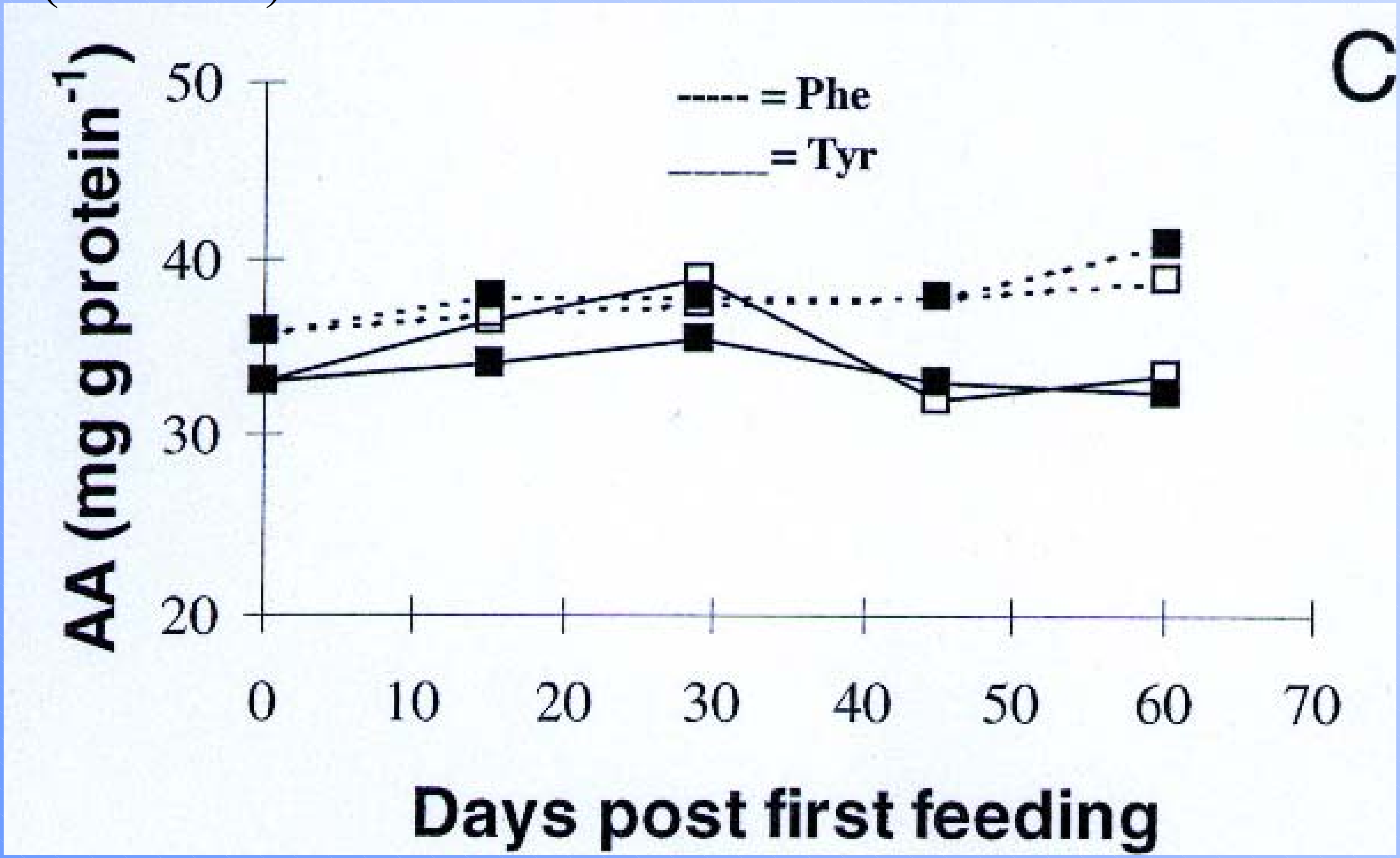
(In prey)

	Wild zooplankton	Artemia
Iodine (ug g dw^{-1})	**350 +/- 19 (n=5)**	**0.5+/-0 (n=4)*** **
Selenium (ug g dw^{-1})	2 +/- 0.2 (5)	2.2 +/-0.1 (4)
Phenylalanine (mg g protein^{-1})	32+/- 2 (5)	39 +/- 1 (4)
Tyrosine (mg g protein^{-1})	37 +/- 3 (5)	37 +/- 1 (4)

from: Solbakken, Berntssen, Norberg, Pittman & Hamre (submitted)

Feeding with Artemia or Zooplankton

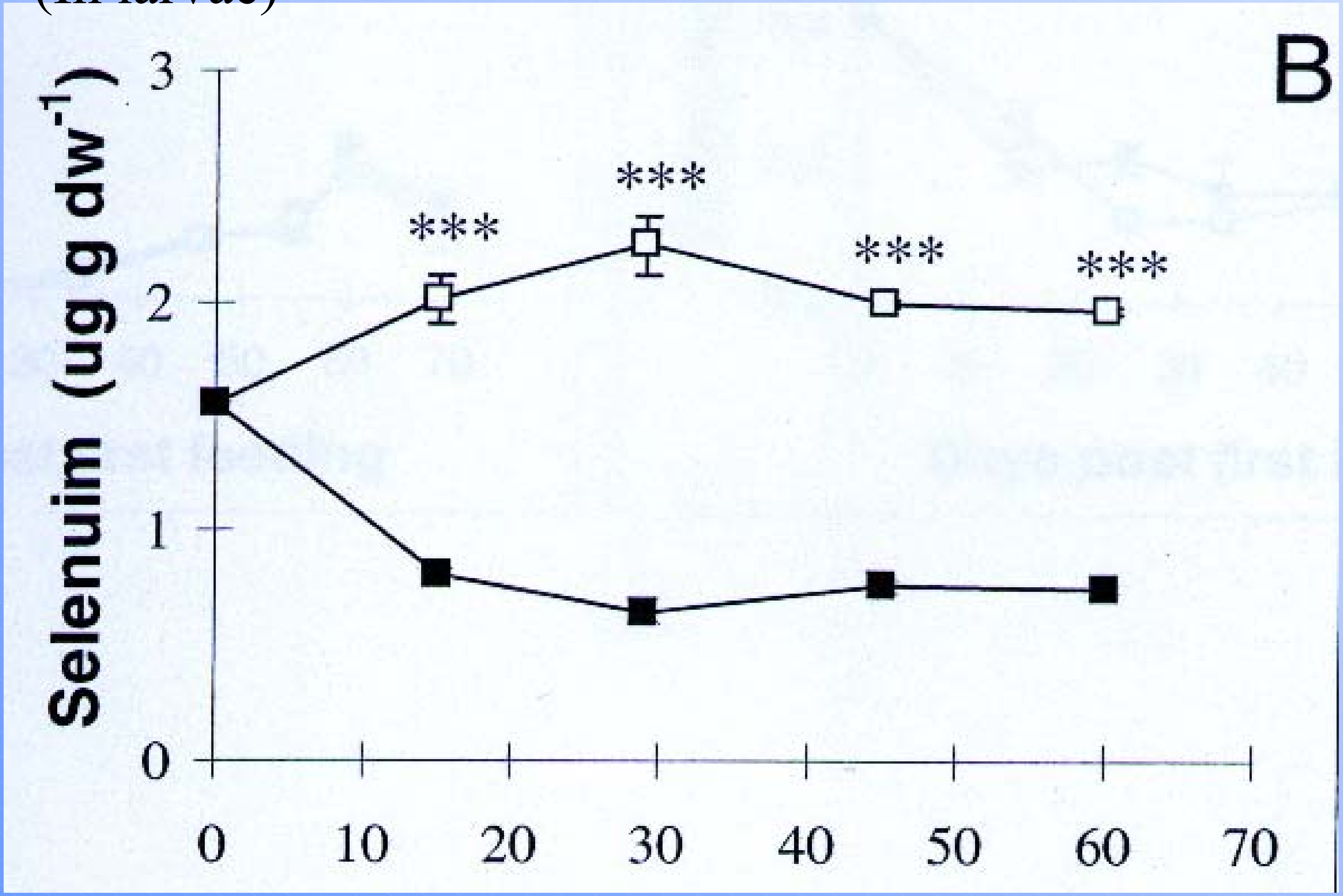
(In larvae)



From Solbakken et al. and Hamre et al. (2001) submitted

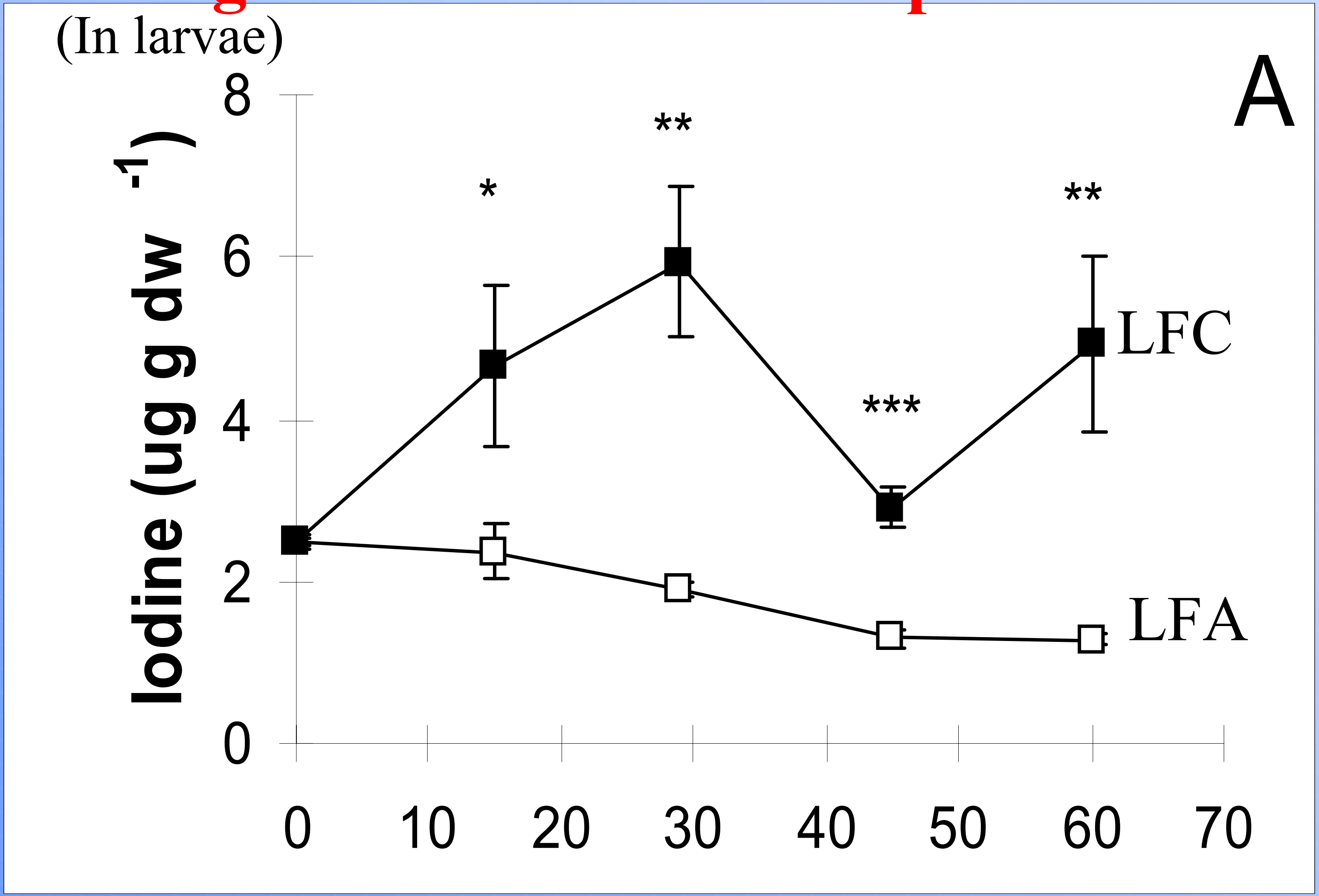
Feeding with Artemia or Zooplankton

(In larvae)



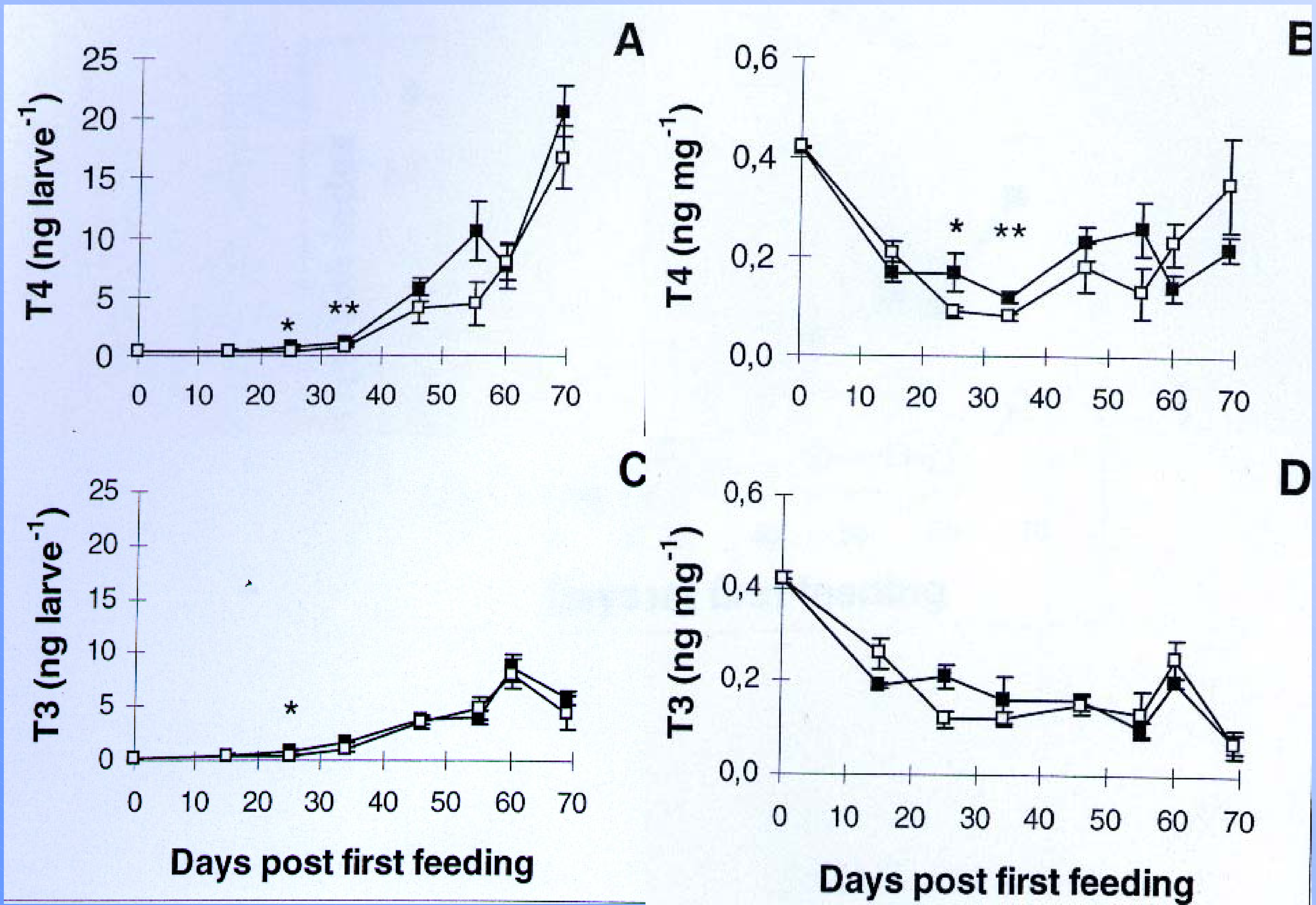
From Solbakken et al. and Hamre et al. (2001) submitted

Feeding with Artemia or Zooplankton



From: Solbakken, Berntssen, Norberg, Pittman & Hamre submitted

Feeding with Artemia or Zooplankton



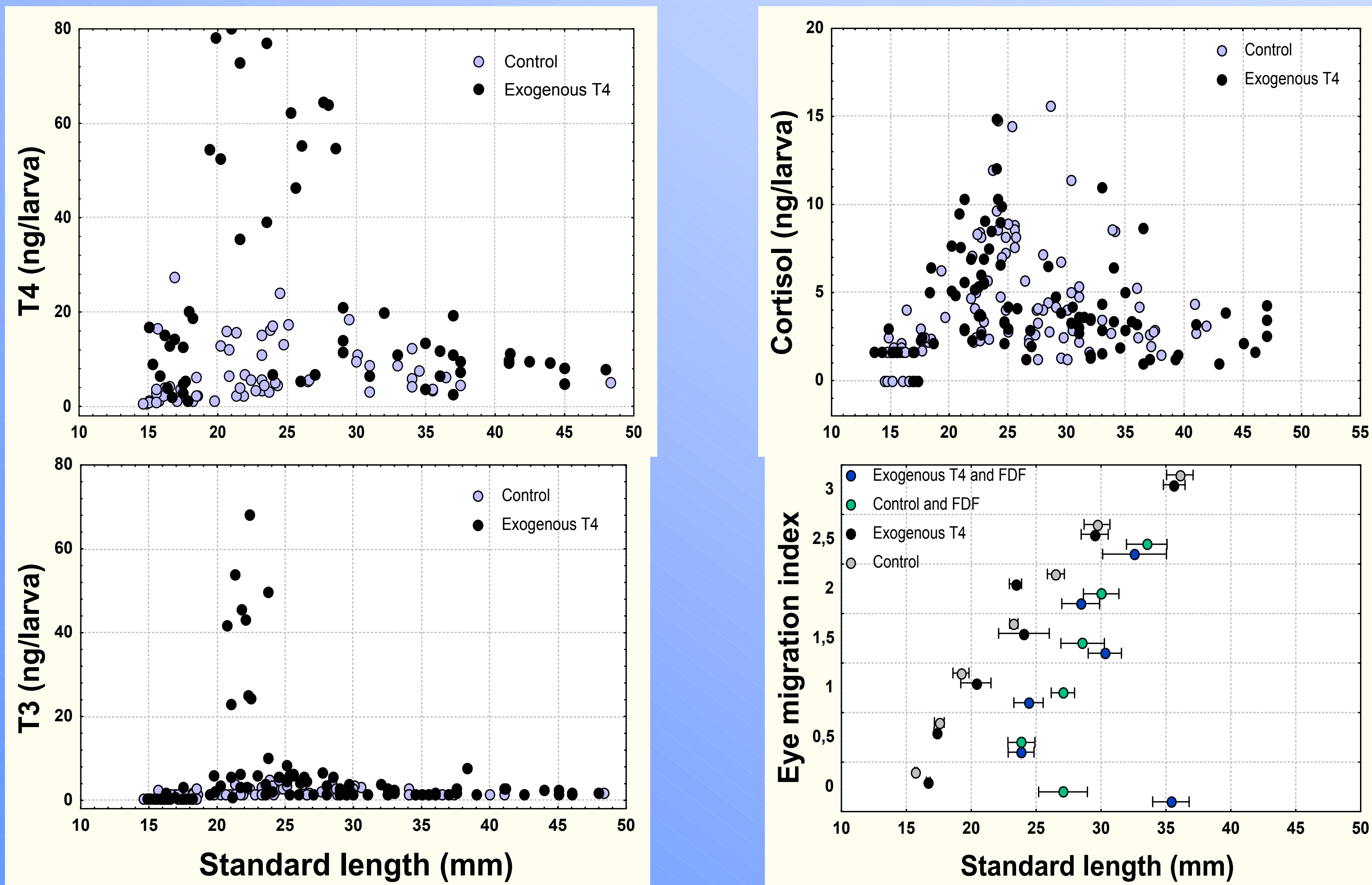
Window of metamorphosis

critical size about 18 mm for halibut?

17.99 mm SL

Foto: Ø. Sæle

Exogenous Thyroxine - continuous



Solbakken et al. (subm.)

Exogenous Thyroxine - stages

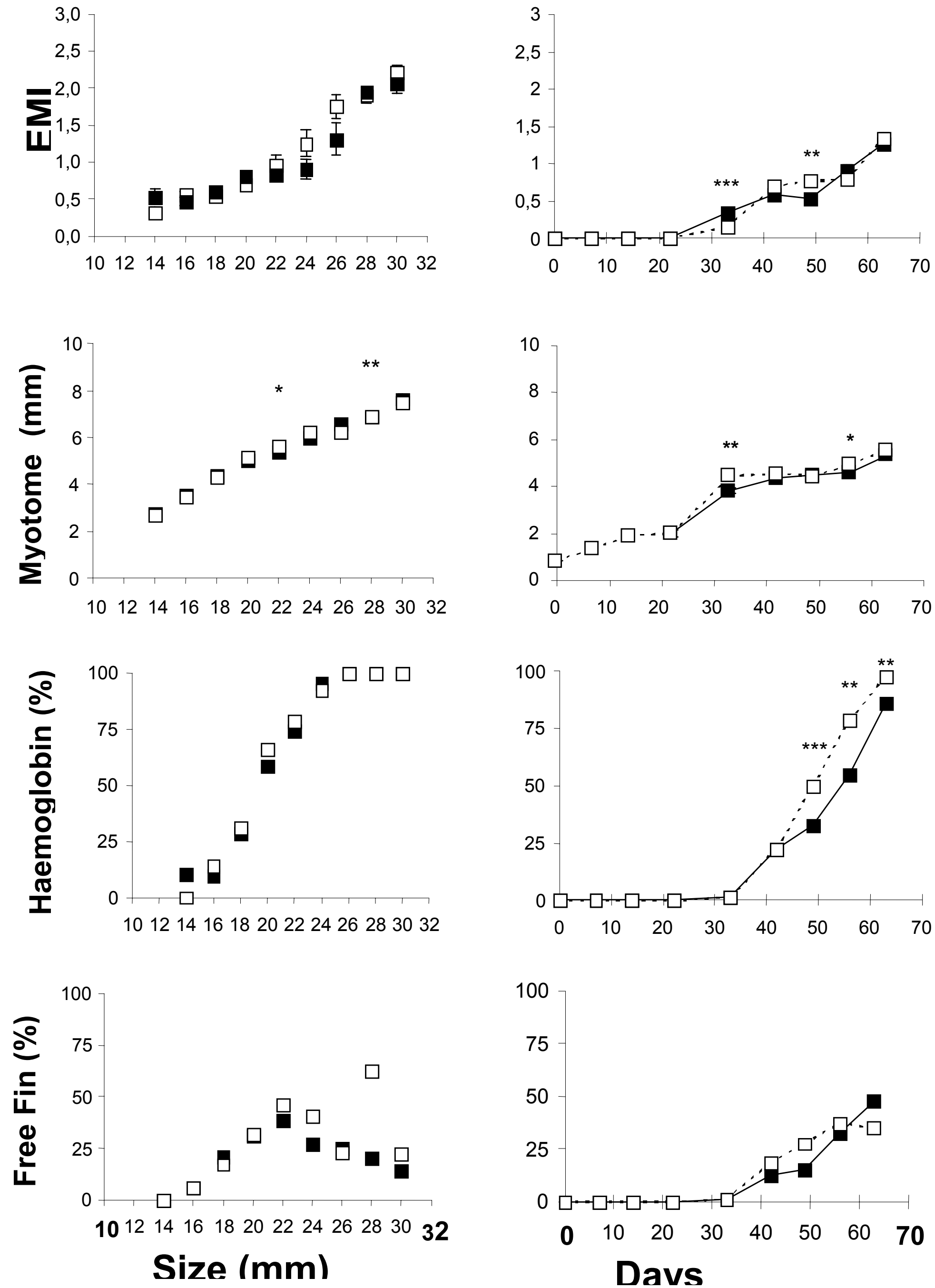
Age (DPF)	SL (mm)	Stage	MH (mm)
15	15.3 ± 0.6	Pre-M – Pro-M	1.7 ± 0.4
37	18.2 ± 1.9	Pro-M - MC	4.4 ± 1.1
62	29.3 ± 4.2	Late MC - JUV	7.2 ± 1.1

Exogenous Thyroxine - stages

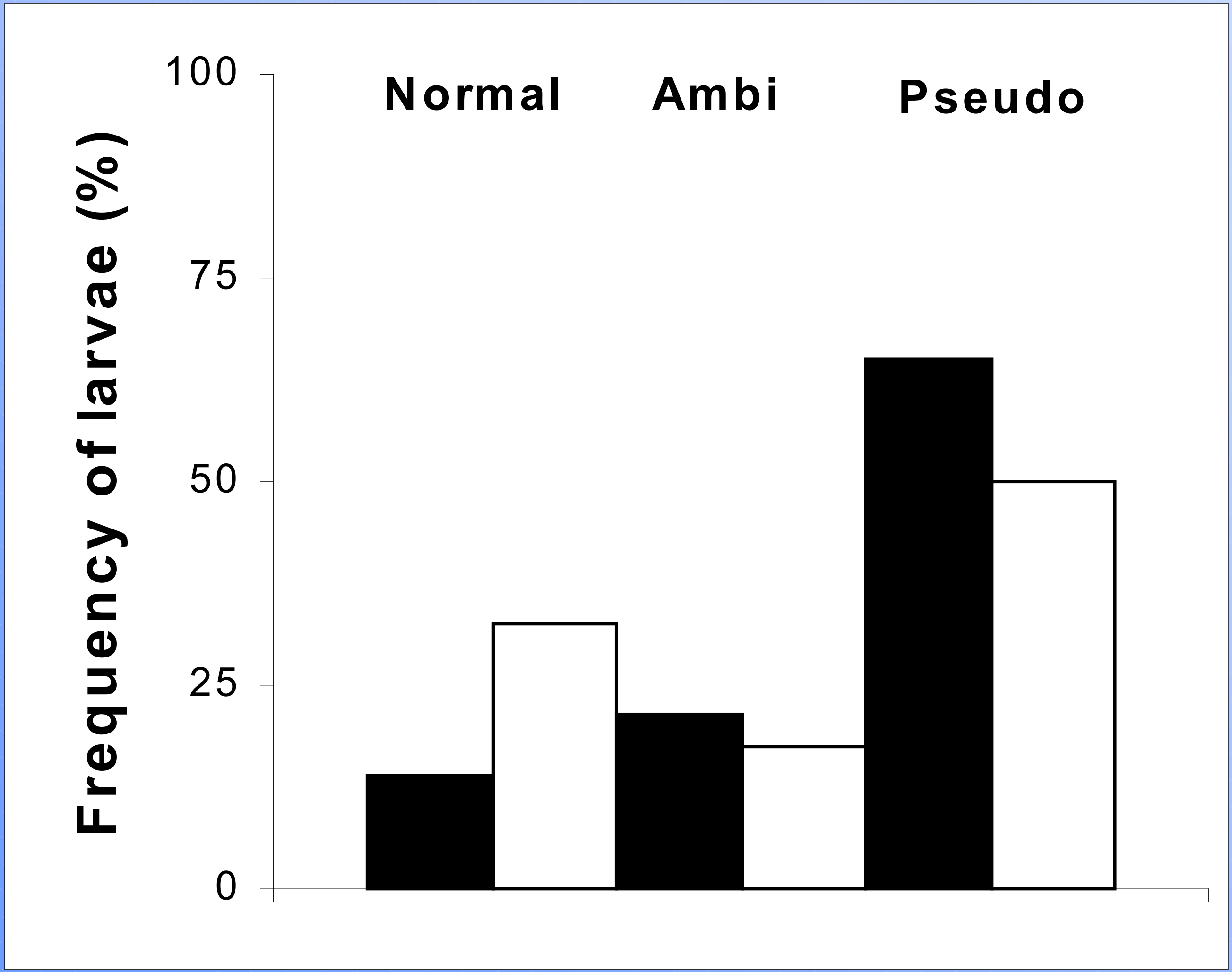
DPF	***SL (mm)***	
	Exogenous T4	Controls
15	15.3 ± 0.1 (40)	
22	16.3 ± 0.1 (60)	15.6 ± 0.1 (55) ***
29	17.3 ± 0.2 (49)	16.4 ± 0.2 (40) ***
37	18.2 ± 0.3 (30)	
44	22.2 ± 0.2 (56)	22.7 ± 0.2 (47)
51	24.8 ± 0.4 (56)	25.1 ± 0.4 (48)
62	29.3 ± 0.8 (28)	
69	32.4 ± 0.5 (56)	32.7 ± 0.6 (48)
76	38.0 ± 0.9 (56)	36.6 ± 1.2 (28)

Photoperiod

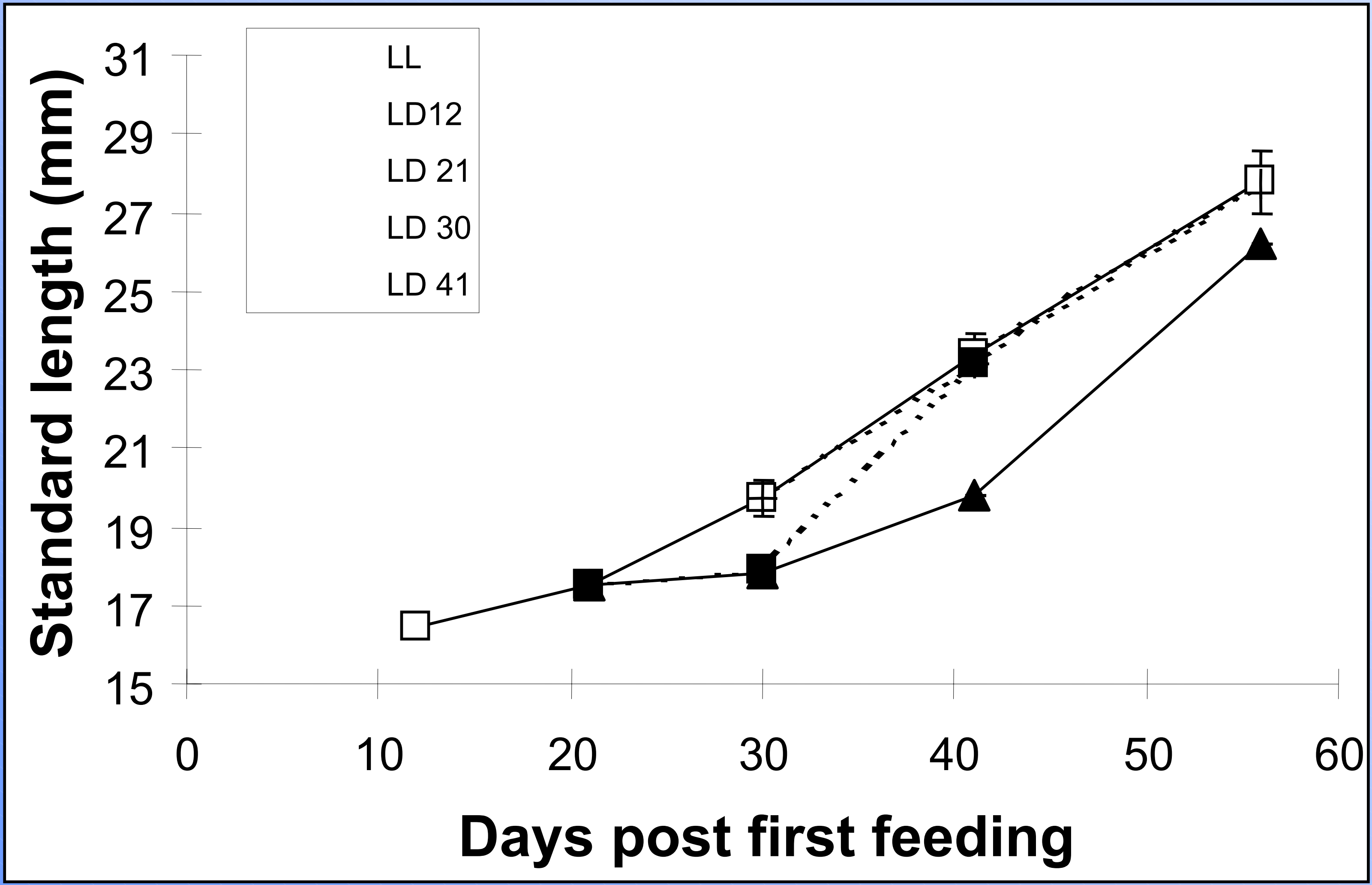
Continuous 22DPF



Photoperiod - continuous

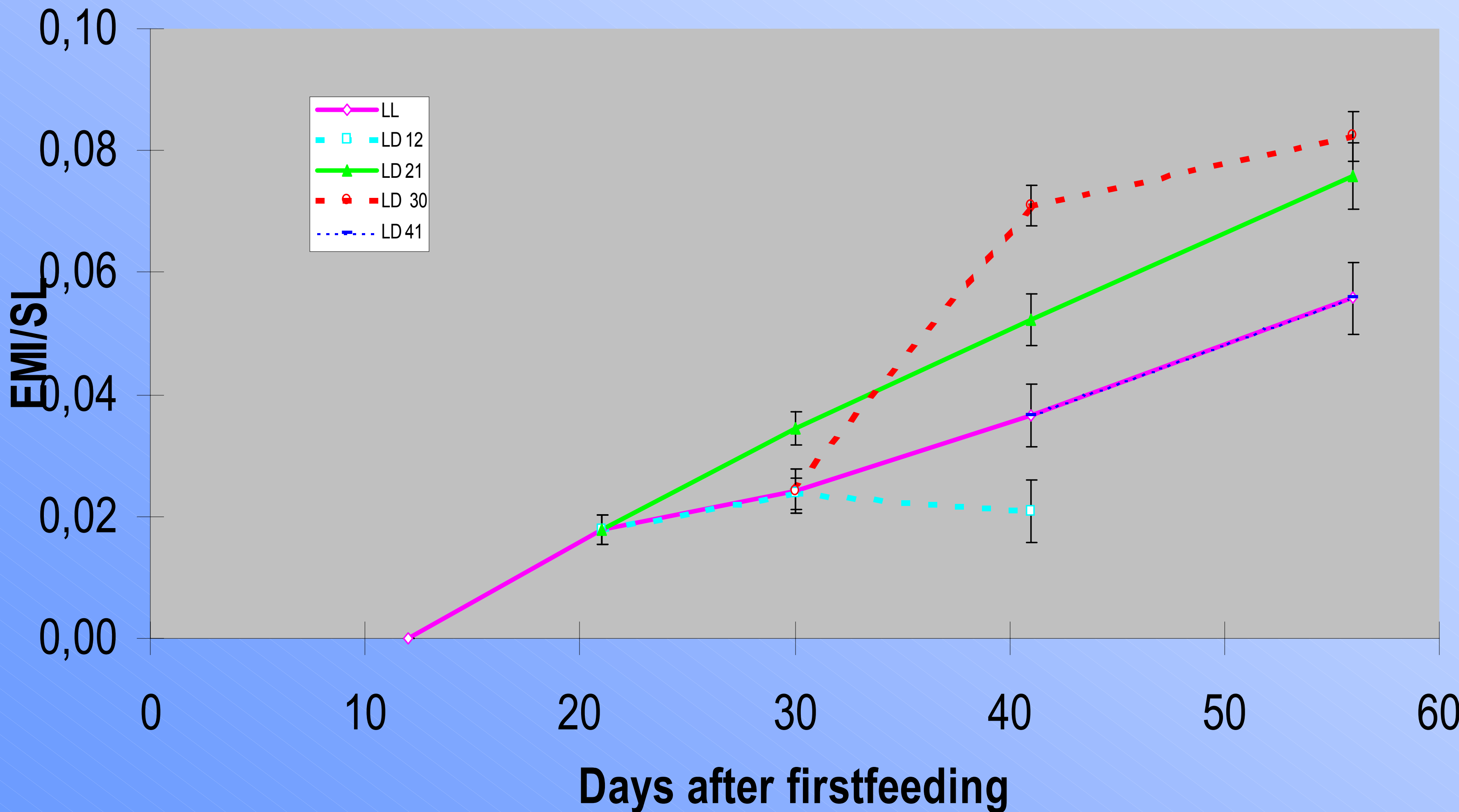


Photoperiod - ages



Solbakken et al. (in prep.)

Photoperiod - ages

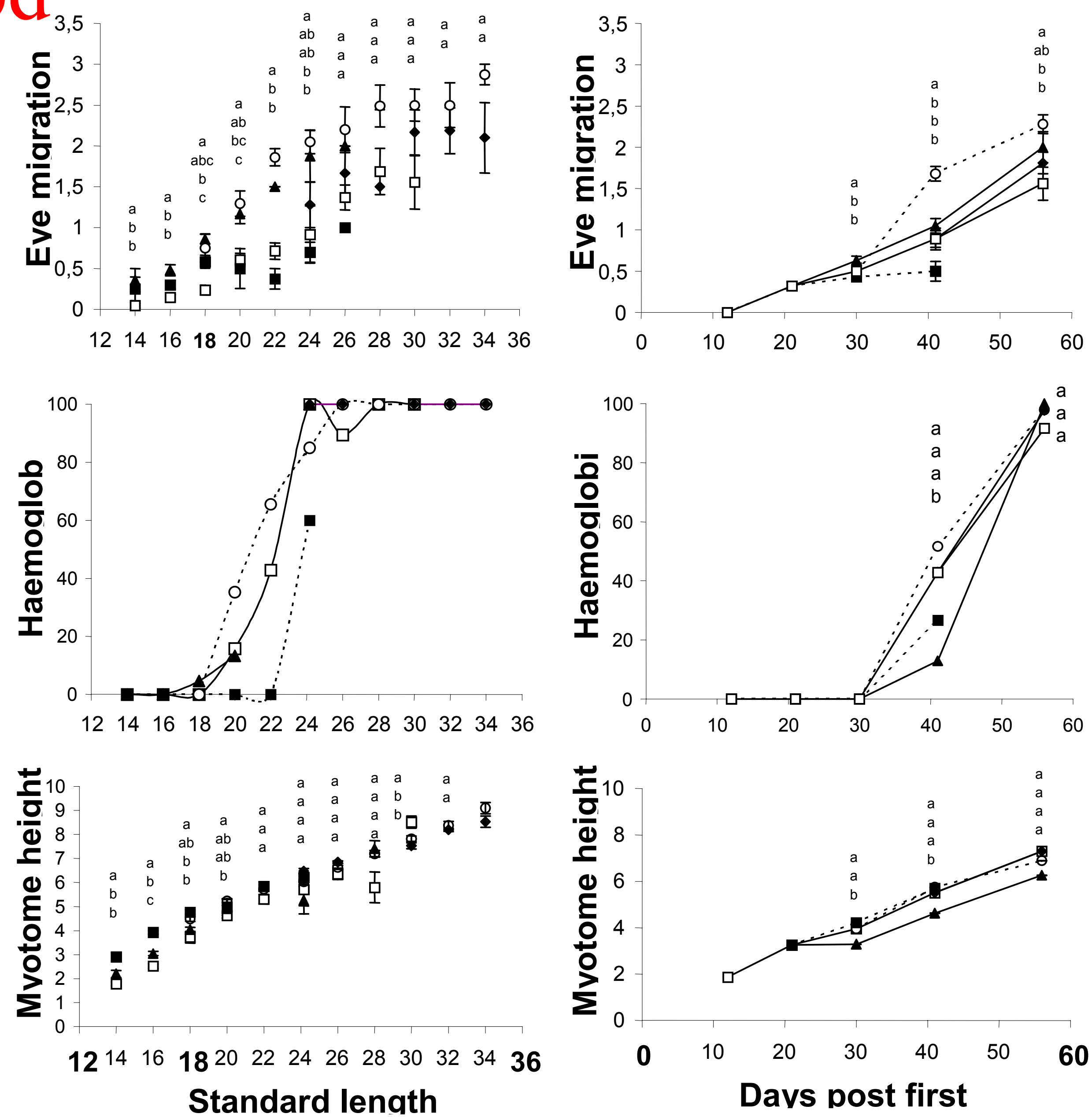


Solbakken et al. (in prep.)

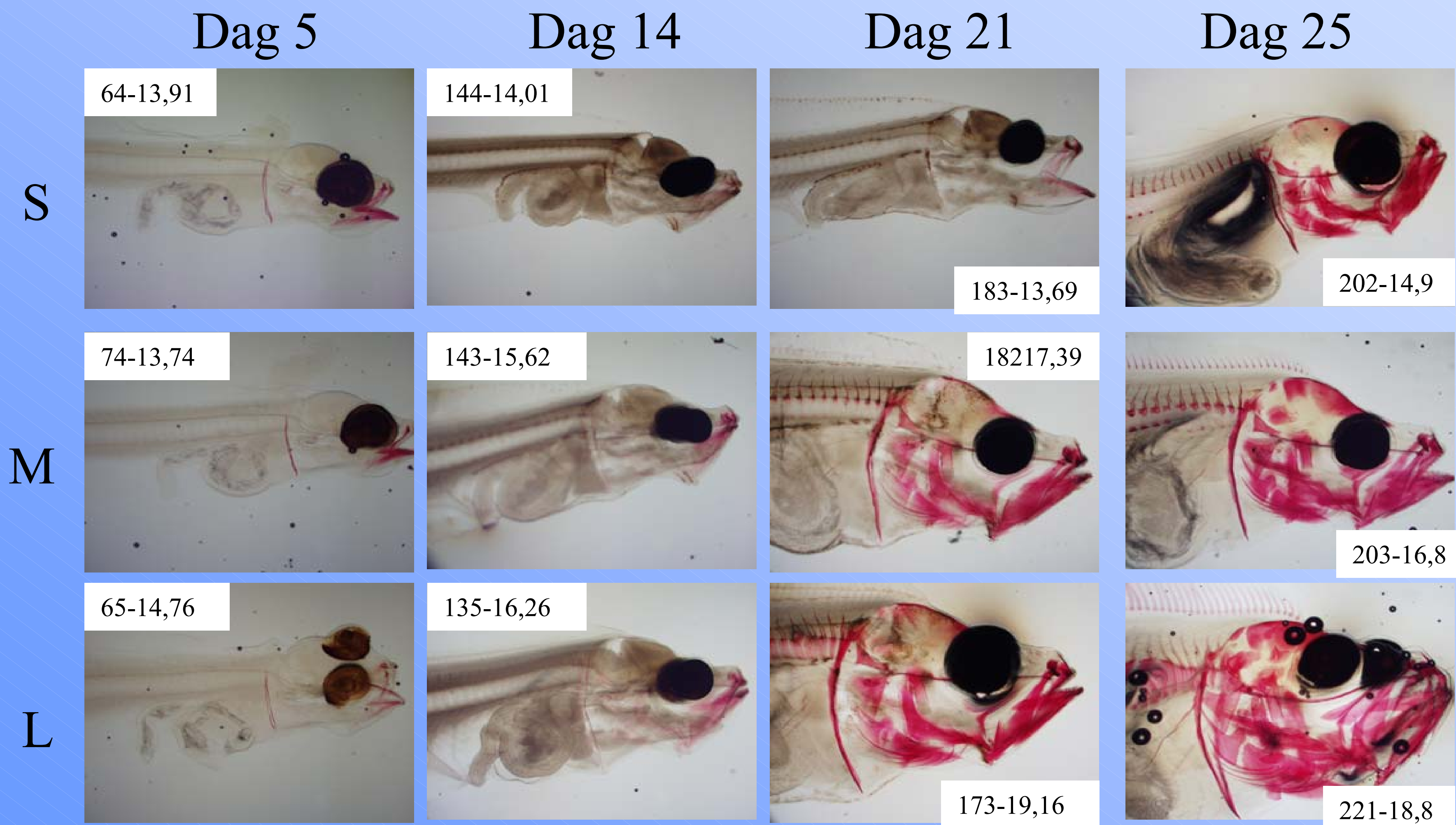
Photoperiod

ages

size vs age



Age vs Size: example from diet expt



Ø. Sæle

Hypothalamus-pituitary-thyroid axis

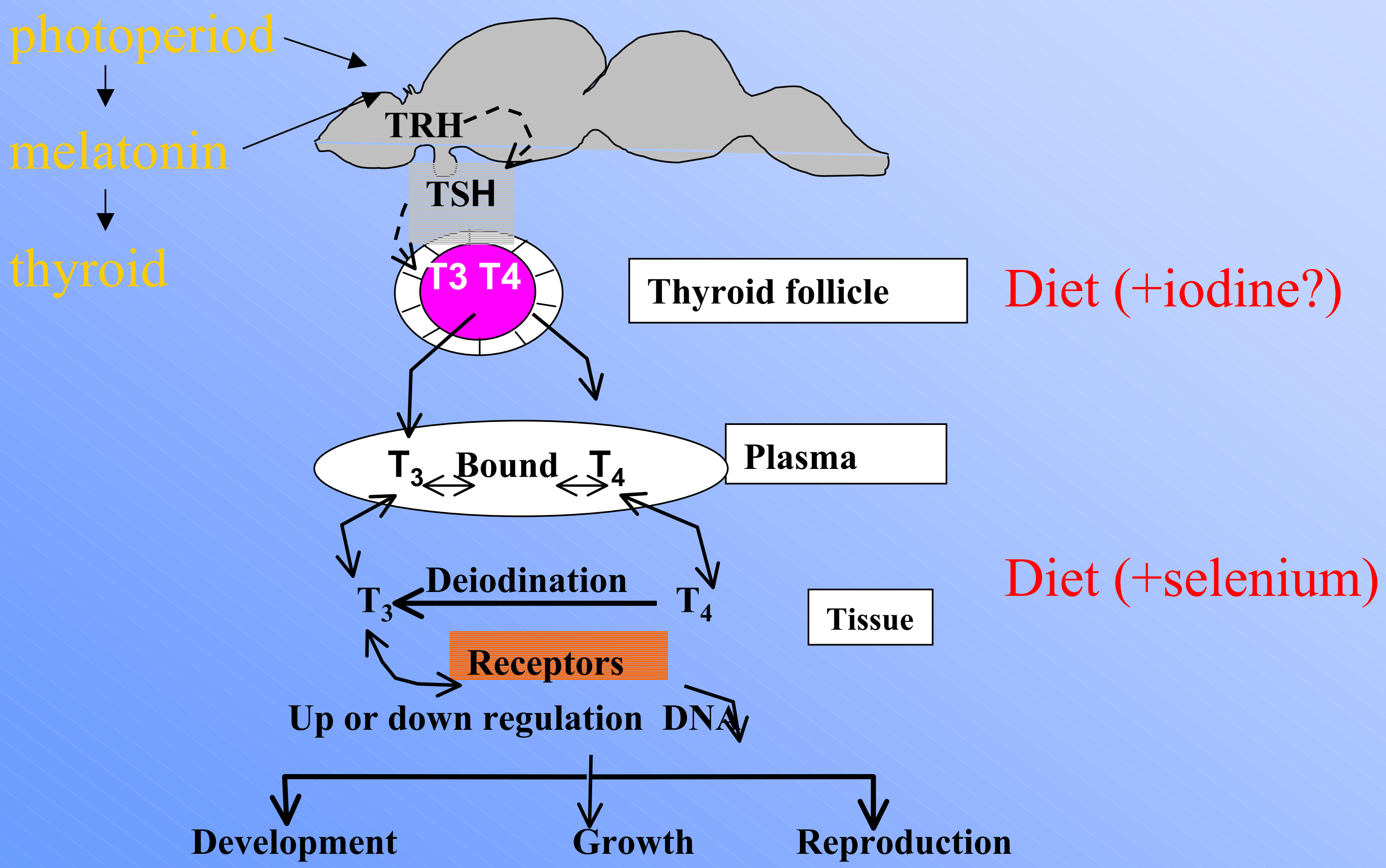


Fig: Ø. Sæle

Proposed pathway to pigmentation and settlement

phenylalanine (essential a.a.) **diet**

phenylalanine 4-monooxygenase

tyrosine 3-monooxygenase | | iodine **diet (& seawater)**

dopa — tyrosine — thyroxin (T_4)

Monophenol monooxygenase

Deiodinases with selenocystein (types 1& 3 ID) (type 2 ID)

diet

dopaquinone

Monophenol monooxygenase

melanin

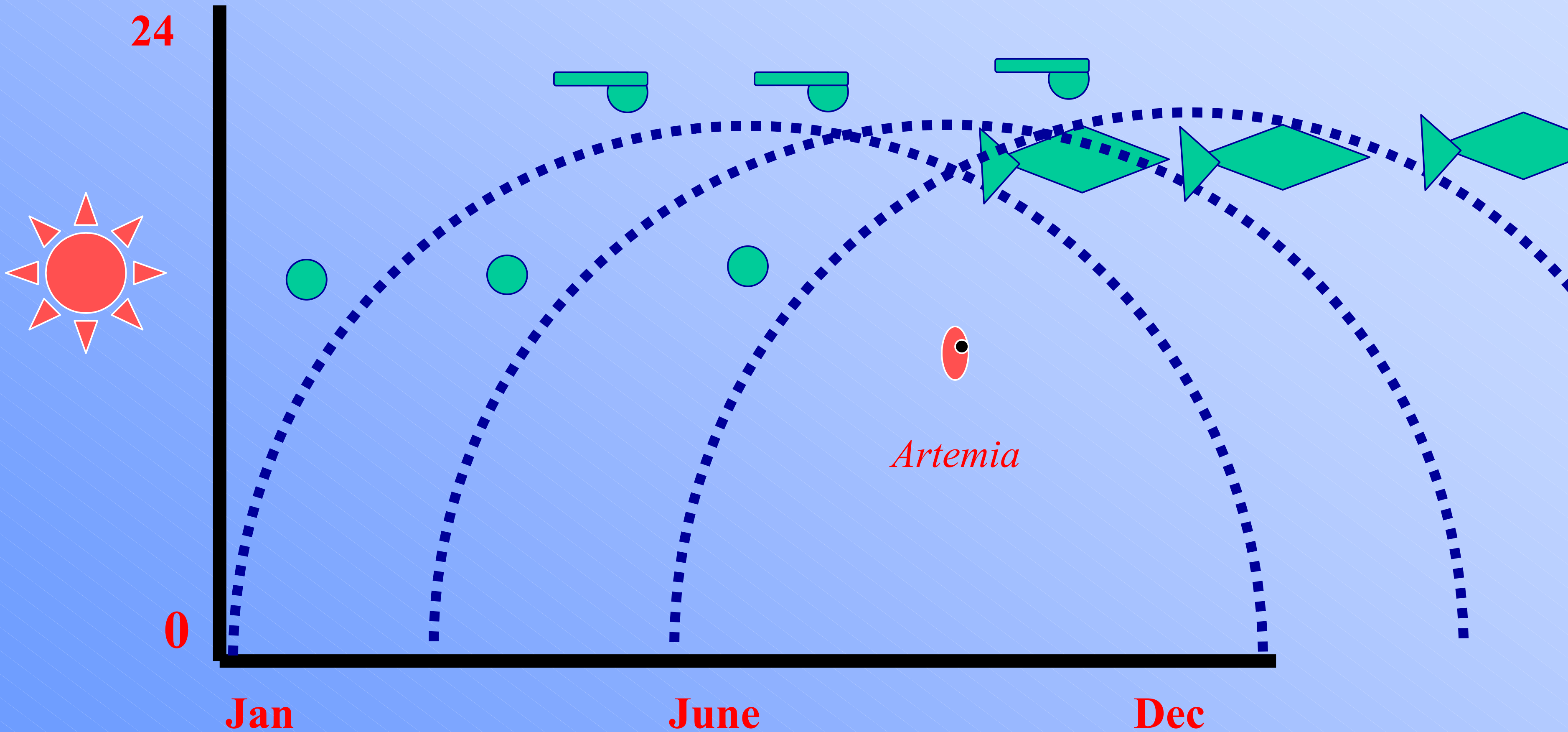
triiodothyronine (T_3)

Deiodinases (type 1 & 3 ID)

pigmentation

neural + skeletal change

Aseasonal Reproduction



Conclusions

1. Dietary micronutrients important for endocrine control of metamorphosis (iodine & selenium)

2. Peak deiodinase activity in 24-26 mm size, after metamorphosis has started - T4 more impt initially?

3. Window of opportunity 18-20 mm size (pre-pro metamorphosis)

4. Photoperiod induces heterochrony of eye migration, hemoglobin and pigmentation effects

5. Exogenous thyroid has positive effect on skeletal growth at pre-pro metamorphosis, among other effects

Conclusions

6. Order of metamorphic events is i) neural ii) growth and skeletal change iii) circulation changes iv) pigmentation finally established

7. Heterochrony is more related to age than size

8. Stage dependent response to photoperiod-melatonin-thyroid stimulation?

Future: effects on immunology (IgM), TRs, TRIPs