Recent developments in the application of live feeds in the freshwater ornamental fish culture






Lian Chuan LIM,

Agri-food & Veterinary Authority of Singapore

Philippe Dhert,

INVE Technologies NV, Belgium

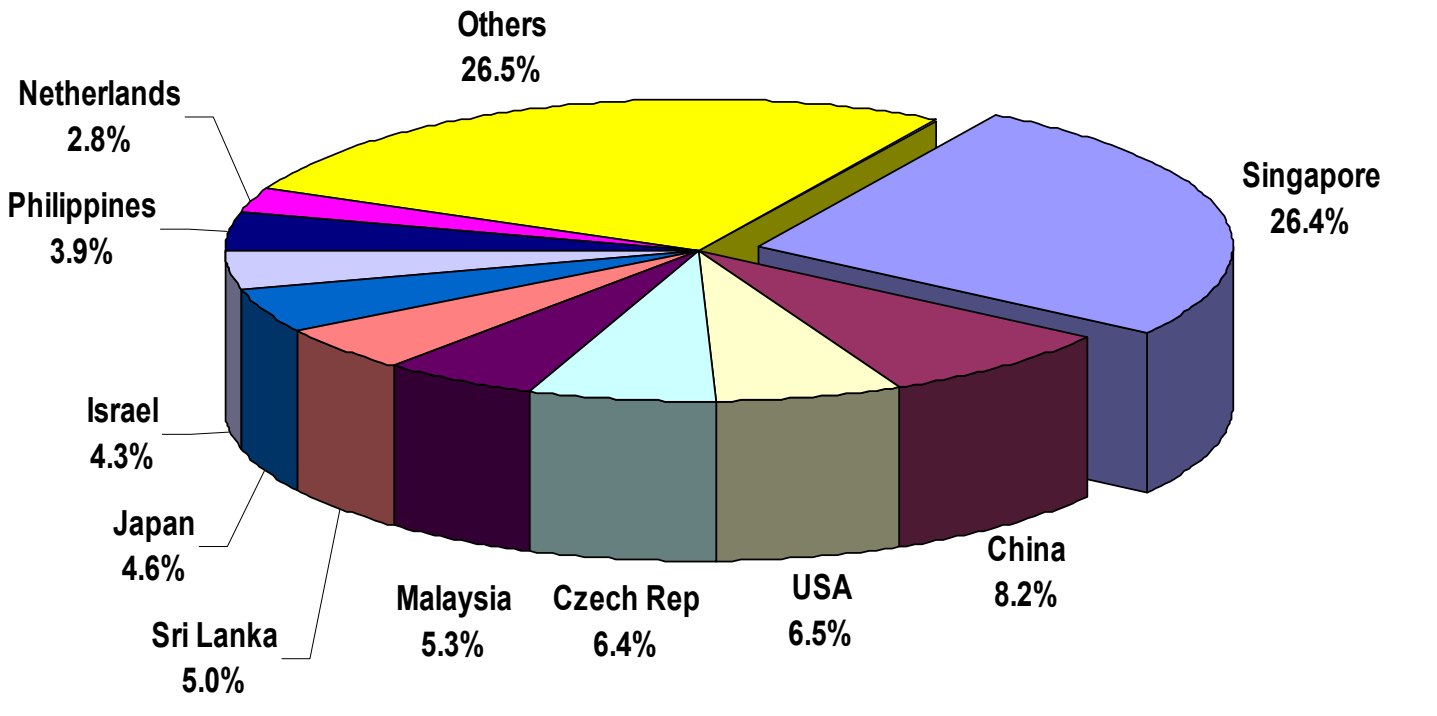
Patrick Sorgeloos,

Ghent University, Belgium





Ornamental Fish Business



Multi-million-dollar business

Total export trade in 1998: US$ 163 mil.

Due to lack of research input and technology promotion, the freshwater ornamental fish culture technology lags far behind that of marine foodfish, especially in larviculture

Live Feeds for Fry Production

- Marine foodfish species: Availability of large quantity of live feeds has contributed to its successful fry production

- Freshwater ornamental fish culture: Industrial development has been hampered by the lack of suitable live feeds for feeding

Traditional Feeds for Freshwater Ornamental Fish Culture

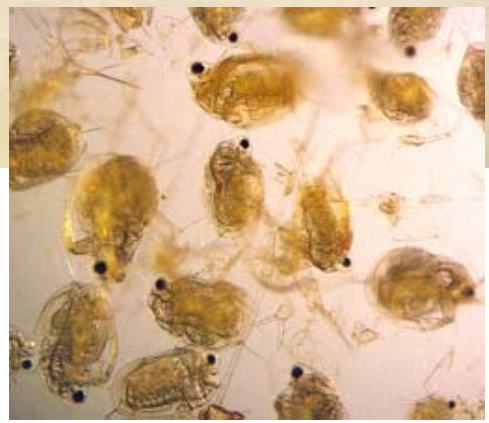
- For larval feeding
  - Inert food items: Egg yolk suspension, milk powder or powdered feeds
  - Natural plankton bloom induced by pond fertilization.

- Feeding of larger fish and brooders
  - *Moina* & *Tubifex* cultured in water fertilized with organic manure

Problems of using traditional feeds

- limits the fish stocking density due to poor water quality

- adversely affects fish quality, e.g. parasitic infection



- no suitable live feed for feeding larvae with small month size

Objective

To explore the application of four live feeds in freshwater ornamental fish culture:

Freshwater rotifers, *Brachionus calyciflorus*

Artemia nauplii

Decapsulated *Artemia* cysts

On-grown *Artemia*

Use of rotifers

- Marine rotifers (*Brachionus plicatilis*)
  - can survive in fresh water for at least 2 h
  - sink quickly to bottom - not suitable for feeding pelagic larvae
- More appropriate to use freshwater rotifers, e.g. *B. calyciflorus*

Use of *Artemia* nauplii

- Major drawback in feeding *Artemia* nauplii to freshwater fish: Nauplii die in fresh water within an hour

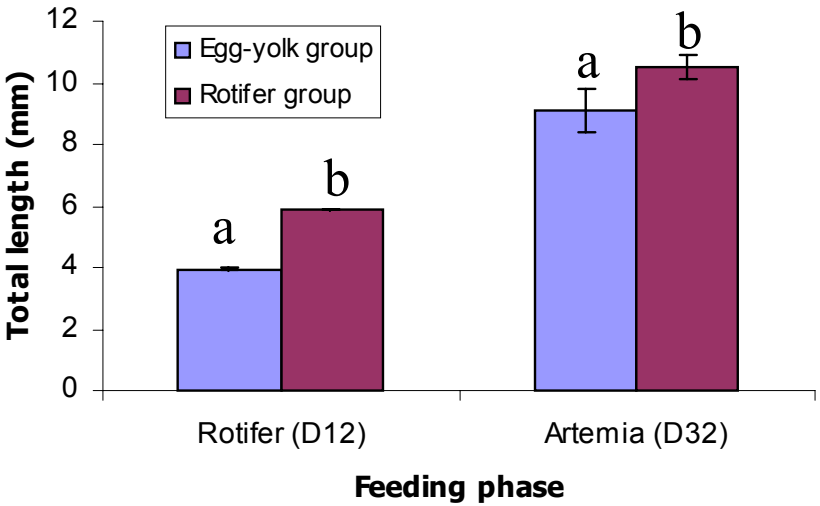
- Can be overcome by cold storage nauplii at 4 ^{o}C. The technique would
  - allow a constant supply of high quality nauplii,
  - more frequent feeding to FW fish larvae and fry

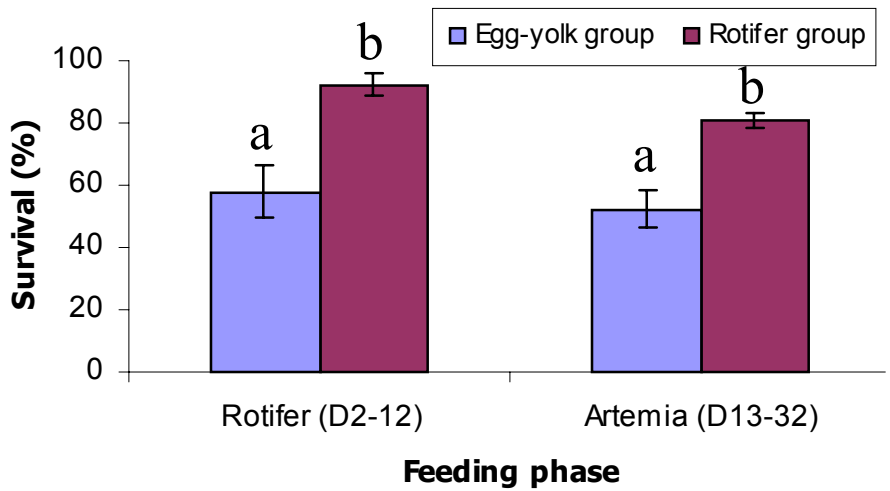
Dwarf Gourami (*Colisa lalia*)

- Larvae measure 2.74 mm
- Raised in fertilized ponds of >100 m^3 capacity
- Fed natural plankton supplemented with egg yolk particles for first 10 days
- Low stocking density of <0.5/l

Dwarf Gourami: Effects of rotifer feeding

- Phase 1: Rotifer vs egg-yolk feeding, 30 larvae/l
- Phase 2: Both groups fed *Artemia*, 10 larvae/l





- Food is not limiting, quality of feed in initial feeding is crucial to later developments

	Extensive culture in ponds using egg-yolk	Intensive culture in tanks using rotifers
Overall survival (%)	17.5%	65.1-74.5%
Yield (No./m^3)	90	6,500 – 7,500

Use of rotifers for feeding would enable intensive larviculture and improve the larval performance in freshwater ornamental fish.

Discus: Parental feeding

- Feed on body mucus of parent fish during first two weeks
- Problems:
  - Risk of larvae being eaten up
  - Parent fish do not spawn

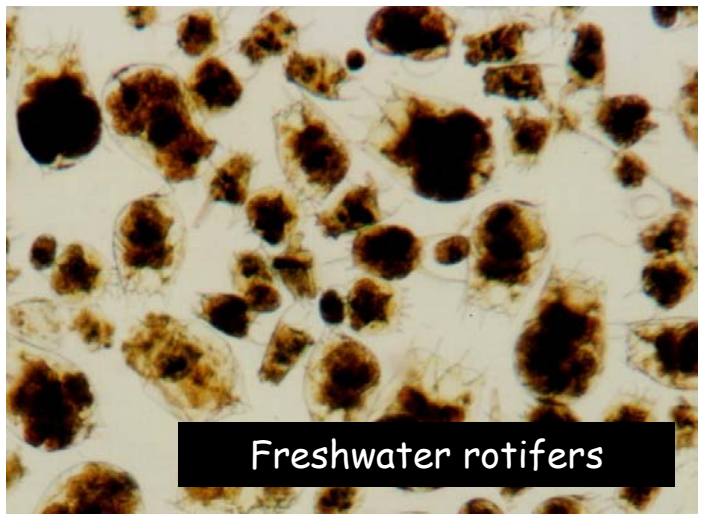
Discus: Artificial feeding

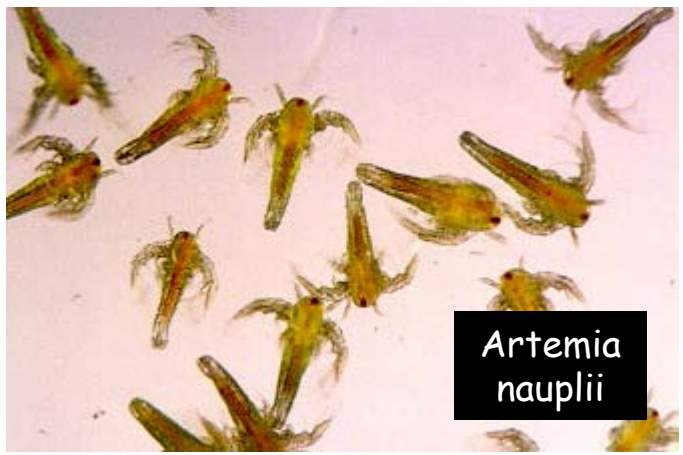
← Smuggle valuable larvae to low quality parents (foster parents) : Risk of cannibalism

↑ Smear yolk-food below water line: change water and food prepared afresh; tedious and laborious

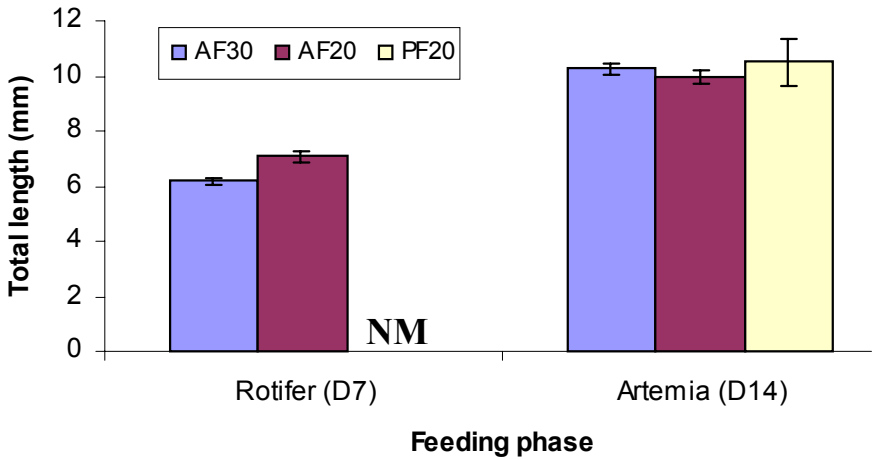
Discus larvae could be raised in the absence of the parent fish through feeding with

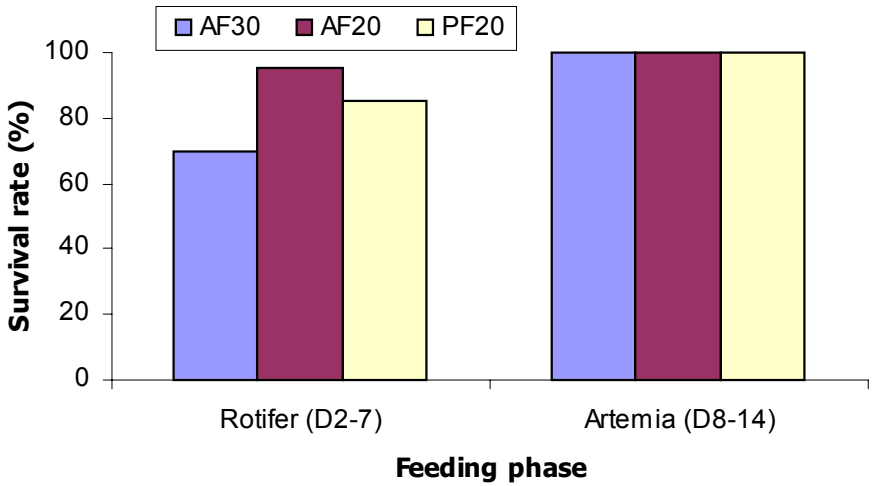
- B. calyciflorus from D4-7
- Artemia nauplii for a week, D8-14





- Growth and survival were comparable to parental feeding





AF30: Artificial feeding; 30 larvae/l; AF20: Artificial feeding; 20 larvae/l

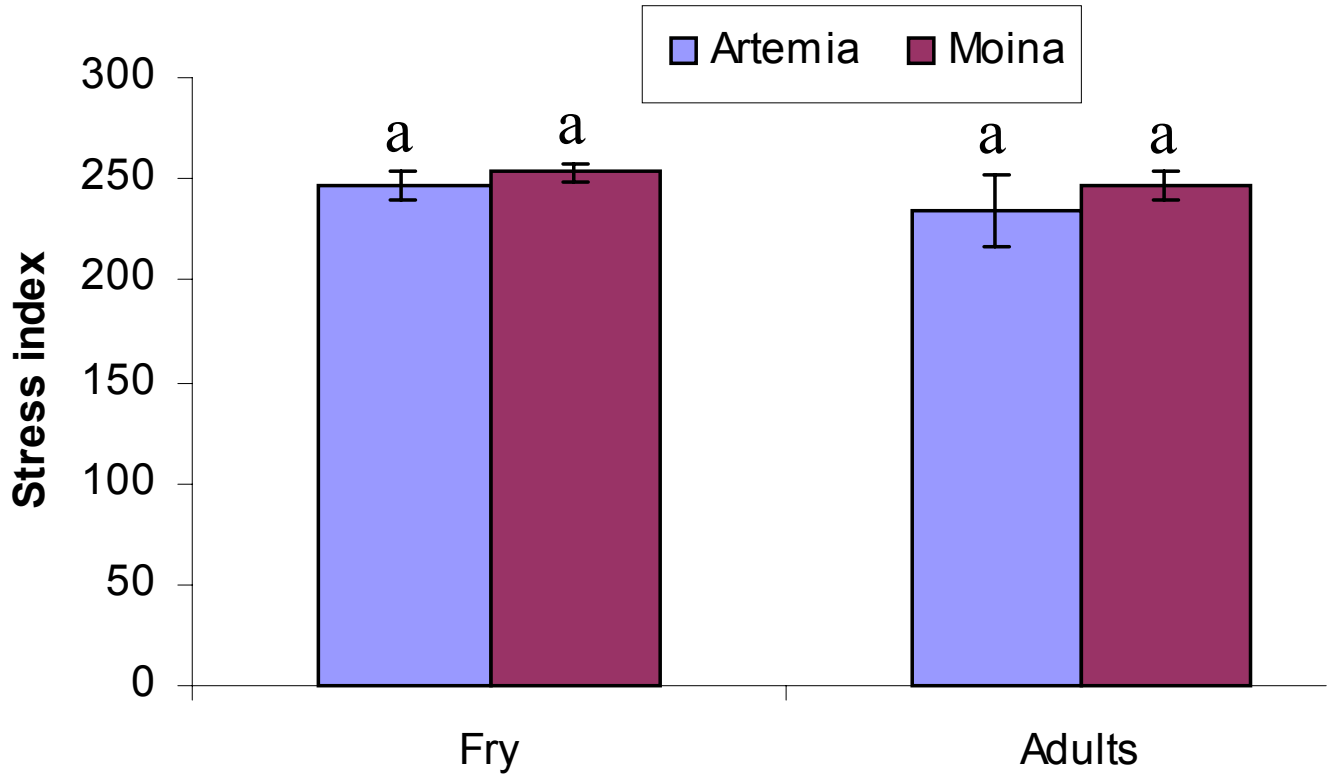
PF30 : Parental feeding; 30 larvae/l; NM: Not measured

Discus: Advantages of using live feeds for artificial feeding

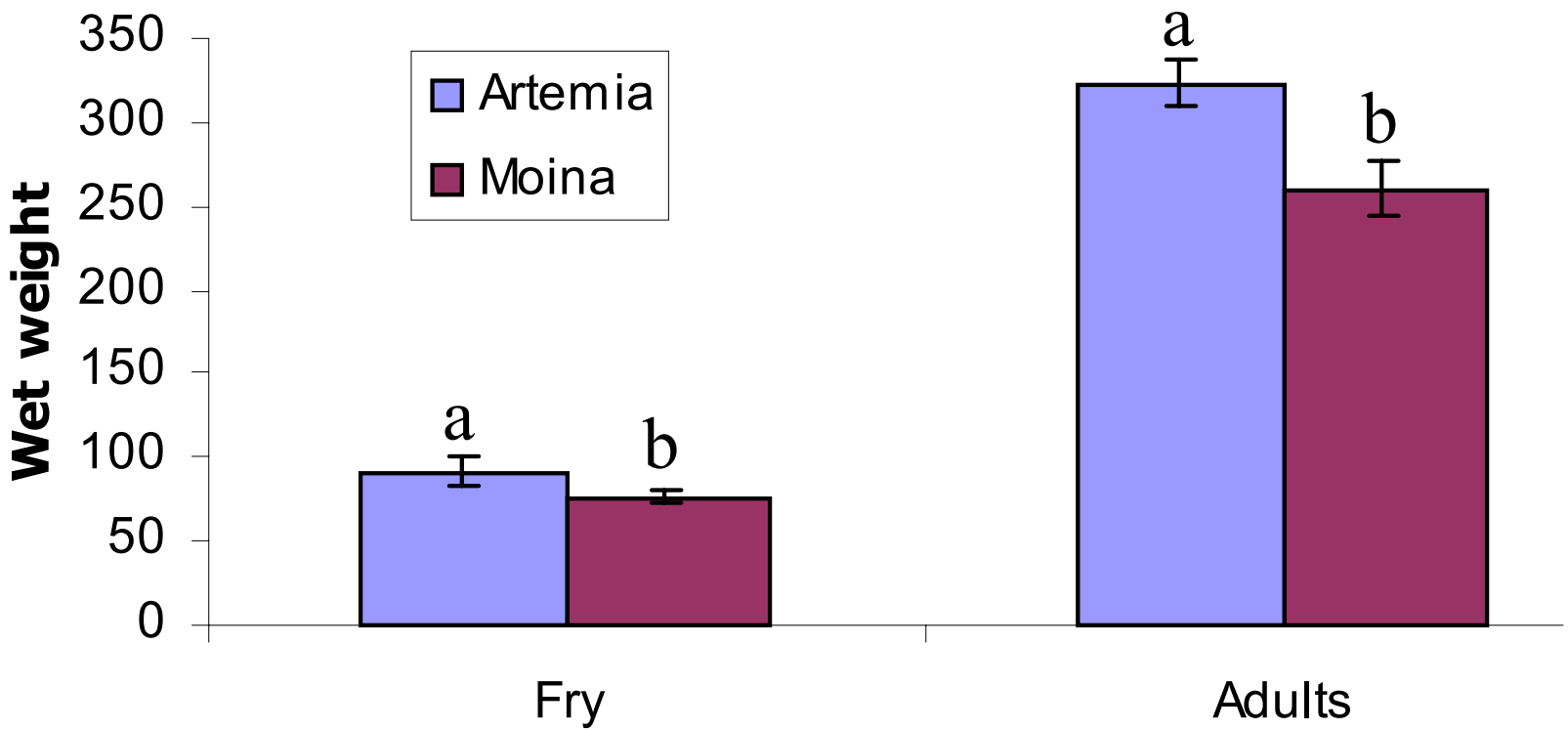
- Safe: no cannibalism
- Less tedious: frequent change of water not required
- More practical for commercial application

Use of *Artemia* nauplii in Guppy Culture: Stress resistance

Performances of Guppy adults and fry fed Artemia nauplii are better than those fed Moina



Use of *Artemia* nauplii in Guppy Culture: Growth



Use of decapsulated cysts

- Have been used for feeding larvae and fry of
  - marine shrimp
  - freshwater prawn
  - freshwater foodfish

- Their use in marine fish not successful, as the larvae and fry do not have the necessary enzyme for digestion of the cysts' embryonic membranes.

Guppy Adults

Parameters	Brine cysts	Dried cysts	Artemia nauplii	Moina
Stress index (at 35 ‰)	225.5 a (4.80)	242.8 a (9.91)	233.5 a (17.75)	246.5 a (7.33)
Wet weight (mg)	323.3 a (19.06)	343.9 a (15.48)	323.1 a (14.43)	260.3 b (15.76)
Dry weight (mg)	112.6 a (10.97)	119.5 a (6.12)	110.1 a (2.62)	78.0 b (2.44)
Total length (mm)	30.2 a (0.25)	31.1 a (0.53)	30.2 a (0.52)	29.0 b (0.62)
Survival rate (%)	100.0 a (0)	99.8 a (0.50)	99.5 a (1.00)	98.0 b (0.82)

Fish fed on cyst diets:

- No difference in stress resistance with AN and MN
- No difference in growth & survival with AN
- Better growth and survival than MN

Guppy fry

Parameters	Brine cysts	Dried cysts	Artemia nauplii	Moina
Stress index (at 30 ‰)	210.5 a (3.11)	221.8 b (5.25)	247.0 c (6.88)	253.5 c (4.51)
Wet weight (mg)	92.0 b (1.04)	122.3 a (4.94)	91.9 b (8.51)	76.7 c (4.71)
Dry weight (mg)	24.9 b (1.54)	37.0 a (2.87)	23.9 b,c (2.51)	19.1 c (2.58)
Total length (mm)	20.6 b (0.47)	21.7 a (0.46)	20.2 b (0.51)	20.1 b (0.66)
Survival rate (%)	65.3 a (4.33)	60.6 a,b (1.11)	58.0 b (2.71)	57.0 b (3.72)

Fry fed on cysts diets displayed:

- Better stress resistance than AN & MN
- Better growth than MN; better or comparable growth with AN
- Better or comparable survival with AN or MN

- For Guppy fry and adults fed cysts diet, their performance in terms of stress resistance, growth and survival are better than or comparable with those fed Artemia nauplii and Moina

- Similar results were obtained in the fry of
  - Molly (Poecilla sphenops)
  - Platy (Xiphophorus maculatus)
  - Swordtail (X. helleri)
  - Black Neon Tetra (Hyphessobrycon herbertaxelrodi)

- Better performance in cyst-fed fish could at least partly due to superior fatty acid composition of cysts
- Corresponds to higher energy content in Artemia cysts than nauplii

Fatty acids (mg/g DW)	Brine cysts	Dried cysts	*Artemia* naplii	*Moina*
20:5(n-3) EPA	4.0	4.4	0.9	2.3
22:6(n-3) DHA	0.7	1.9	0.3	0.2
Total (n-3)HUFA	6.0	8.0	2.0	3.1
DHA/EPA ratio	0.17	0.44	0.35	0.10
(n-6)/(n-3)	0.21	0.22	0.26	0.84
Total FAME	109.1	126.4	47.5	73.2

- Decapsulated Artemia cysts can be used as a substitute for Artemia nauplii or Moina
- Advantages
  - Being a hygienic off-the-shelf feed
  - Direct use of the cysts signifies a new area of application of low-hatch cysts in the OF industry
  - Saving in feed cost

Use of on-grown *Artemia*

- Bigger and older on-grown Artemia may be a good alternative live feed for feeding to larger OF including brooders
- Its use not as popular as Artemia nauplii, due to lack of supply

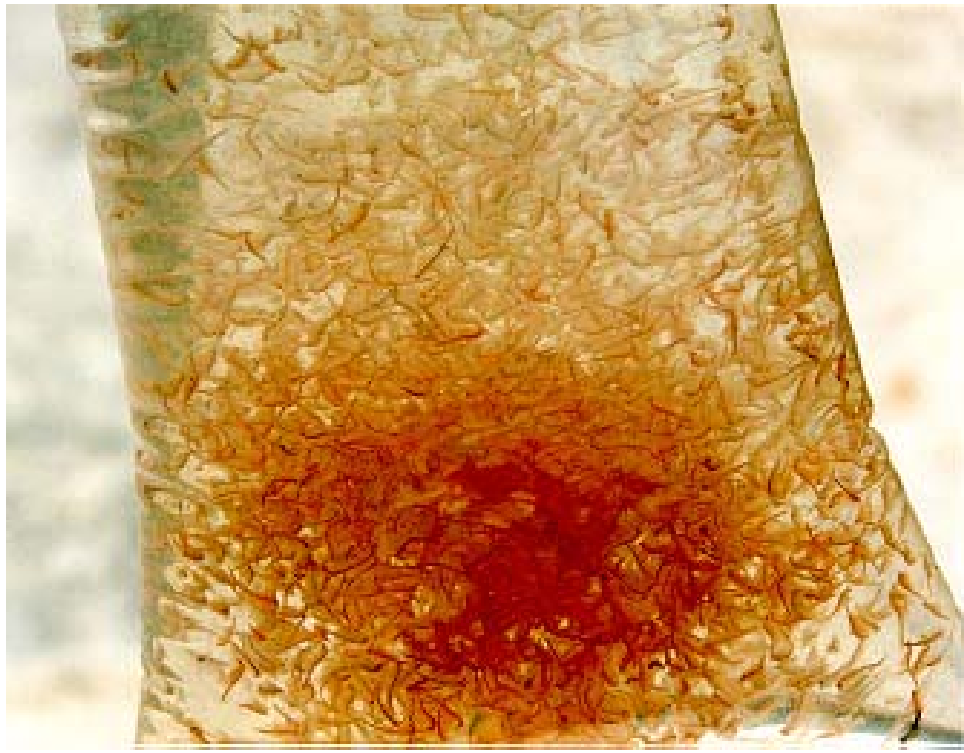
- Culture system developed in Singapore to facilitate supply for OF culture

Pilot production system for On-grown *Artemia*

21 culture raceways (5.6 m^3 each); each unit consists of 18 air-lift pumps and 2 waste collectors

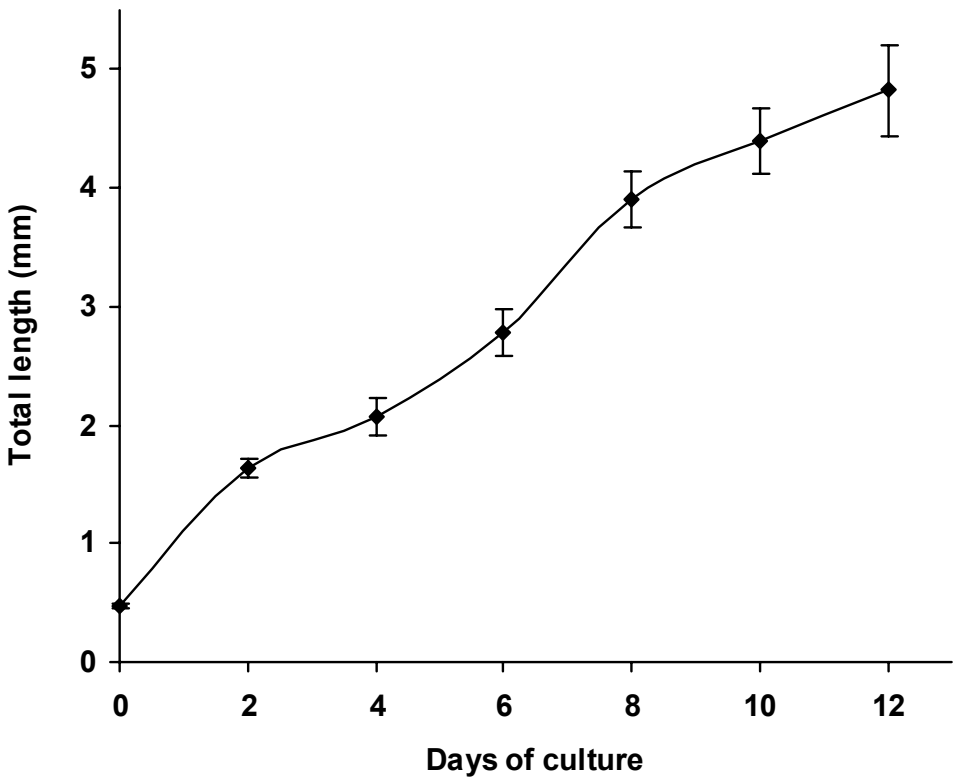
Pilot production system for On-grown *Artemia*

- Uses artificial seawater of 20‰ for culture
- Artemia are fed rice bran and de-fat soybeans
  Production rate: 3 kg/m^3 in 12-day cycle
- Production capacity: 8 mt./yr
- Construction cost: US$ 82,000



- Compared with existing system: cost effective, simple and easy to set up and operate

Size of on-grown *Artemia*



- Grew from 0.45 mm to 5mm in 12 days - size range suitable for feeding all ornamental fish up to 10 cm TL.
- By varying harvesting time, possible to tailor prey size accordingly to size and age of fish - other live feeds such as rotifers and Artemia nauplii do not have such flexibility

Feeding of on-grown *Artemia* to Discus juveniles

- Due to more effective food uptake, the Artemia-fed group grew faster than fish fed Moina or frozen bloodworms
- Survival: no significant difference

Parameters	Fish feeds		
	On-grown *Artemia*	*Moina*	Frozen bloodworms
Wet weight (g)	0.85 a (0.01)	0.81 b (0.01)	0.75 c (0.01)
Total length (mm)	3.48 a (0.03)	3.44 a,b (0.04)	3.37 b (0.04)
Survival rate (%)	90.0 a (13.2)	78.3 a (10.4)	91.7 a (2.89)

Fatty acids composition of four diets

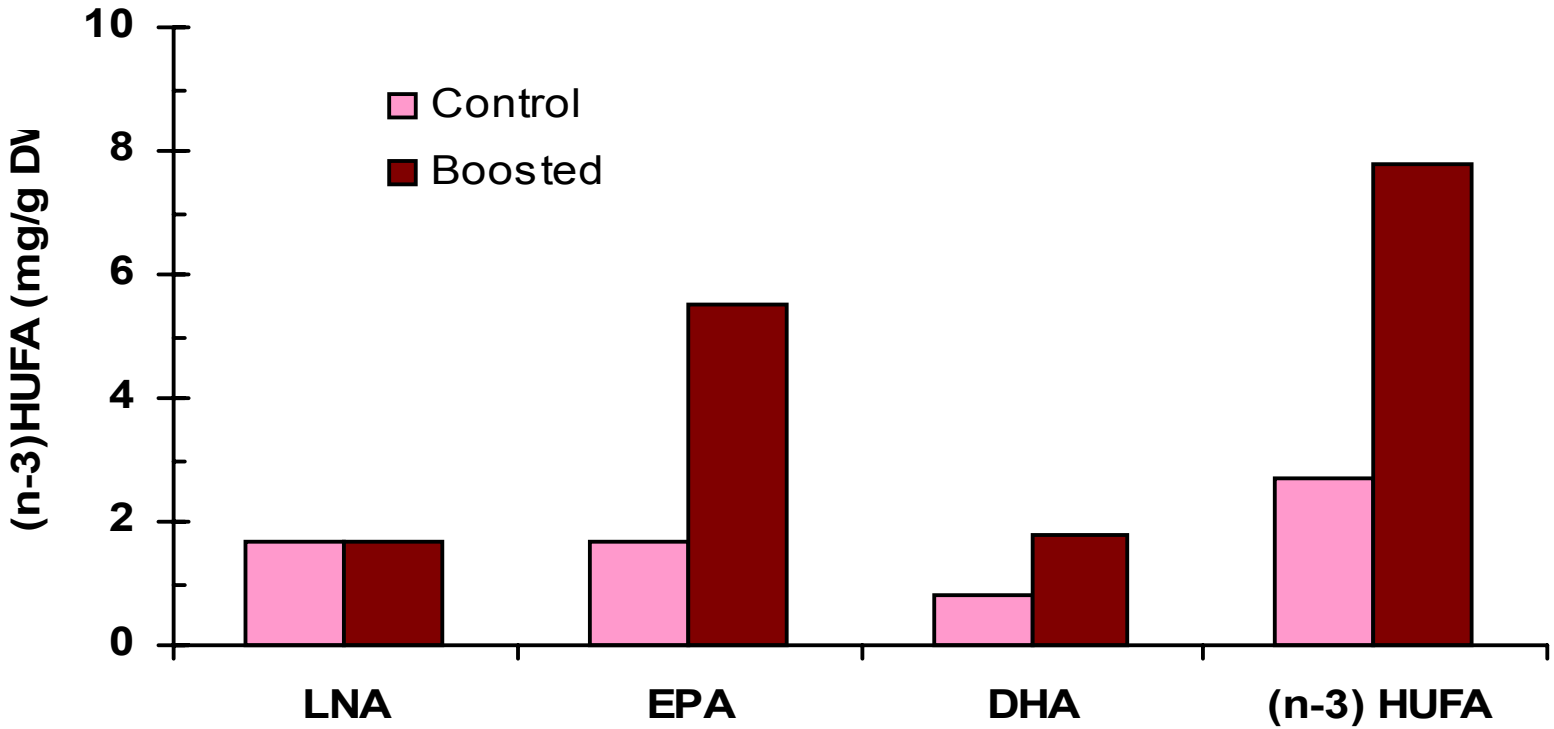
Fatty acids (mg/g DW)	On-grown *Artemia*	*Artemia* nauplii	*Moina*	Bloodworms
18:2(n-6) LLA	15.4	2.9	9.4	8.1
20:4(n-6) AA	1.8	1.0	0.8	0.7
Total (n-6)HUFA	1.9	1.1	0.9	0.8
18:3(n-3) LNA	1.7	12.9	10.7	7.1
20:5(n-3) EPA	1.7	0.9	1.0	0.9
22:6(n-3) DHA	0.8	0.3	0.1	0.1
Total (n-3)HUFA	2.7	2.0	1.3	1.1
Total Fame	49.50	47.50	72.30	62.40

On-grown Artemia

- Deficient in LNA
- Highest in LLA AA, total (n-6)HUFA, EPA & DHA
- AA might be essential to maturation and spawning of FW ornamental fish

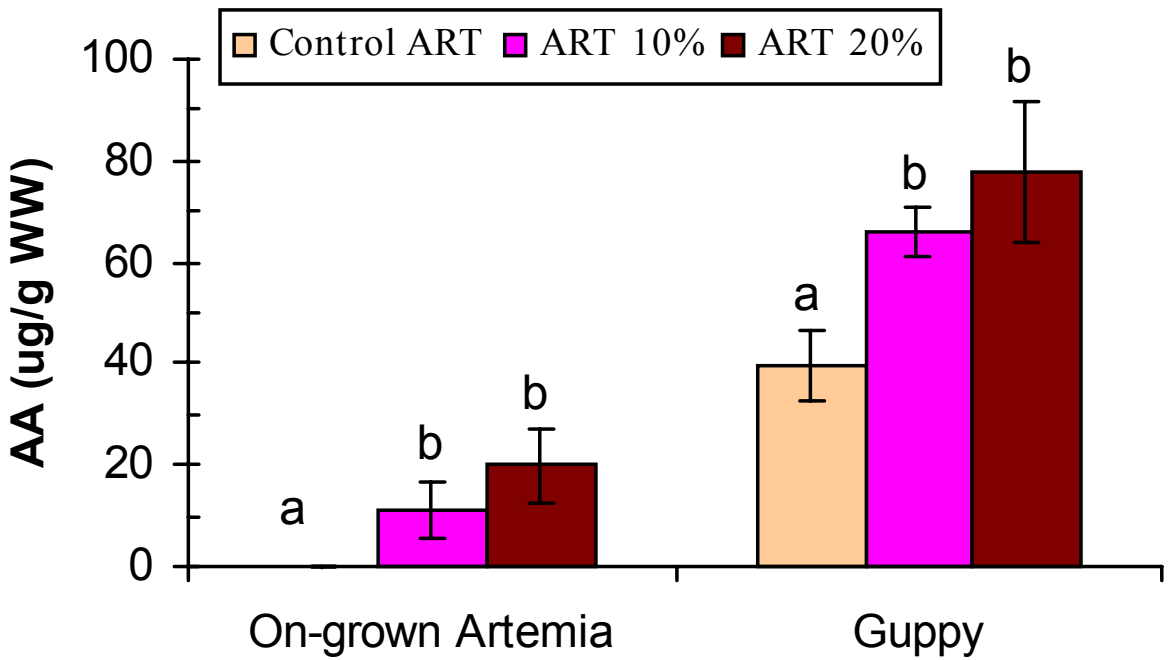
Bioencapsulation of on-grown *Artemia* with DHA

- Continuous, non-selective feeding behavior - an ideal booster diets
- On-grown Artemia boosted with DHA show increases in EPA, DHA and (n-3)HHFA



Bioencapsulation of on-grown *Artemia* with AA

- On-grown Artemia boosted with ascorbyl palmitate displayed significant increases in AA

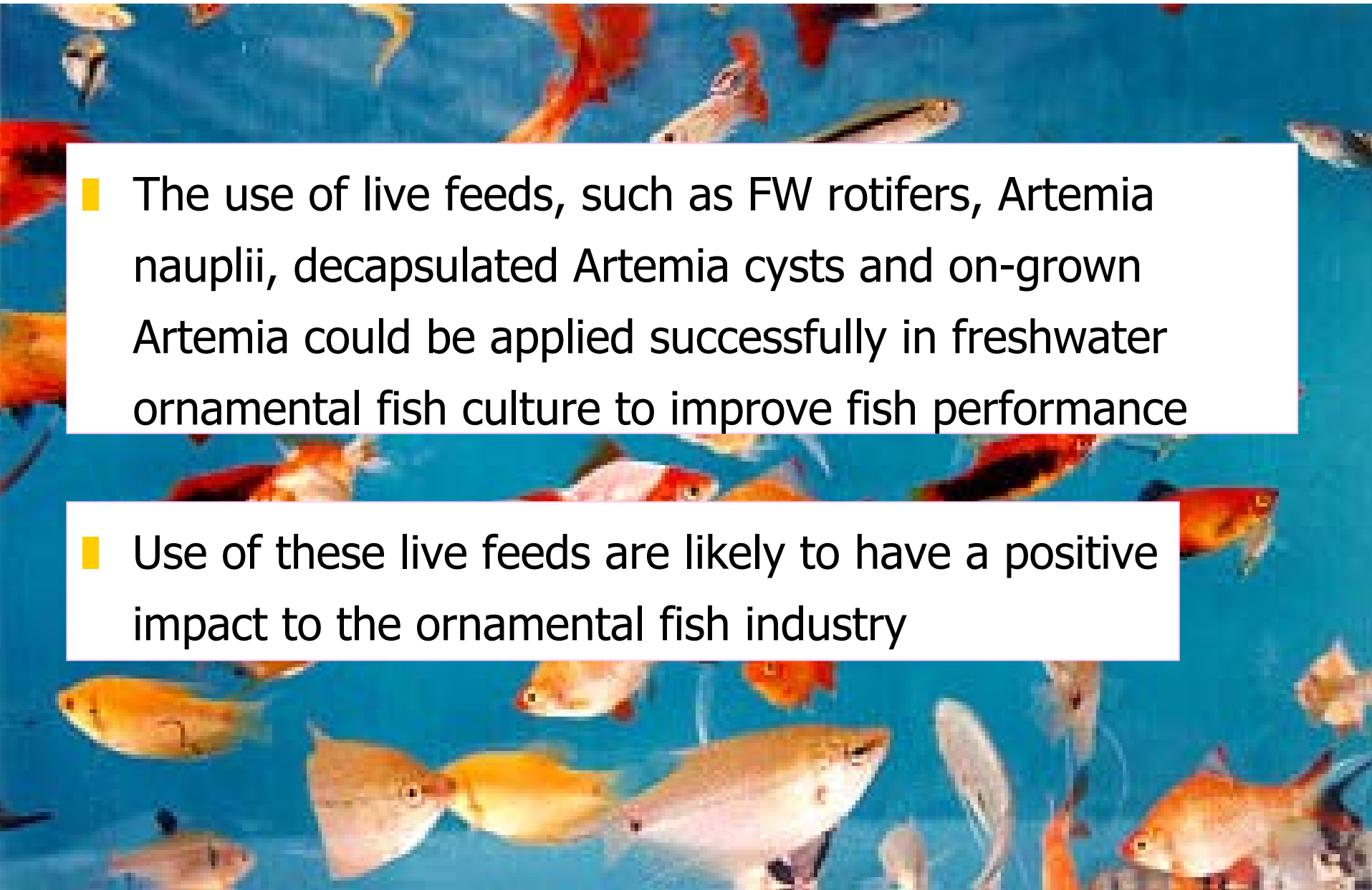


- Guppy fed boosted on-grown Artemia also resulted in concomitant increase in incorporated AA

Availability of on-grown *Artemia* would

- offer farmers and exporters a bigger alternative live feed for feeding larger ornamental fish and brooders
- More importantly, offer possibility of enhancing fish performance and quality through bioencapsulation

Conclusion



- The use of live feeds, such as FW rotifers, Artemia nauplii, decapsulated Artemia cysts and on-grown Artemia could be applied successfully in freshwater ornamental fish culture to improve fish performance

- Use of these live feeds are likely to have a positive impact to the ornamental fish industry

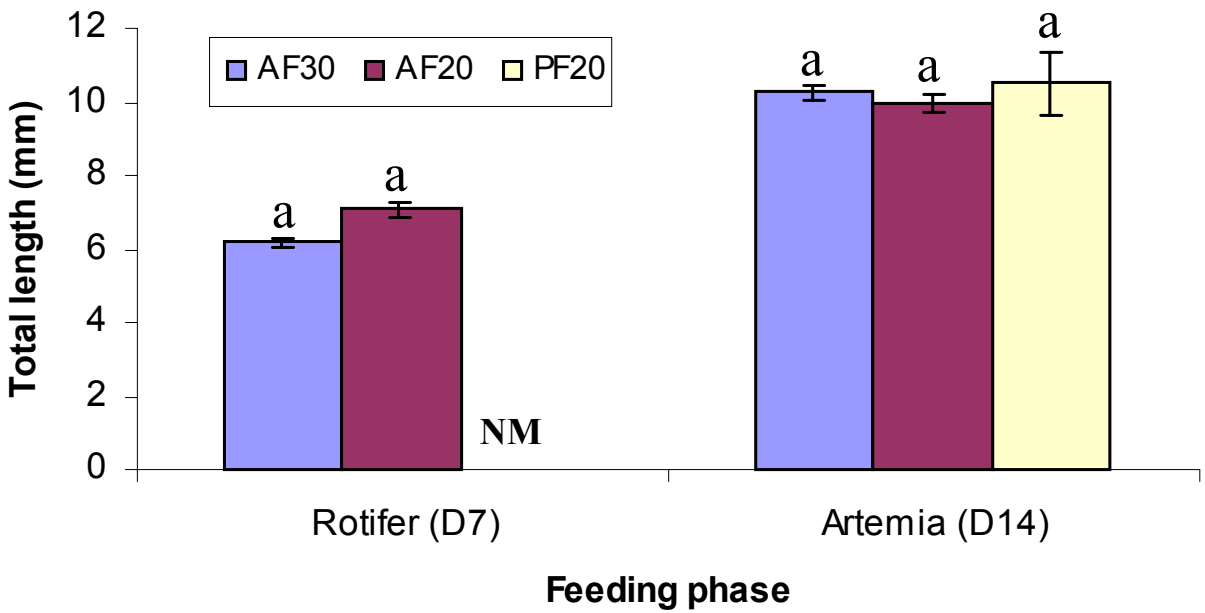
Thank you

Application of bio-encapsulation

Many possible applications, including boosting the on-grown *Artemia* with

- essential nutrient such as HUFAs to improve growth, survival & increase vigor
- pigments or color enhancer to obtain better coloration
- therapeutic drugs for disease treatment
- vitamin C or immuno-stimulants to enhance stress and disease resistance, and
- hormone to induce sex reversal, maturation & spawning

Discus:
Parental feeding vs Artificial feeding



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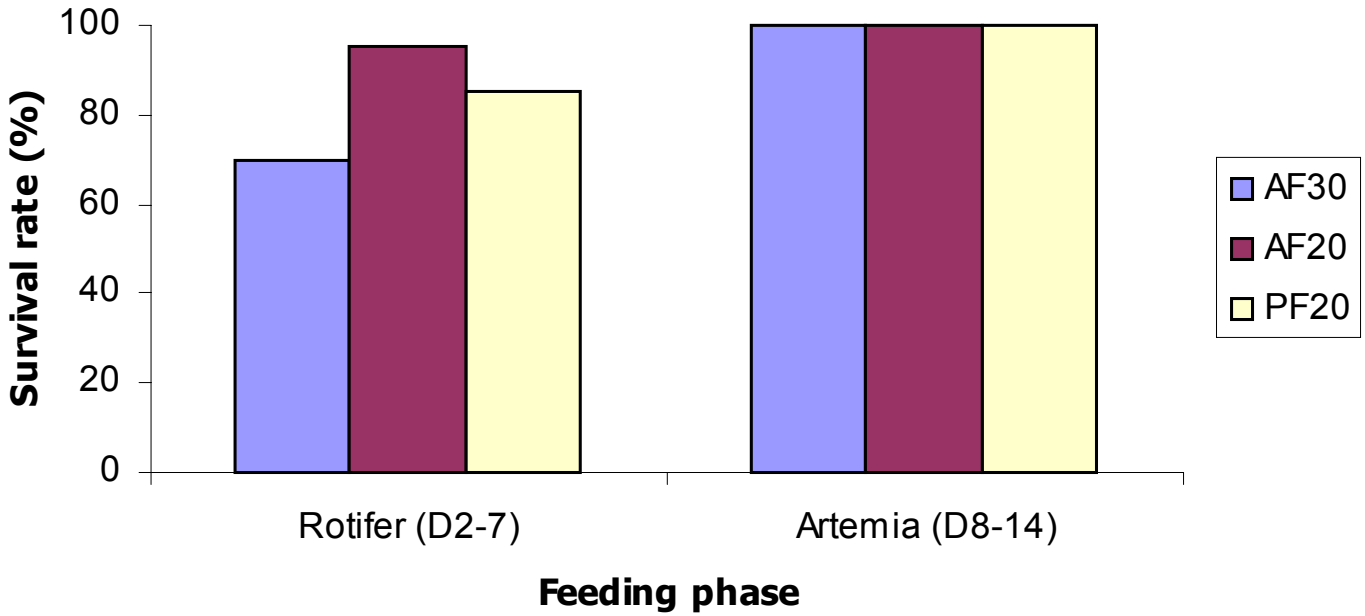
Discus:
Parental feeding vs Artificial feeding



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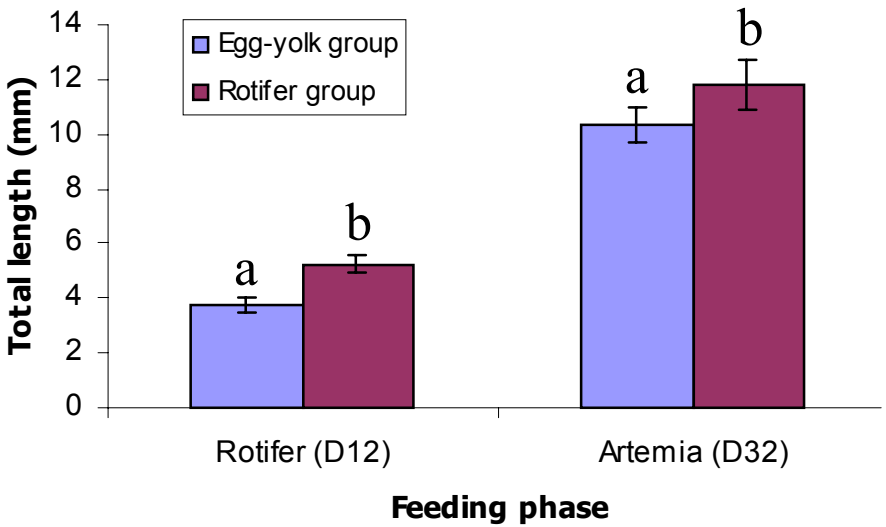

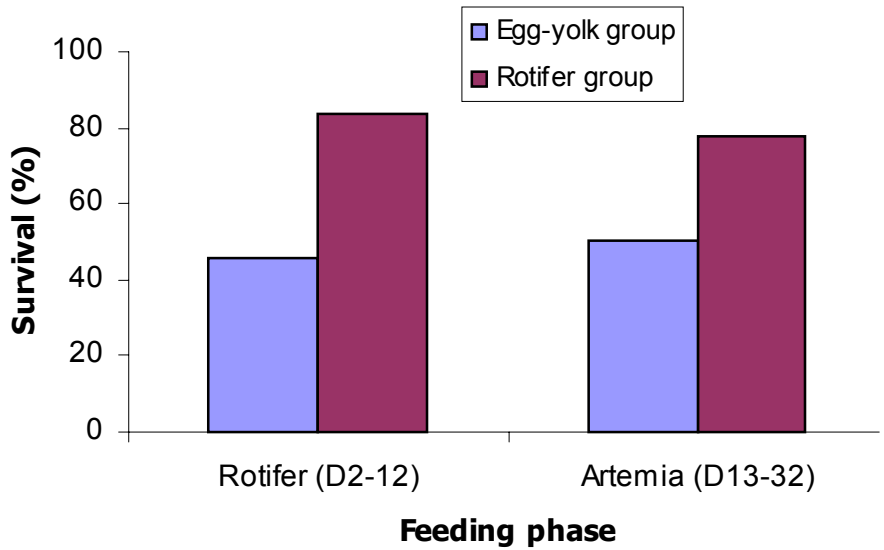

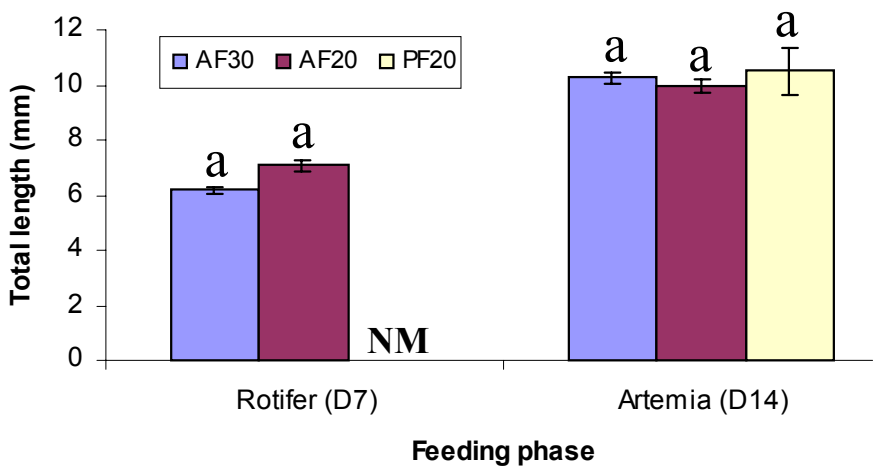
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10
8
6
4
2
0
Total length (mm)
AF30
AF20
PF20
a
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NM
Rotifer (D7)
Artemia (D14)
Feeding phase