

Diel feeding rhythm of finfish larvae and establishment of appropriate feeding schedule

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1. Introduction

“When should we feed on larvae and juveniles?”



“How should we decide when we feed on larvae and juveniles?”

“When do larvae and juveniles ingest actively?”



Feeding rhythm



Fishes have the time zones when they ingest actively
(reviewed in Boujard and Leatherland, 1992)



When larvae ingest?



Less knowledge

If the feeding schedule is not appropriate,

Feedings are performed when ingestion is inactive



the nutritional value of live feeds declines

Feedings are not performed when ingestion is active



the amount of live feeds is short in the culture water



The decline in nutritional value or the shortage of live feed influence on larviculture performance



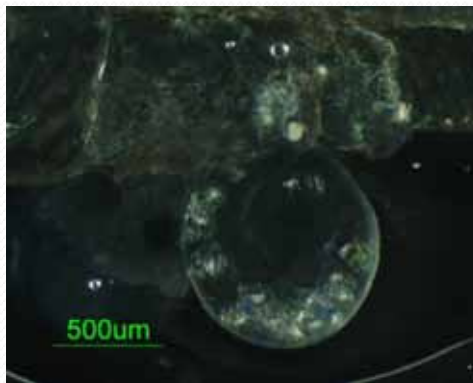
Larvae should be fed before they start active feeding



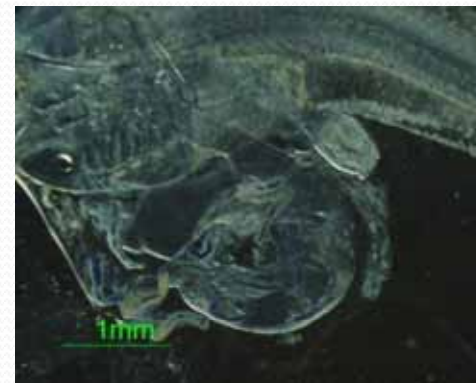
**important to know
when larvae show the active ingestion**

Methods

- Photoperiod in cultures was 12L12D.
- Larvae were placed on a slide glass and were crushed using a cover glass.
Under an optical microscope, the number of mastax of rotifers or head of *Artemia* nauplii in the gut was counted.
- The observation of gut contents was started after mouth opening (2-5 days after hatching).
- The gut contents were observed every 30 minutes.
- In each experimental day, experiment was performed for 25-26 hours.
- In each observation, 10 larvae were used.



Rotifers in the gut of crushed larva



Artemia nauplii in the gut of crushed larva

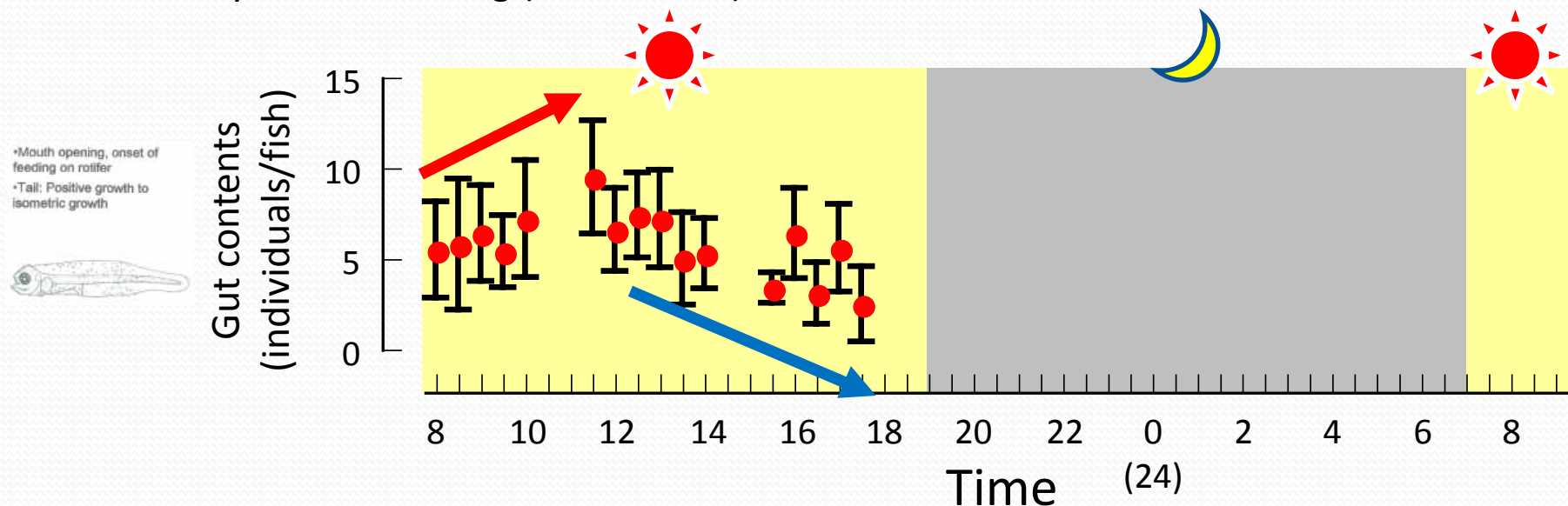
2. Japanese flounder *Paralichthys olivaceus*

Flounder larvae show the active feeding in dawn or dusk in the wild.

(Koshiishi et al., 1982; Hirota et al., 1990; Katayama et al., 2007)

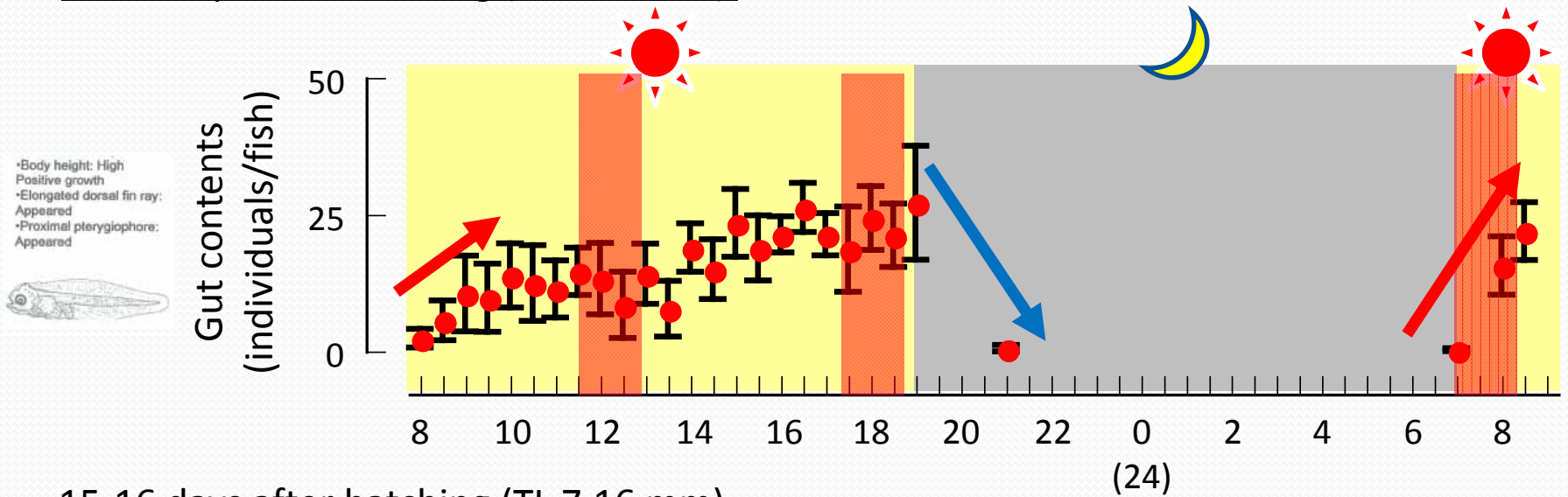
- Time of lighting: 7am
- Time of lights out: 7pm
- Feeding schedule: 7am, 10 am, 3pm
- Rotifer density: 5 rotifers/ mL
- *Artemia* nauplii density: 1-5 nauplii/ mL from 20 days after hatching

5-6 days after hatching (TL 3.47 mm)

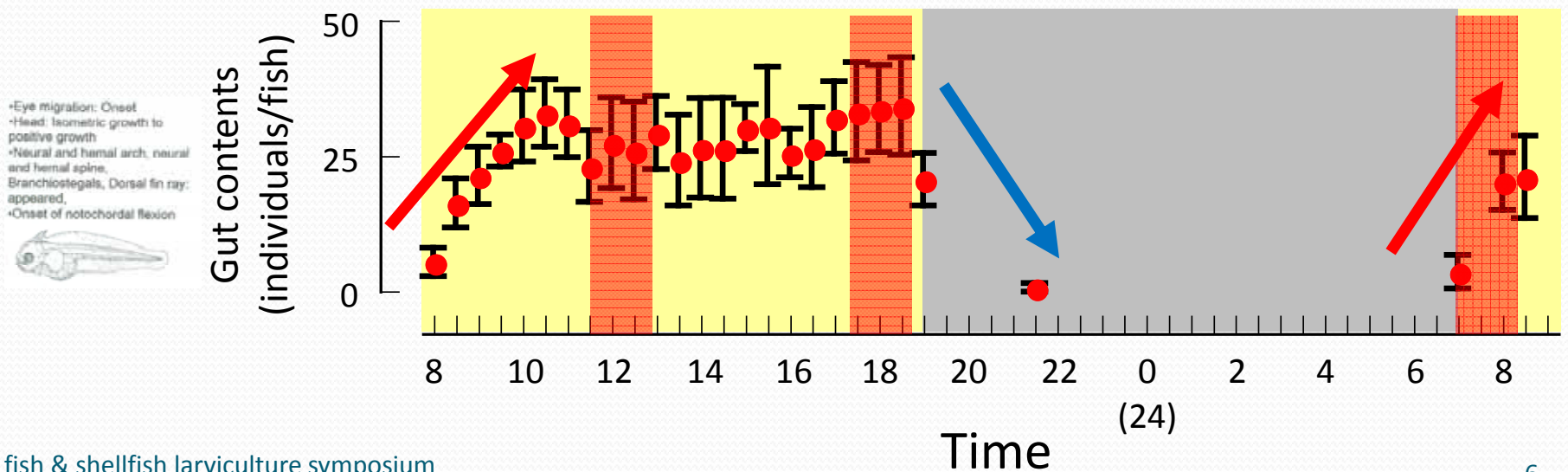


● : Rotifer

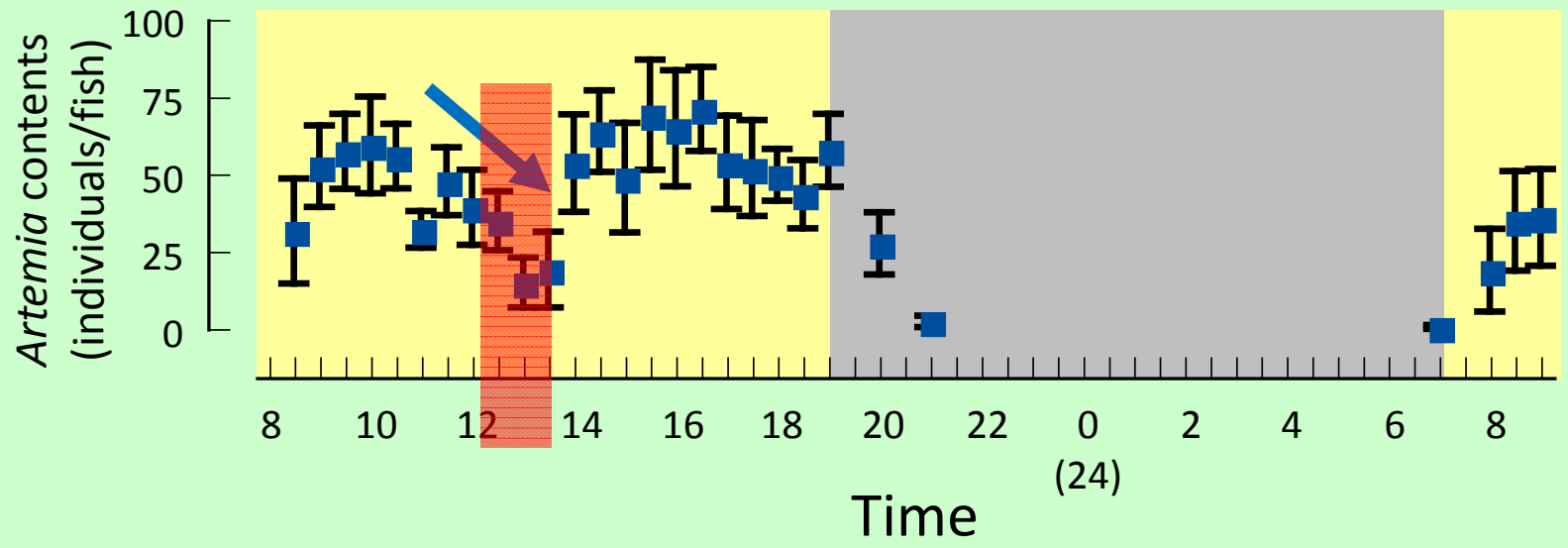
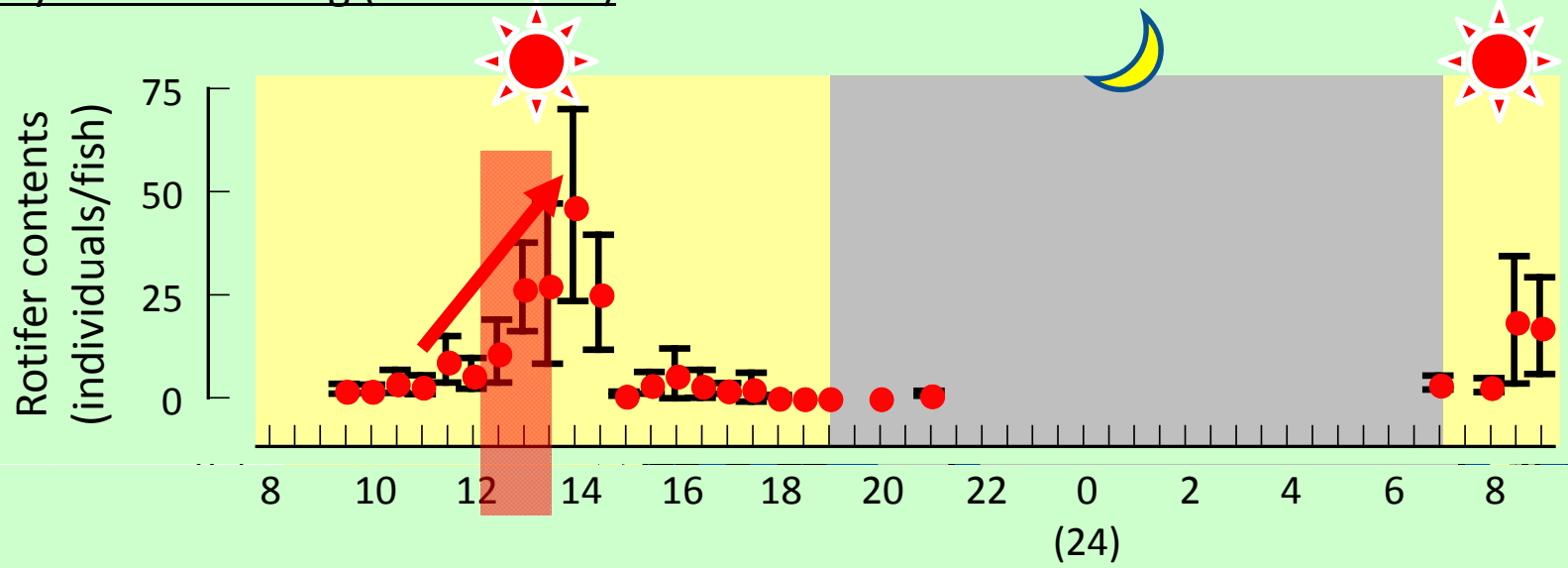
11-12 days after hatching (TL 5.93 mm)



15-16 days after hatching (TL 7.16 mm)



25-26 days after hatching (TL 9.89 mm)

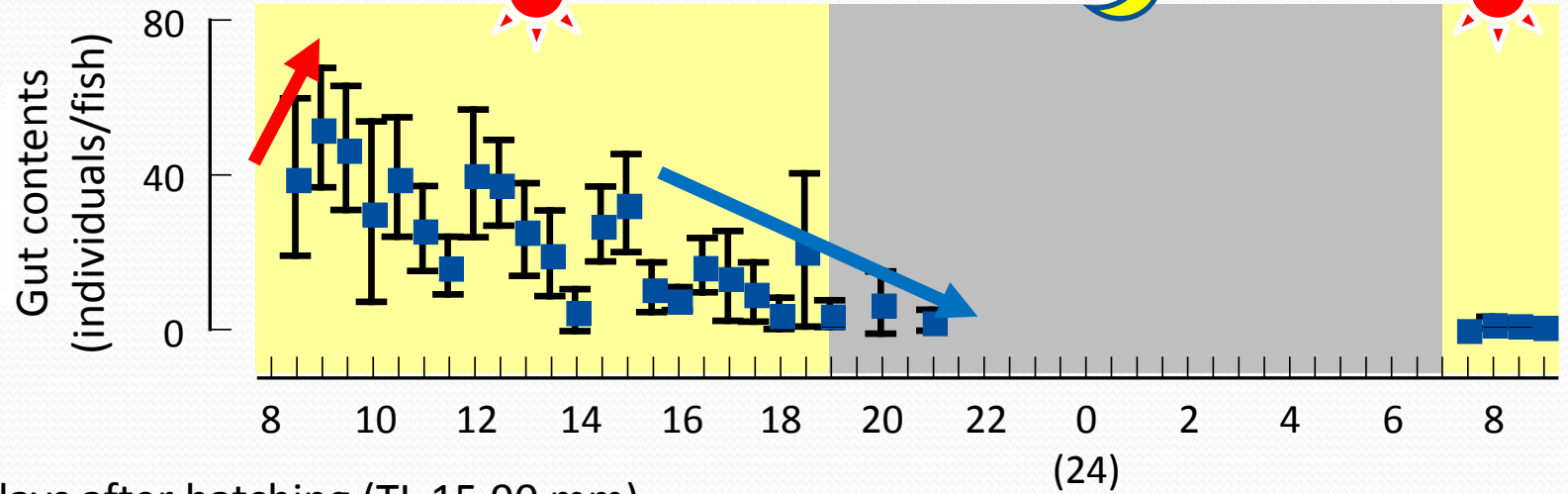


Time

■ : *Artemia nauplii*


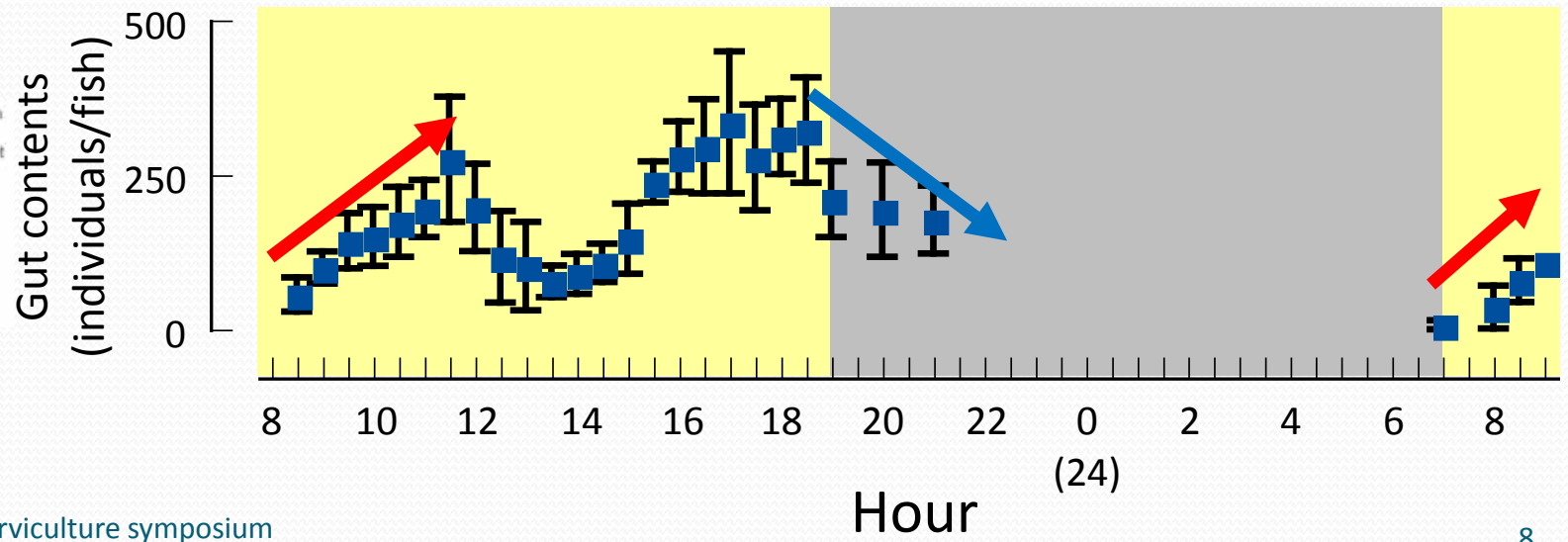
30-31 days after hatching (TL 13.16 mm)

•Head: Positive growth to isometric growth
 •Hypural: Onset of ossification
 •Elongated dorsal fin: Completion
 •Melanophore: Juvenile melanophore to adult one

35-36 days after hatching (TL 15.90 mm)

•Body height: Isometric growth to negative growth
 •cartilagenous ossification: Onset

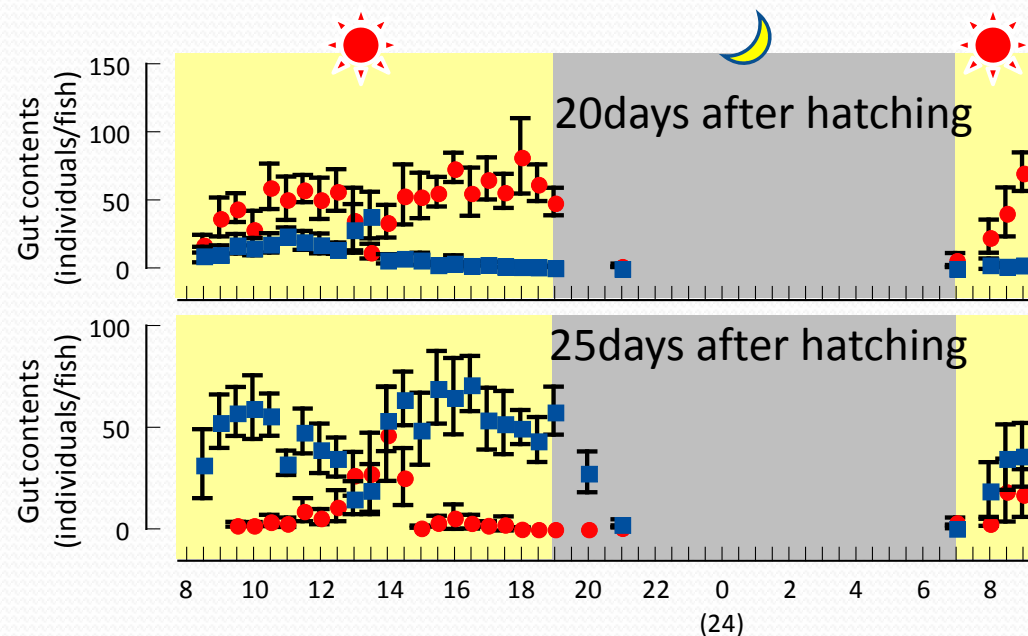
Results (Japanese flounder)

- Flounder larvae ingest food in daytime.
- No gut content was observed at 2 hours after lights out.
- Larvae ingest actively in the morning and after noon.
- In the period when rotifers and *Artemia* nauplii were fed, larvae increased the feeding amount of rotifers or *Artemia* nauplii and decreased its amount of another.

Effective feeding schedule:

Just after lighting, after noon and 2-3 hours before lights out

Specific feeding rhythm
of flounder?



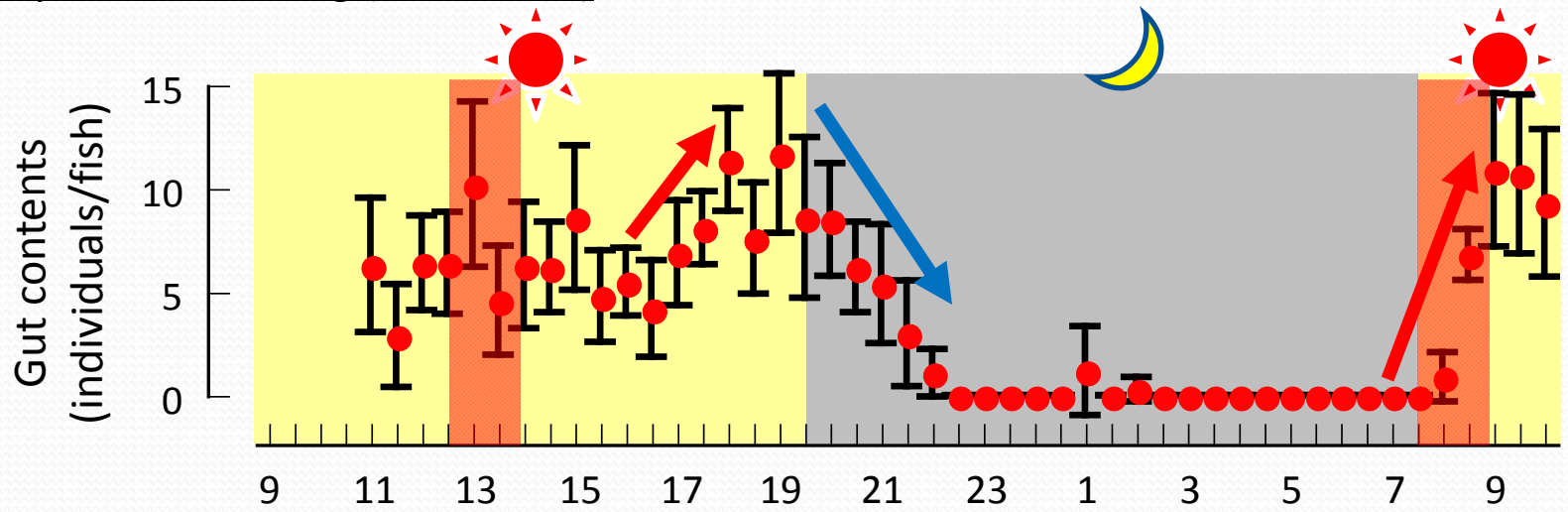
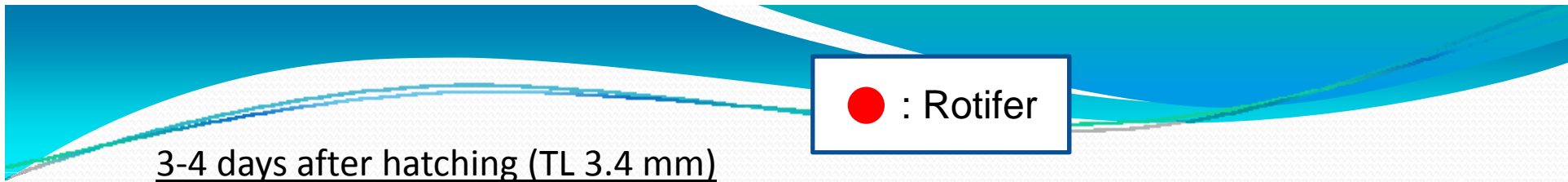
3. Red sea bream *Pagrus major*

In the wild, Red sea bream larvae shows the active feeding in the dusk.

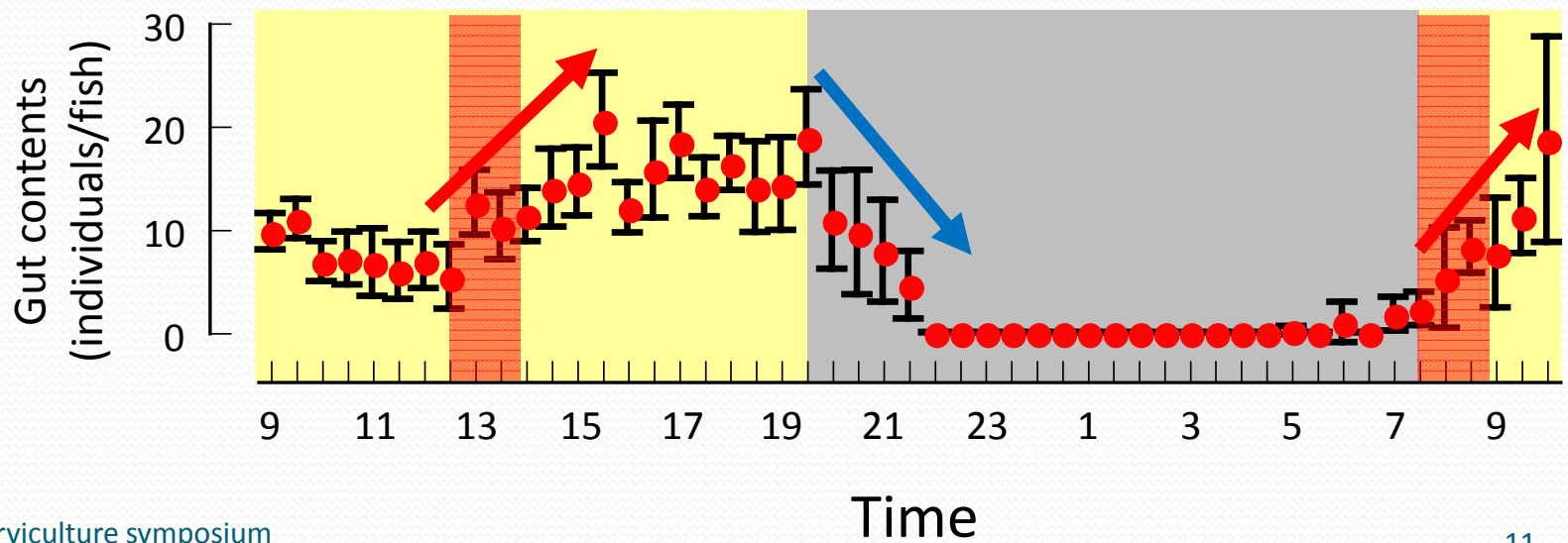
(e.g. Okada, 1967; Handa et al., 1980)

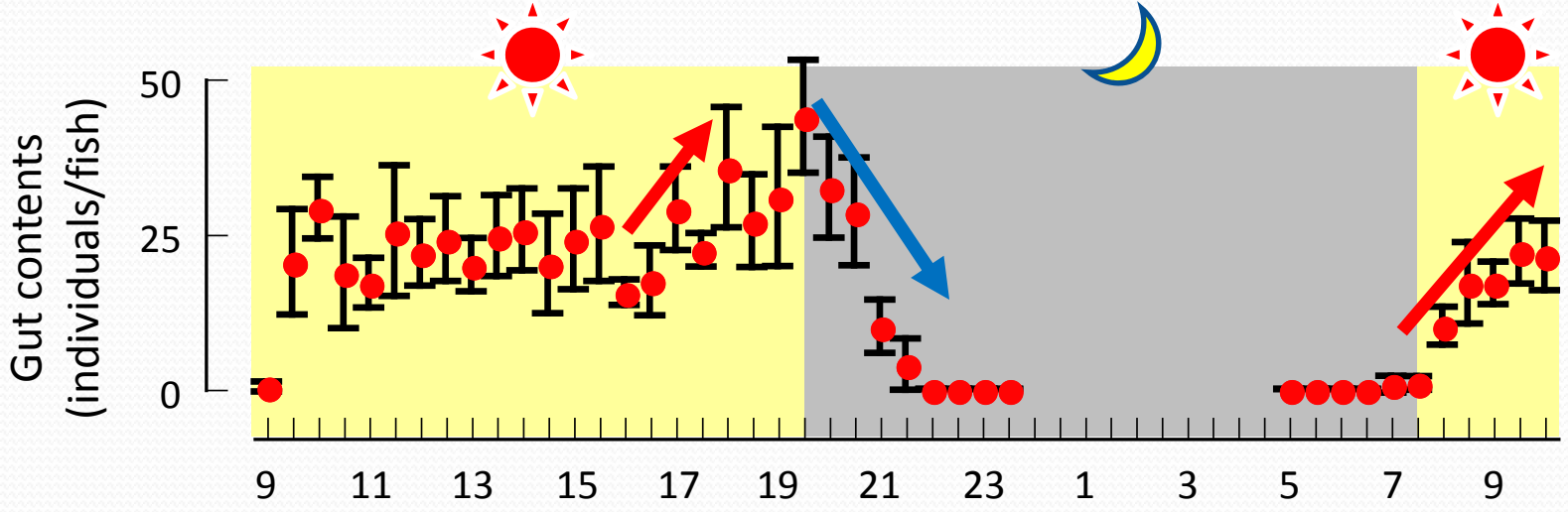
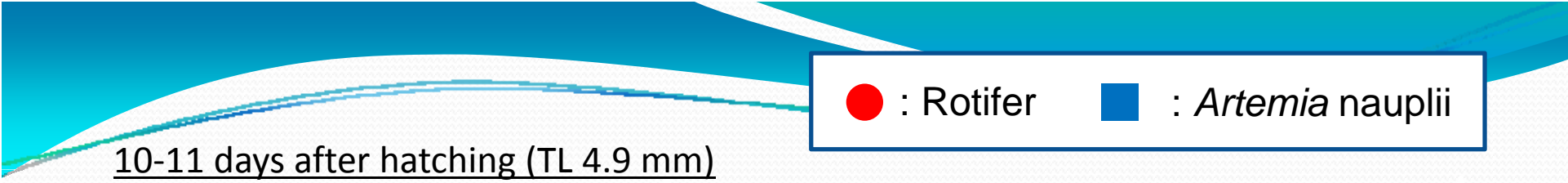


- Time of lighting: 7:30am
- Time of lights out: 7:30pm
- Rotifer density: 5 rotifers /mL (mouth opening-21days after hatching)
3 rotifers /mL (22-23 days after hatching)
- *Artemia* nauplii density: 1-5 nauplii/ mL from 20 days after hatching
- Rotifers were fed at 8:30am and 2:30pm.
- *Artemia* nauplii were fed at 8:30am, 2:30pm and 5:30pm.

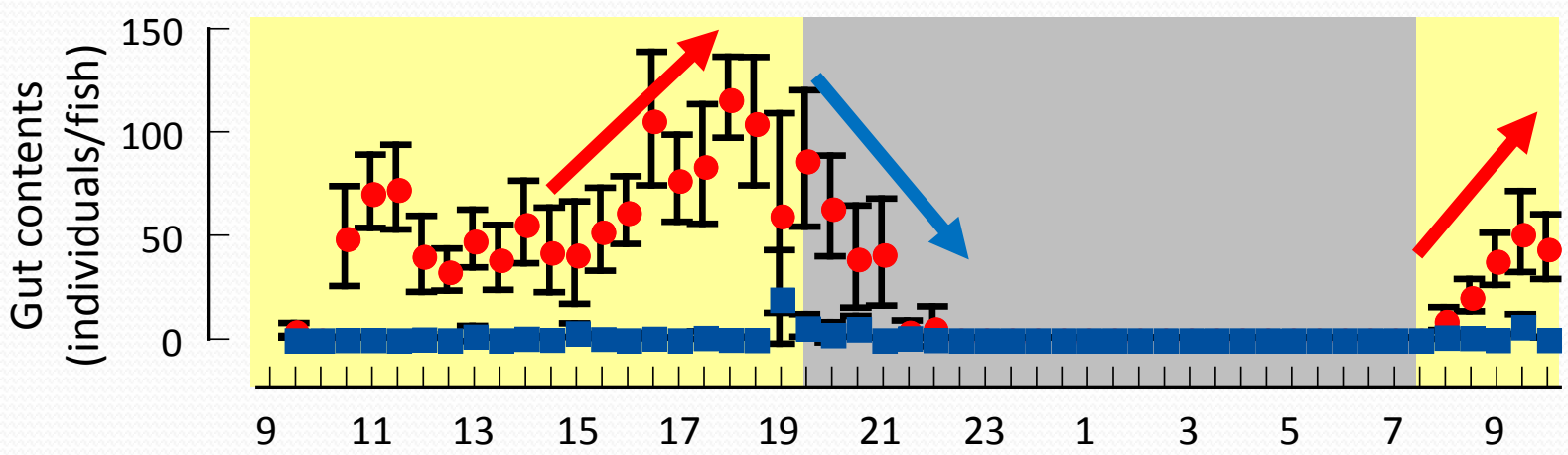


5-6 days after hatching (TL 3.7 mm)

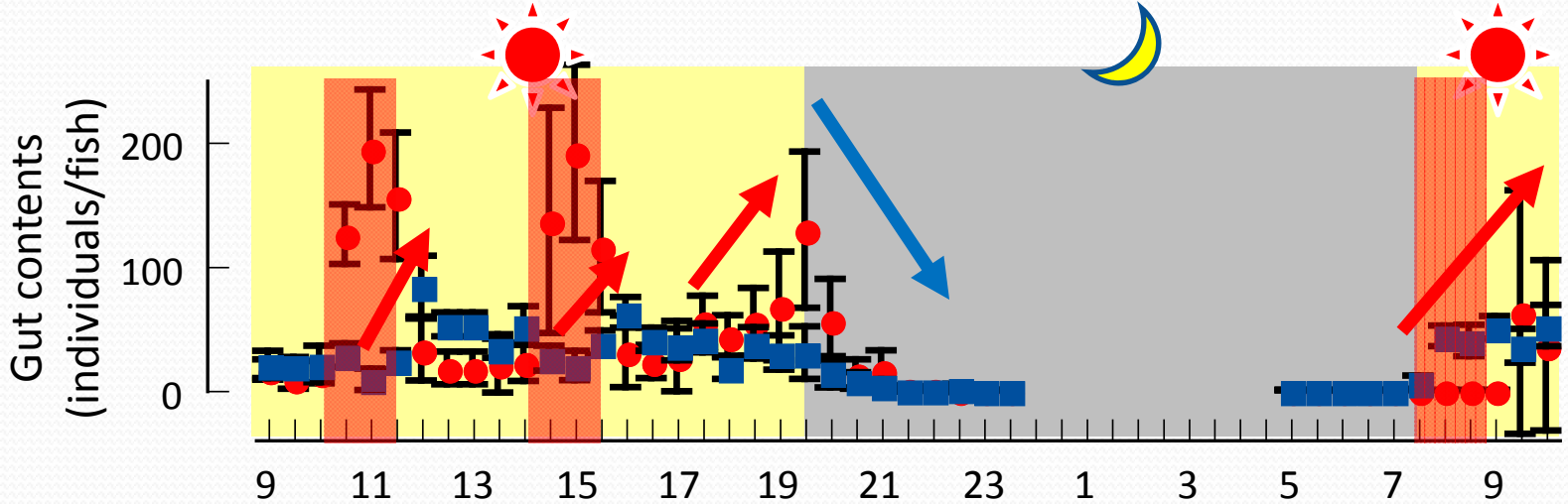
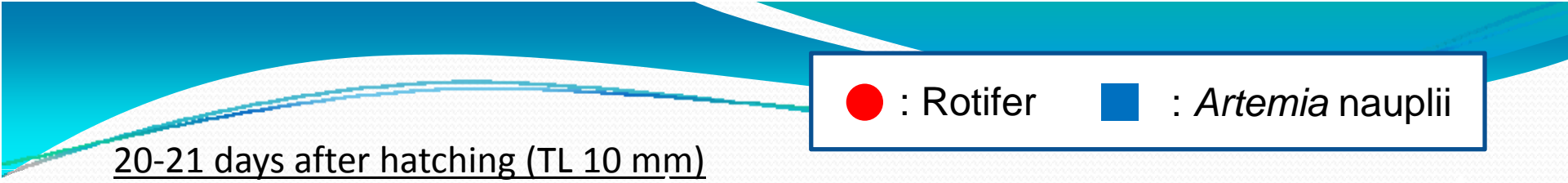




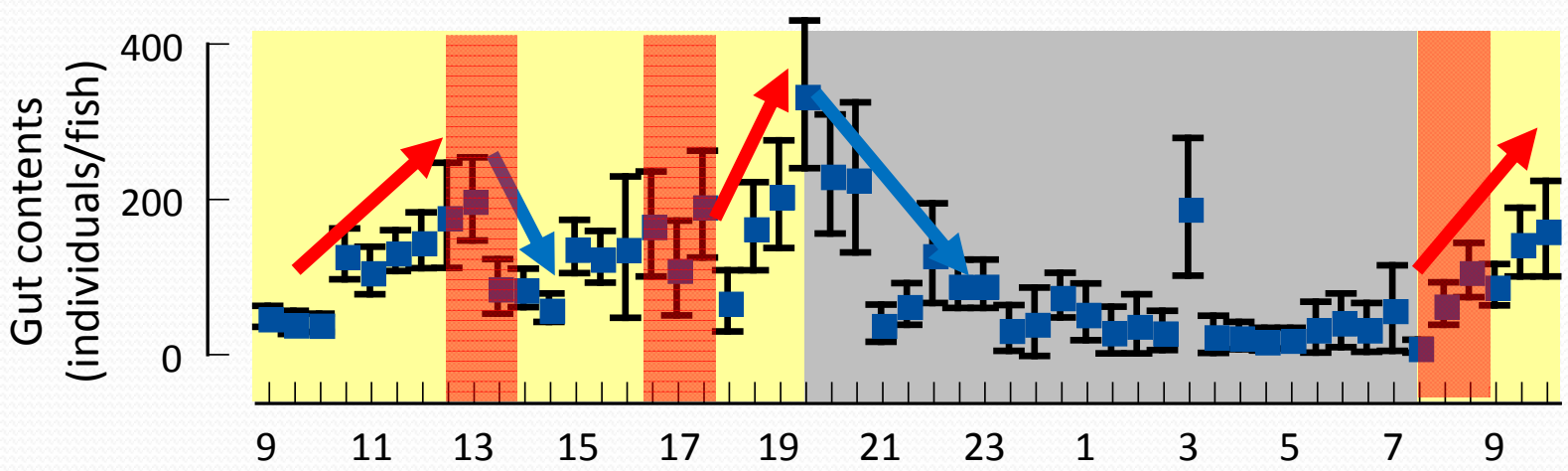
15-16 days after hatching (TL 6.2 mm)



Time



24-25 days after hatching (TL 11 mm)



Results (Red sea bream)

- Larvae ingest in daytime.
- In the period when rotifers were fed, larvae showed the active feeding from 7am to 10am, and from 1pm to 7pm.
- In the period when rotifers and *Artemia* nauplii were fed, larvae showed the active feeding from 7am to 10am, from 11am to noon and from 3pm to 4pm.
- In the period when *Artemia* nauplii were fed, larvae showed the active feeding from 7am to 10am, from 2pm to 3pm and from 6pm to lights out.
- The feeding rhythm of red sea bream larvae did not change drastically with their growth.

Effective feeding schedule:

Rotifer feeding → Just after lighting and after noon

Artemia feeding → Just after lighting, before noon and 2-3hours after noon

(in the period when mixed with rotifers)

Artemia feeding → Just after lighting, 2-3hours after noon and 1-2hours before

lights out

(in the period when feed without rotifers)

4. Devil stinger *Inimicus japonicus*

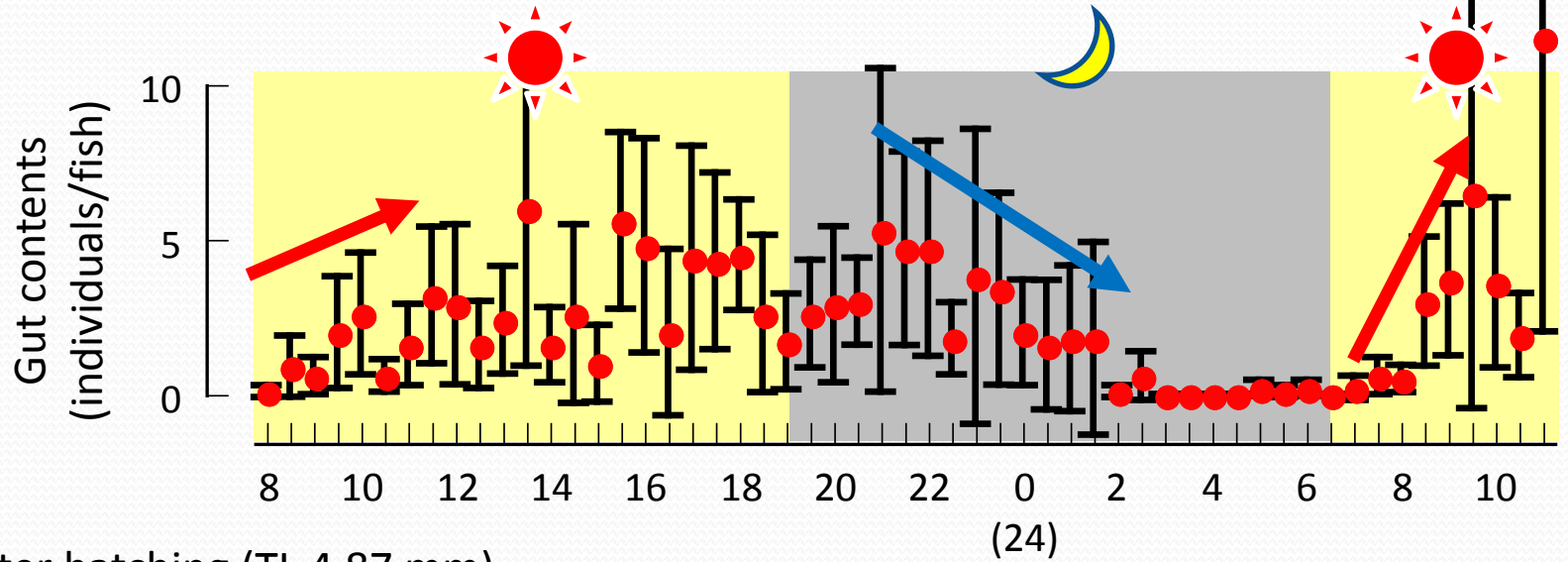
No knowledge of feeding rhythm in the wild.
Adult is a nocturnal feeder.

- Time of lighting: 630am
- Time of lights out: 650pm
- Feeding schedule
 - Single feeding 730am, 3pm
 - Mixture feeding 830am, 4pm (rotifers)
 - 730am, 3pm (*Artemia* nauplii)

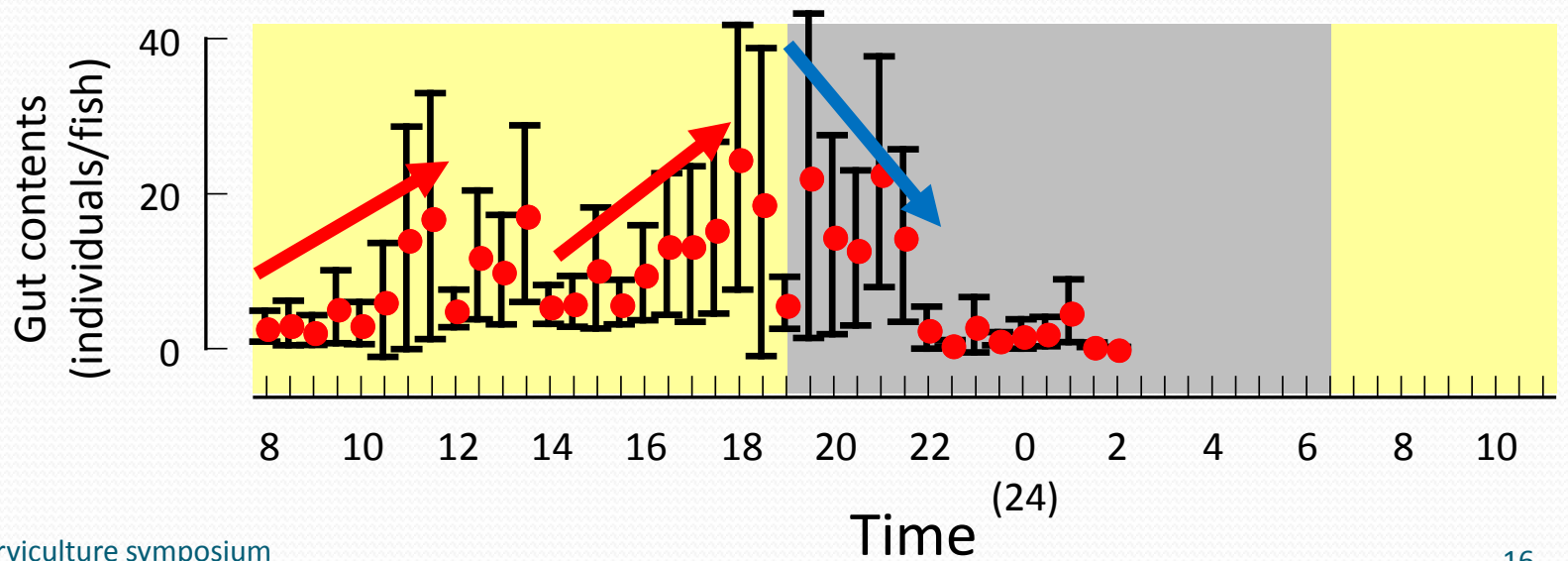


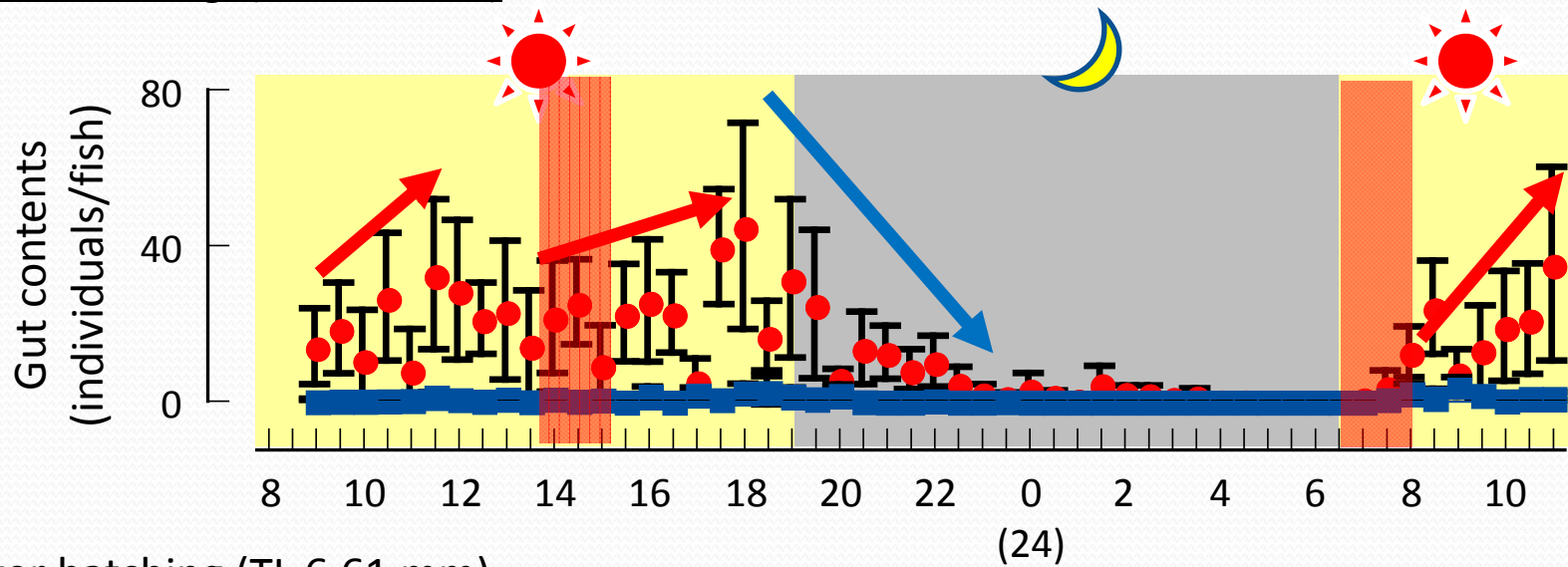
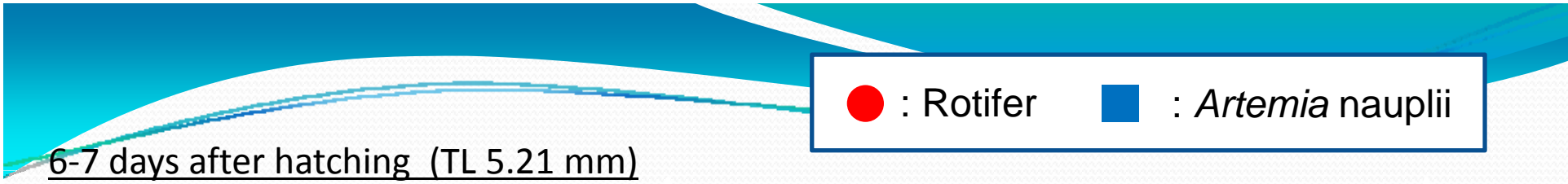


2-3 days after hatching (TL 4.12 mm)

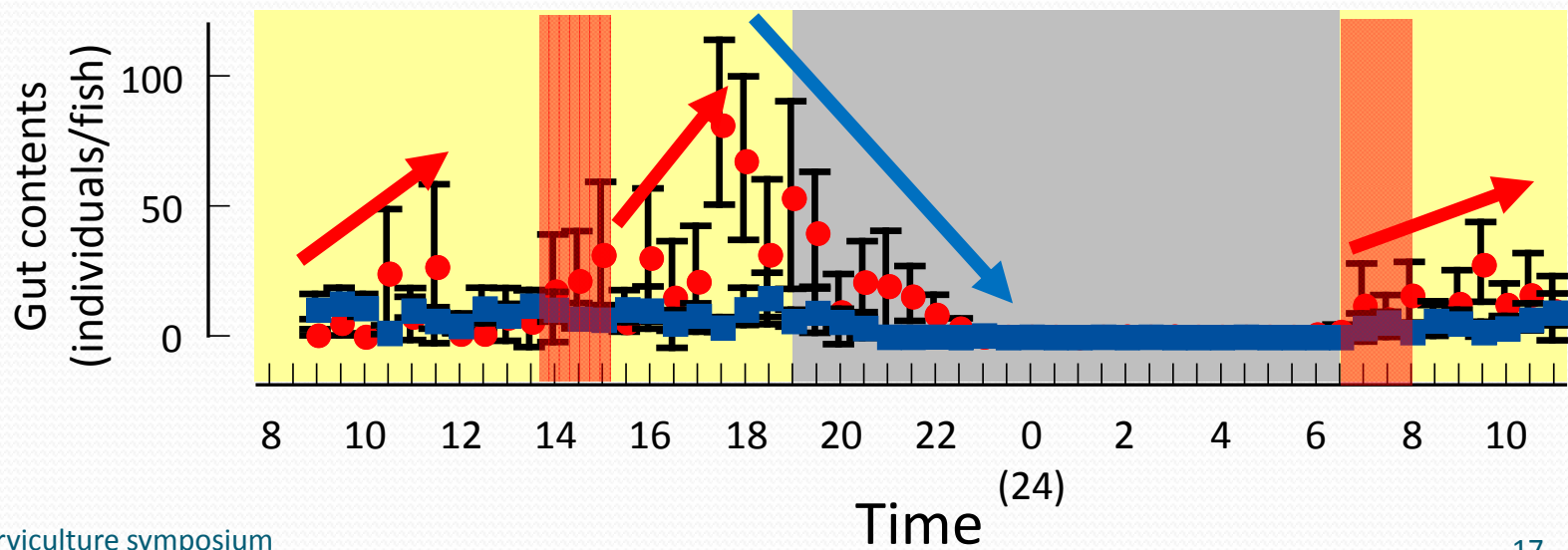


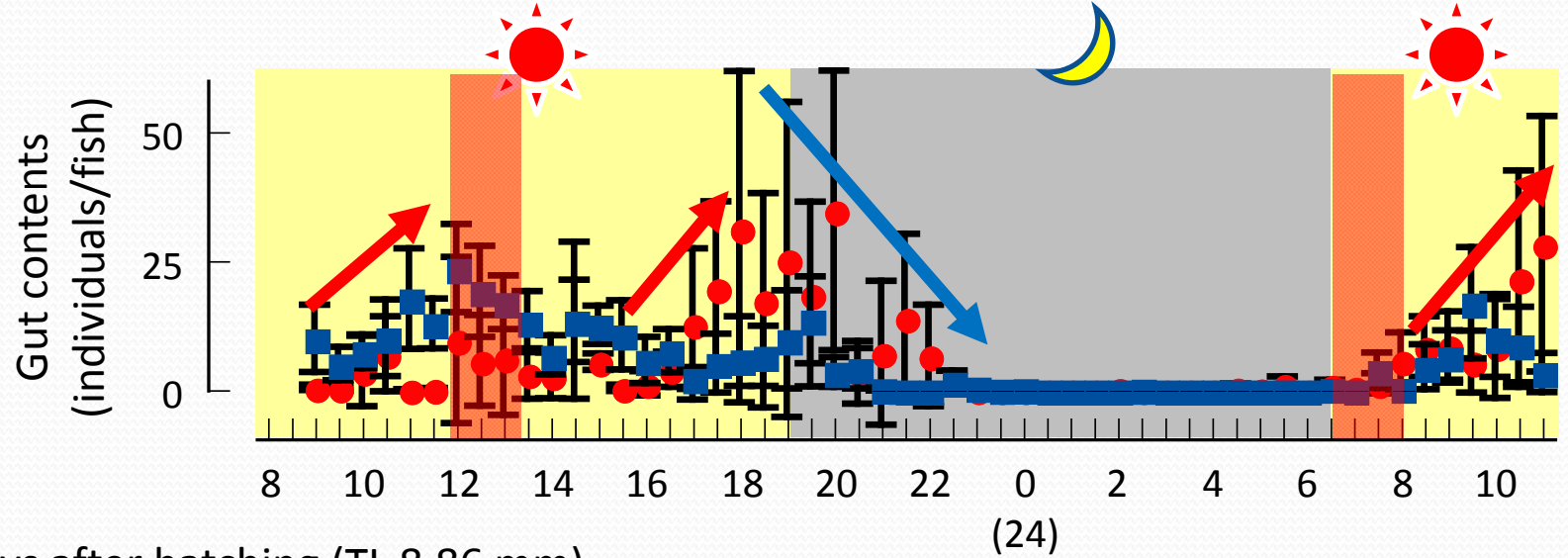
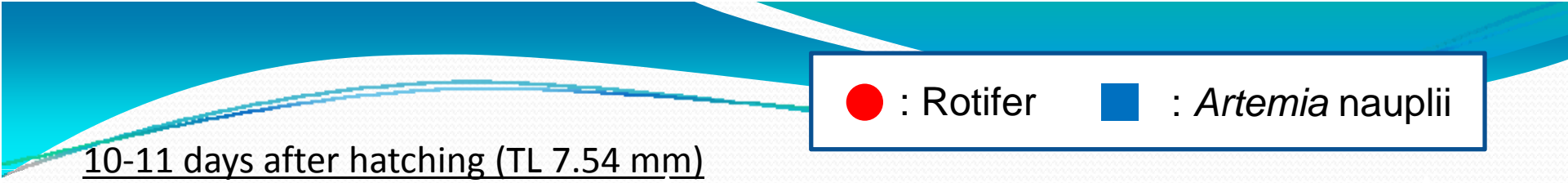
4-5 days after hatching (TL 4.87 mm)



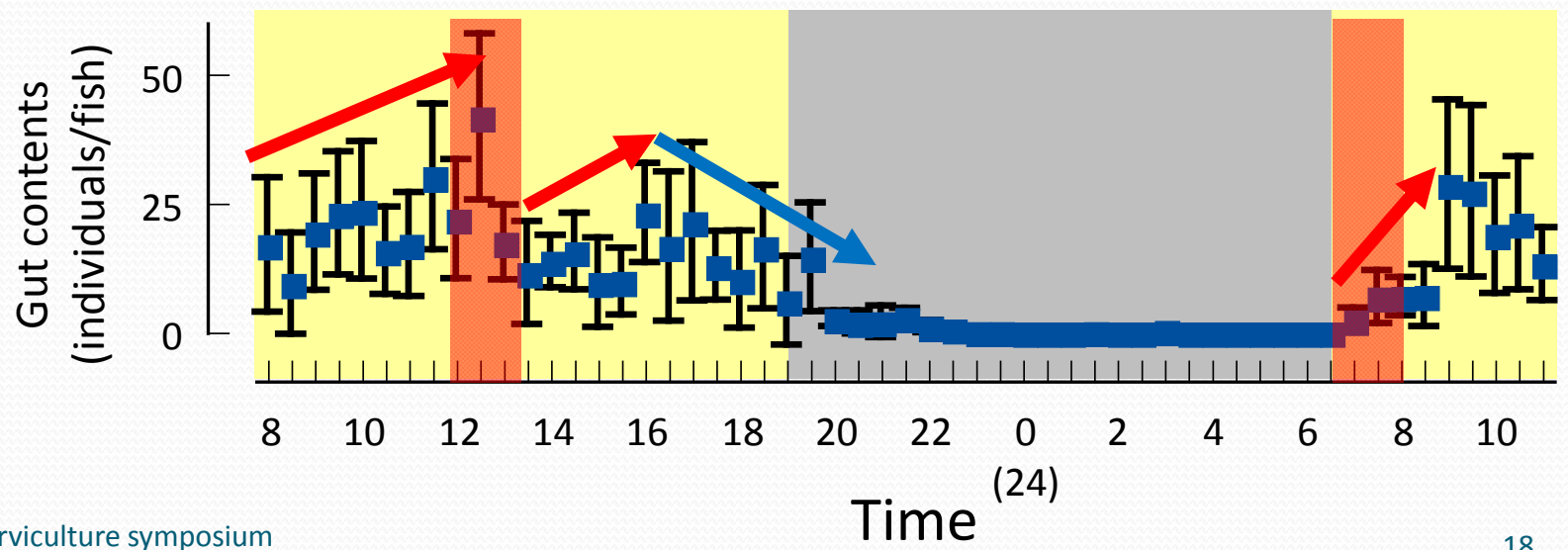


8-9 days after hatching (TL 6.61 mm)





13-14 days after hatching (TL 8.86 mm)



Results (Devil stinger)

- Larvae fed in daytime.
- In the experimental period when rotifers were fed, larvae showed the active feeding from 7am to 10am, and from 3pm to 7pm.

➔ Feeding rhythm of devil stinger larvae did not change with their growth.

Effective feeding schedule:

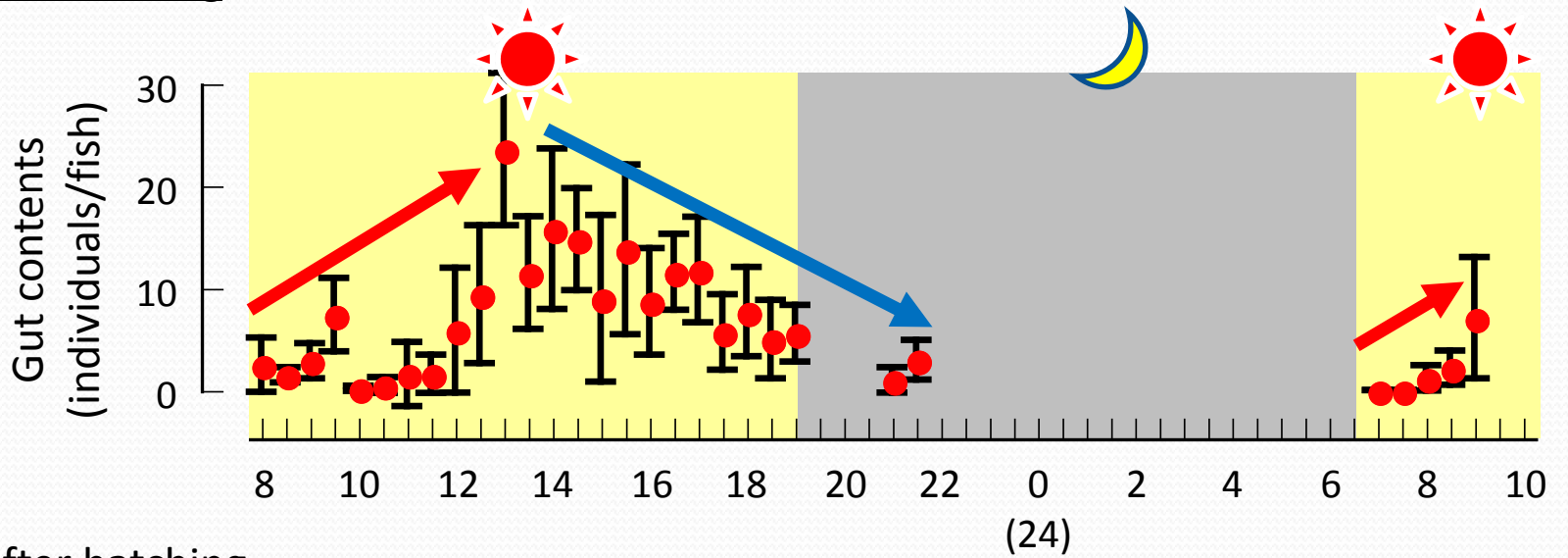
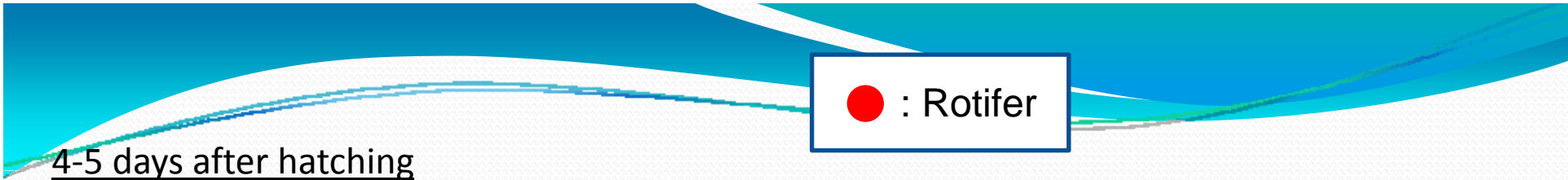
→ Just after lighting and 3-4hours before lights out

5. Ocellate puffer *Takifugu rubripes*

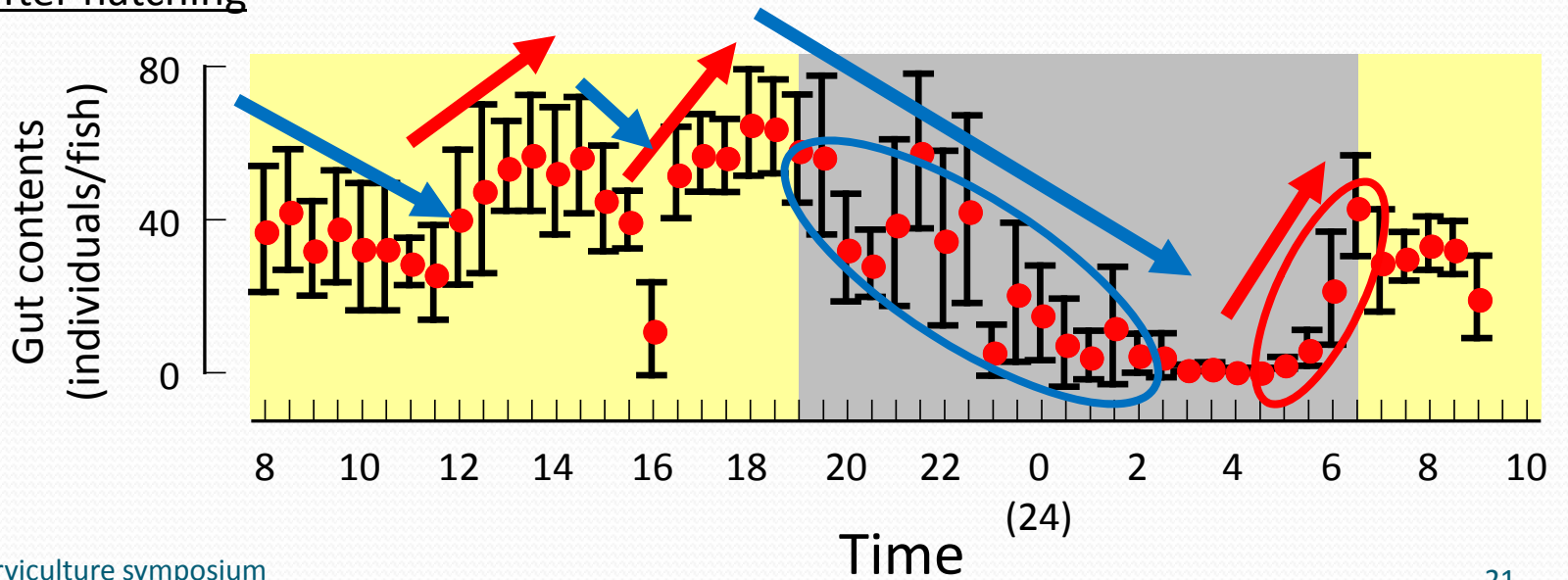
No knowledge of feeding rhythm in the wild

- Time of lighting: 630am
- Time of lights out: 650pm
- Feeding schedule
 - Single feeding 730am, 1pm
 - Mixture feeding 830am, 2pm (rotifers)
 - 730am, 3pm (*Artemia* nauplii)



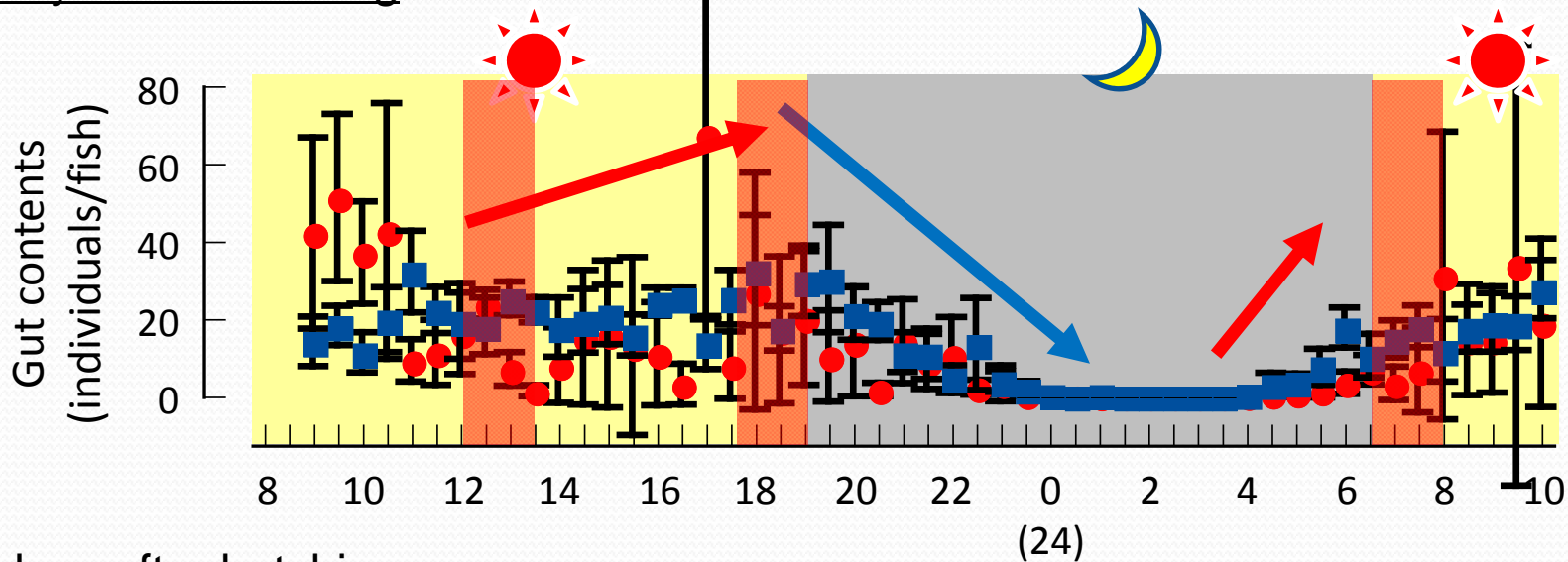


9-10 days after hatching

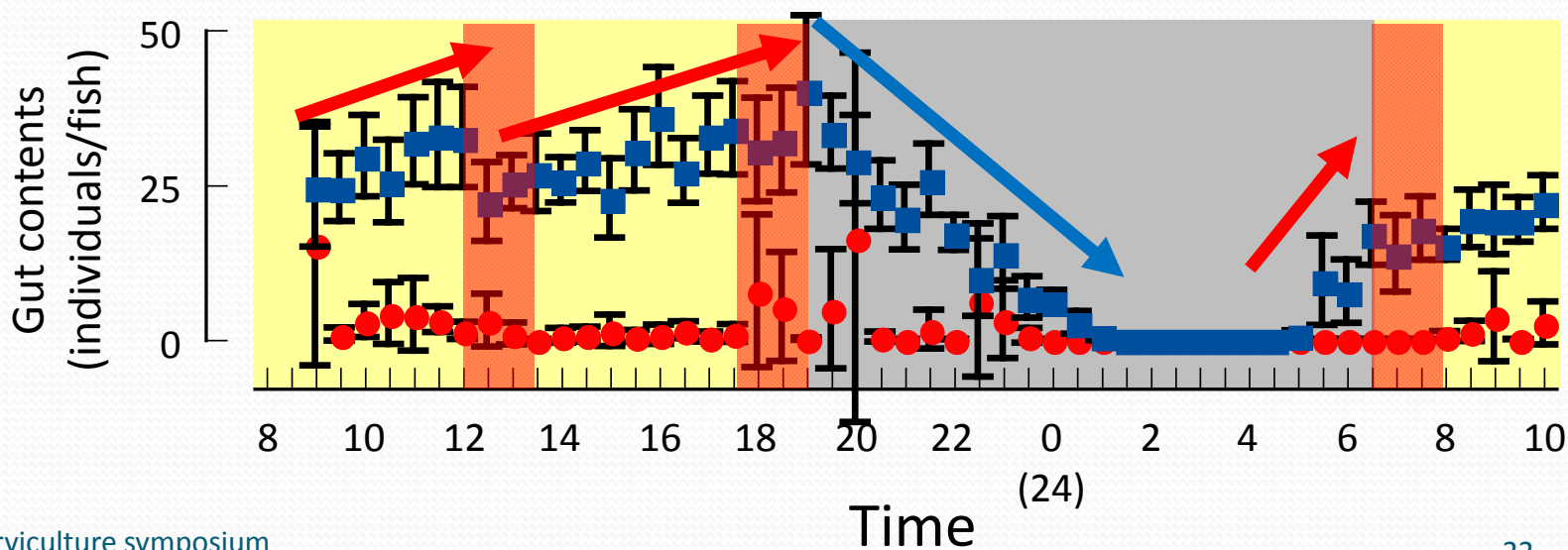




13-14 days after hatching

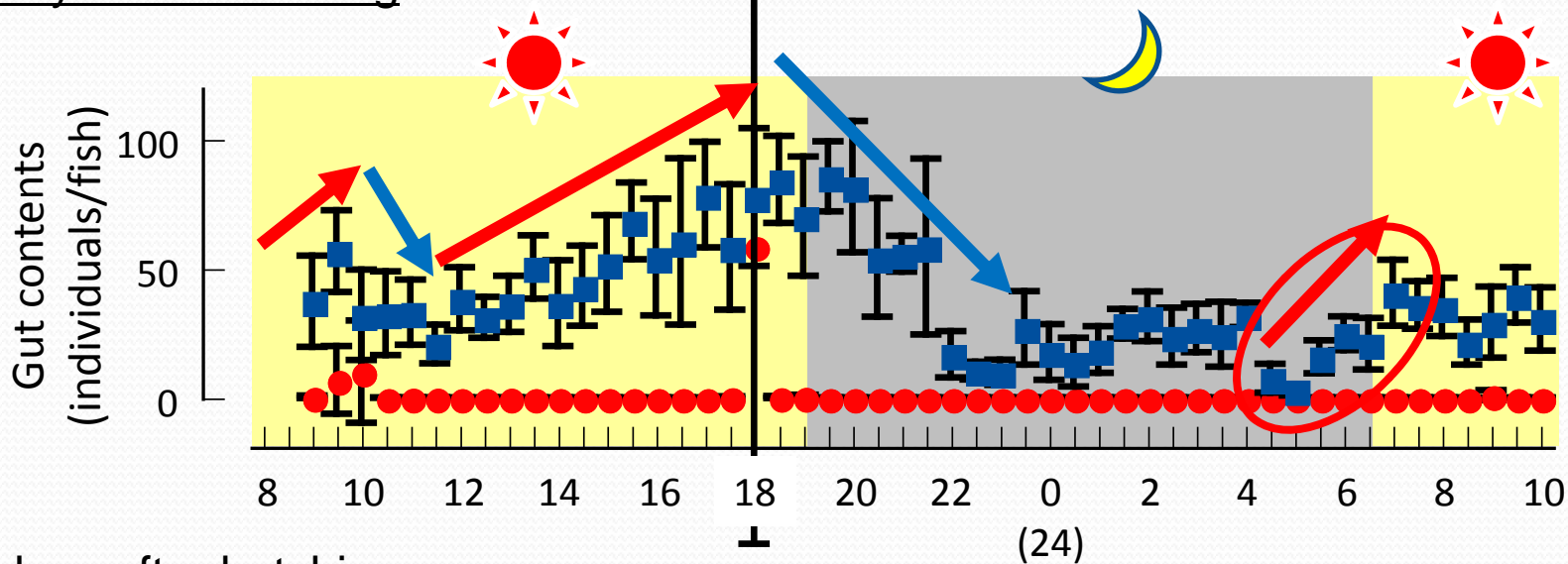


17-18 days after hatching

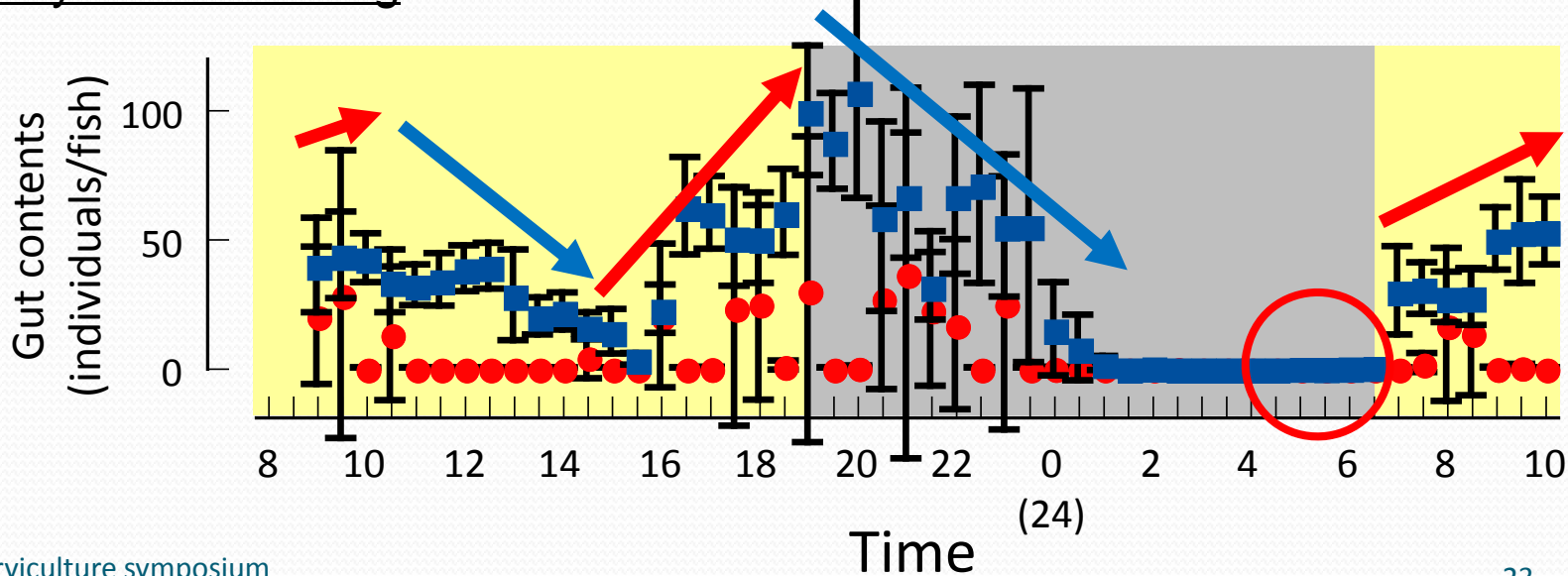


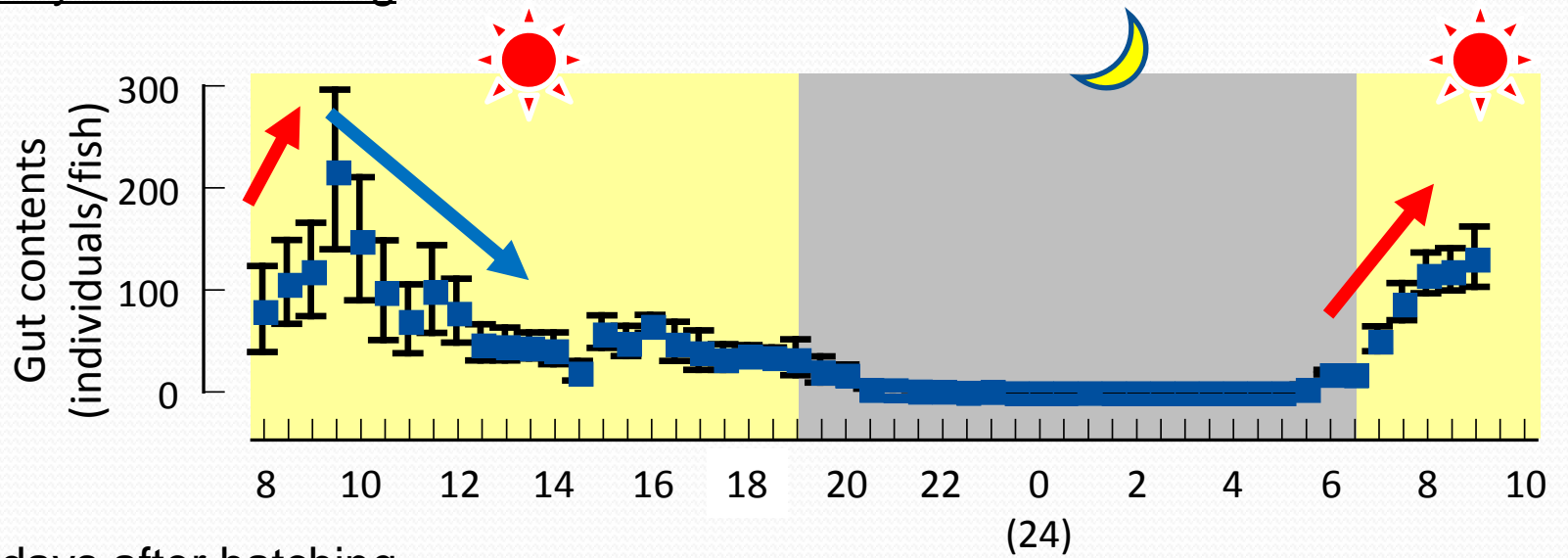


21-22 days after hatching

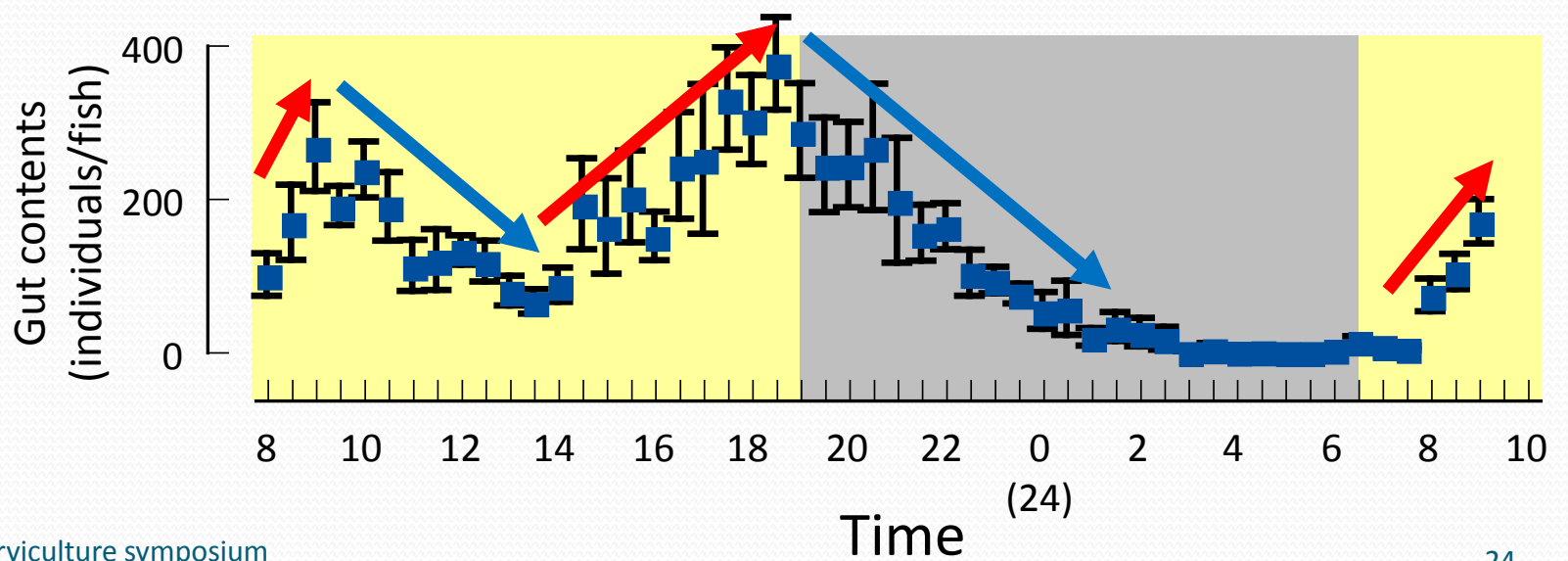


25-26 days after hatching





35-36 days after hatching



Results (ocellate puffer)

- Larvae had some periods of time with active feeding.
- Larvae started feeding before lighting.
- Larvae had a peak of feeding after lights out.



Feeding rhythm of devil stinger larvae was quite different from other species.



Different feeding strategy is necessary.

Effective feeding schedule:

Rotifer feeding → Just after lighting, afternoon and 2-3 hours before lights out

Artemia feeding → Just after lighting, afternoon and 2-3 hours before lights out

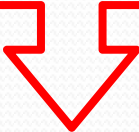
Suggestions

Larvae should be fed before they start active feeding.

- The feeding rhythm varied among fish species.



- Japanese flounder, red sea bream and devil stinger larvae showed active feeding in daytime and did not eat in nighttime. They started feeding just after lighting.
- Ocellate puffer larvae started feeding before lighting.

- 
- The feeding schedule should not be standardized.
 - Characteristic feeding rhythm of each reared fish species should be investigated.

Suggestions (continued)

In order to develop the new species for aquaculture

Feeding schedule should not be determined under the impression, such as “larvae show the ingestion in daytime”.



Ocellate puffer larvae start ingestion before lighting.

Feeding schedule should not be determined with the convenience of mankind.



Larvae of Japanese flounder and red sea bream start ingestion just after lighting.



Students who charged experiments

- Takayuki Okada, Jun Hosaka, Makoto Aoki (Japanese flounder)
 - Hisaki Kanbayashi, Kensuke Sudo, Shota Enomoto (Red sea bream)
 - Yosuke Watanabe, Keita Shioya, Tomoaki Takemura, Takuhiro Nakata
(Devil Stinger)
 - Yoshiyuki Wakiyama, Hiromichi Yashiki, Tatsuhiko Imoto
(Ocellate puffer)
- • •and more students who backuped these experiments



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For providing eggs.

Nobumitsu Sato (Nagase Sun-bio Co., Ltd.)

For supporting these experiment.



Thank you for your attention

Prospects

- should investigate the feeding rhythm of reared fish species

“It is impossible to feed before daybreak or at early morning.”

- How long does the effect of enrichment on rotifers or *Artemia* nauplii lasts ?
→ Can rotifers inoculated at dusk keep the enrichment effect until daybreak?

“In this study, lighting cycle was 12L12D.”

- Does long or short daytime influenced on the feeding rhythm or rearing performances ?