

The culture of sand goby, *Oxyeleotris marmoratus* II: Gastric emptying times and feed requirements of larvae

Thumronk Amornsakun¹ Wasan Sriwatana²
and Uraiwan Chamnanwech²

Abstract

Amornsakun, T.¹ Sriwatana, W.² and Chamnanwech, U.²

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Time of digestion experiments were carried out in a 15-liter rearing glass aquaria (water volume 10 liters) containing 1,500 larvae. The larvae were fed with sufficient rotifer, *Artemia* or *Moina* and then transferred to another rearing glass aquarium without food. Samples of 20 larvae were checked at 10-minute intervals until no food remained in the larval digestive tract. It was found that the time required to empty the larval digestive tract with rotifer, *Artemia* or *Moina* was as follows. Larvae 3-18 days old fed with rotifer took 130-180 minutes to empty the digestive tract while larvae 21-27 days old fed with rotifer and *Artemia* took 110-120 minutes and larvae 30-45 days old fed with *Moina* took 80-100 minutes at water temperature of 25-29°C. Time consumed to empty the gut content tended to decrease as larval age increased.

Experiments to determined the time and amount of prey required to get satiation were carried out in a 15-liter rearing glass aquaria (water volume 10 liters) containing 1,500 larvae. The larvae were fed with rotifer, *Artemia* or *Moina* after starvation of 24 hr. Samples of 20 larvae were checked at 10-minutes intervals after the start of feeding until 3 hr. It was found the time required to fill the larval digestive tract with rotifer,

¹Ph.D. (Aquaculture), Asst. Prof., Department of Technology and Industries, Faculty of Science and Technology, Prince of Songkla University, Pattani Campus, Pattani 94000 ²B.Sc. (Fisheries), Pattani Inland Fisheries Development Center, Amphoe Yarang, Pattani 94160 Thailand.

Corresponding e-mail: thumronk@bunga.pn.psu.ac.th

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Artemia or *Moina* for 3-18 days old larvae was 80-110 minutes and amount of rotifer to get satiation was 4.8-26 ind/larvae. For 21-27 day-old larvae the corresponding time was 60-80 minutes and was 28.5-31.6 ind/larvae. For 30-45 day-old larvae the time was 40-60 minutes and amount of *Moina* to get satiation was 34.6-52.4 ind/larvae at water temperature of 25-29°C. The time required to fill the larval gut, tends to decrease with larval age but the amount of prey required to fill the larval gut, tends to increase with larval age.

Experiments to determined the amount of food uptake in a day were done in a 15-liter rearing glass aquaria (water volume 10 liters) containing 500 larvae, and 10 ind/ml of rotifer, *Artemia* or *Moina*. The amount of food taken was calculated based on changes of rotifer, *Artemia* or *Moina* density in the rearing glass aquarium with and without fish larvae, the 5 samples of each replication were examined at 2 hourly intervals. The average amounts of rotifer uptake in a day for 3, 6, 9, 12, 15 and 18 day-old larvae were 58.8, 95.4, 64.0, 88.8, 134.0 and 147.4 ind/larvae, respectively. The mean numbers of rotifer added *Artemia* uptake in a day by 21, 24 and 27-day old larvae were 181.6, 185.6 and 241 ind/larvae, respectively. And average amounts of *Moina* uptake in a day for 30, 33, 36, 39, 42 and 45 day-old larvae were 177.4, 179.4, 214.8, 249.6, 362.8 and 366.2 ind/larvae, respectively.

Key words : time of digestion, time of satiation, daily food uptake, larviculture, sand goby, *Oxyeleotris marmoratus*

บทคัดย่อ

ฉำรงค์ ออมรสกุล¹ วสันต์ ศรีวัฒนา² และ อุไรวรรณ ชำนาญเวช²

การเลี้ยงปลาตู้ทราย 2: ระยะเวลาในการย่อยและปริมาณความต้องการอาหารของลูกปลาระยะวัยอ่อน

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ศึกษาระยะเวลาในการย่อยอาหาร โดยใส่ลูกปลาจำนวน 1500 ตัว ในตู้ปลาขนาดปริมาตร 15 ลิตร (ปริมาตรน้ำ 10 ลิตร) ให้ลูกปลาดังกล่าวกินโรติเฟอร์ อาร์ทีเมีย หรือไรแดง ขึ้นอยู่กับระยะของลูกปลา เมื่อลูกปลากินอาหารอิ่มแล้ว ทำการย้ายลูกปลาดังกล่าวลงสู่ตู้ปลาที่ปราศจากอาหาร สุ่มตัวอย่างลูกปลาจำนวน 20 ตัว ทุก ๆ 10 นาที เพื่อใช้ทำการศึกษาโดยการผ่าทางเดินอาหาร ทำการตรวจสอบปริมาณอาหารโดยการนับจำนวนอาหารที่พบในระบบทางเดินอาหาร พบว่า ระยะเวลาในการย่อยโรติเฟอร์ของลูกปลาทูทรายอายุ 3-18 วัน เท่ากับ 130-180 นาที ระยะเวลาในการย่อยโรติเฟอร์และอาร์ทีเมียของลูกปลาทูทรายอายุ 21-27 วัน เท่ากับ 110-120 นาที และระยะเวลาในการย่อยไรแดงของลูกปลาทูทรายอายุ 30-45 วัน เท่ากับ 80-100 นาที ที่อุณหภูมิของน้ำ 25-29°C โดยมีแนวโน้มลดลงเมื่อลูกปลาที่มีอายุมากขึ้น

ศึกษาระยะเวลาและปริมาณอาหารที่กินอาหารจนอิ่ม โดยใส่ลูกปลาจำนวน 1500 ตัว ในตู้ปลาขนาดปริมาตร 15 ลิตร (ปริมาตรน้ำ 10 ลิตร) ให้ลูกปลาดูดอาหารเป็นเวลา 24 ชั่วโมง ให้ลูกปลาดังกล่าวกินอาหารโดยให้โรติเฟอร์ อาร์ทีเมีย หรือไรแดง ตามแต่อายุของลูกปลา สุ่มตัวอย่างลูกปลาจำนวน 20 ตัว ทุก ๆ 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110 และ 120 นาที หลังจากให้อาหารพบว่า ระยะเวลาในการกินโรติเฟอร์จนอิ่มของลูกปลาทูทรายอายุ 3-18 วัน ประมาณ 80-110 นาที ปริมาณของโรติเฟอร์ที่ลูกปลากินจนอิ่มประมาณ 4.8-26 ตัว/ลูกปลา ระยะเวลาในการกินโรติเฟอร์และอาร์ทีเมียจนอิ่มของลูกปลาทูทรายอายุ 21-27 วัน ประมาณ 60-80 นาที ปริมาณของโรติเฟอร์และอาร์ทีเมียรวมกันที่ลูกปลากินจนอิ่มประมาณ 28.5-31.6 ตัว/ลูกปลา และระยะเวลาในการกินไรแดงจนอิ่มของลูกปลาทูทรายอายุ 30-45 วัน ประมาณ 40-60 นาที ปริมาณของไรแดงที่ลูกปลากินจนอิ่มประมาณ 34.6-52.4 ตัว/ลูกปลา ที่อุณหภูมิของน้ำ 25-29°C ซึ่งมีแนวโน้มระยะเวลาในการกินอาหารจนอิ่มจะลดน้อยลง แต่ปริมาณการกินอาหารจะเพิ่มมากขึ้นเมื่อลูกปลาที่มีอายุเพิ่มมากขึ้น

ศึกษาปริมาณอาหารที่ลูกปลาต้องการทั้งวันโดยใช้ตู้ปลาขนาดปริมาตร 15 ลิตร (ปริมาตรน้ำ 10 ลิตร) ใส่ลูกปลาจำนวนตู้ละ 500 ตัว ให้กินอาหารโดยใช้โรติเฟอร์ อาร์ทีเมีย หรือไรแดง ขึ้นอยู่กับระยะของลูกปลาในปริมาณความหนาแน่น 10 ตัว/มล. ปริมาณอาหารที่ลูกปลากินคำนวณได้จากปริมาณความหนาแน่นของโรติเฟอร์ อาร์ทีเมีย หรือไรแดง ในตู้ปลาที่เปลี่ยนแปลงไปทุก ๆ 2 ชั่วโมง สุ่มนับจำนวนความหนาแน่นของโรติเฟอร์ อาร์ทีเมีย หรือไรแดง พบว่าค่าเฉลี่ยจำนวนโรติเฟอร์ที่ลูกปลาอายุ 3, 6, 9, 12, 15 และ 18 วัน กินทั้งวัน ได้แก่ 58.8, 95.4, 64.0, 88.8, 134.0 และ 147.4 ตัว/ลูกปลา ตามลำดับ ลูกปลาอายุ 21-27 วัน จะกินอาหารทั้งโรติเฟอร์และอาร์ทีเมีย ค่าเฉลี่ยจำนวนโรติเฟอร์ที่ลูกปลาอายุ 21, 24 และ 27 วัน กินทั้งวัน ได้แก่ 126.8, 42.8 และ 43.4 ตัว/ลูกปลา ตามลำดับ ค่าเฉลี่ยจำนวนอาร์ทีเมียที่ลูกปลาอายุ 21, 24 และ 27 วัน กินทั้งวัน ได้แก่ 54.8, 142.8 และ 197.6 ตัว/ลูกปลา ตามลำดับ และค่าเฉลี่ยจำนวนไรแดงที่ลูกปลาอายุ 30, 33, 36, 39, 42 และ 45 วัน กินทั้งวัน ได้แก่ 177.4, 179.4, 214.8, 249.6, 362.8 และ 366.2 ตัว/ลูกปลา ตามลำดับ

¹ภาควิชาเทคโนโลยีและการอุตสาหกรรม คณะวิทยาศาสตร์และเทคโนโลยี มหาวิทยาลัยสงขลานครินทร์ วิทยาเขตปัตตานี อำเภอเมือง จังหวัดปัตตานี 94000 ²ศูนย์พัฒนาประมงน้ำจืดปัตตานี อำเภอยะรัง จังหวัดปัตตานี 94160

Studies on the sand goby have been carried out by Hiranwat (1980), Silikun and Buawpun (1980), Pasukdee and Sirikun (1982), Viputhanumas *et al.* (1985) and Tawaratmanikul *et al.* (1989). The growth of larval sand goby fed with living food organisms has not been reported previously. The growth and survival rate of larval and juvenile fish are determined by various environmental factors and food supply. Mass mortality of larval and juvenile fish might occur if the food supply is inadequate (Houde, 1978). For rearing larvae and juveniles on set of feeding, feeding techniques, feeding rate and amount of food uptake in a day are very important. Therefore, it is essential to determine digestion periods of larvae and juveniles because feeding frequency depends upon duration of digestion (Sagar and Glova, 1988).

The purpose of this study was to investigate digestion time, amount of food to achieve satiation in each meal and amount of food intake in a day of larval sand goby in order to indicate the suitable time for feeding and suitable food for larval sand goby.

Materials and Methods

To determine gastric emptying time, experiments were carried out using 15-liter aquaria (water volume 10 liters) each containing 1,500 larvae. The

larvae were fed with living food organisms such as rotifer, *Artemia* or *Moina* depending on larval stage and then transferred to another aquarium without food. Samples of 20 larvae were taken at 10-minute intervals until no food was observed in the larval digestive tract. Specimens were fixed in 5% buffered formalin, and the digestive tract was later dissected (Hassan, 1990).

To examine time and amount of prey required to fill the larval gut, the larvae were fed with living food organisms i.e. rotifer, *Artemia* or *Moina*, depending on larval stage after starvation of 24 h. Samples of 20 larvae were taken at a 10-minute intervals after start of feeding until 3 hr and then fixed in 5% buffered formalin for later digestive tract determination. The time required to fill the larval gut was defined as the time when the greatest number of ingested food was observed (Hassan, 1990). All experiments were done in 15-liter aquaria (water volume 10 liters) containing 1,500 larvae.

To determine the daily food uptake by the larvae and juveniles, three experiments were carried out. All experiments were done in 15-liter aquaria (water volume 10 liters) containing 500 larvae. The larvae were fed with living food organism i.e. rotifer, *Artemia* or *Moina* depending on larval stage with food density of 10 ind/ml. The amount of food intake was calculated based on

changes of food density in the aquarium with and without fish larvae, from which 5 water samples were taken at 2-hour intervals. Aquaria without larvae were set for a control of natural fluctuation in food density (Hassan, 1990). Known numbers of food were added when the density became low.

Results

The times required to empty the larval digestive tract of rotifer for 3, 6, 9, 12, 15 and 18-day-old larvae were 180, 180, 160, 160, 150 and 130 minutes, respectively, at a water temperature of 25-29°C. The times required to empty the larval digestive tract of rotifer and *Artemia* for 21, 24 and 27-day-old larvae were 120, 110 and 110 minutes, respectively, at a water temperature of 25-29°C, and the times required to empty the larval digestive tract of *Moina* for 30, 33, 36, 39, 42 and 45-day-old larvae were 100, 90, 90, 80, 80 and 80 minutes, respectively, at a water temperature of 25-29°C (Figure 1).

The times required to achieve maximum number of rotifer in the larval digestive tract for 3, 6, 9, 12, 15 and 18-day old larvae were 110, 90, 80, 80, 110 and 100 minutes, respectively, and the numbers of rotifer required for satiation of 3, 6, 9,

12, 15 and 18-day old larvae were 4.8, 7.5, 12.3, 13, 13.4 and 26 ind/larvae at a water temperature of 25-29°C. The times required to achieve maximum number of rotifer added *Artemia* in the larval digestive tract for 21, 24 and 27-day old larvae were 70, 80 and 60 minutes, respectively, and the numbers of rotifer required for satiation of 21, 24 and 27-day old larvae were 28.5, 30.7 and 31.6 ind/larvae at a water temperature of 25-29°C. The times required to achieve maximum number of *Moina* in the larval digestive tract for 30, 33, 36, 39, 42 and 45-day old larvae were 60, 50, 50, 40, 50 and 40 minutes, respectively, and the numbers of *Moina* required for satiation of 30, 33, 36, 39, 42 and 45-day old larvae were 34.6, 40.2, 42.8, 46.2, 50.2 and 52.4 ind/larvae at a water temperature of 25-29°C (Figure 2 and 3).

The mean numbers of rotifer eaten in a day by 3, 6, 9, 12, 15 and 18-day old larvae were 58.8, 95.4, 64.0, 88.8, 134.0 and 147.4 ind/larvae, respectively. The mean numbers of rotifer added *Artemia* uptake in a day by 21, 24 and 27-day old larvae were 181.6, 185.6 and 241 ind/larvae, respectively. The mean numbers of *Moina* uptake in a day by 30, 33, 36, 39, 42 and 45-day old larvae were 177.4, 179.4, 241.8, 249.6, 362.8 and 366.2 ind/larvae, respectively (Figure 4).

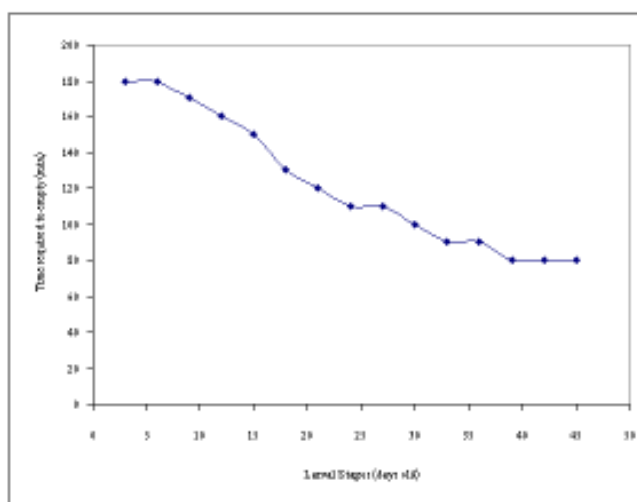


Figure 1. Times required to empty the digestive tract of larval sand goby

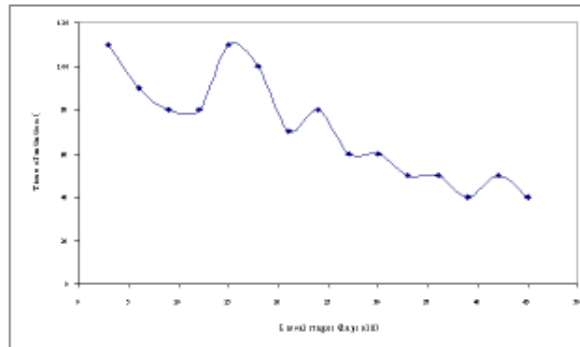


Figure 2. Time required for feeding to satiation by larval sand goby

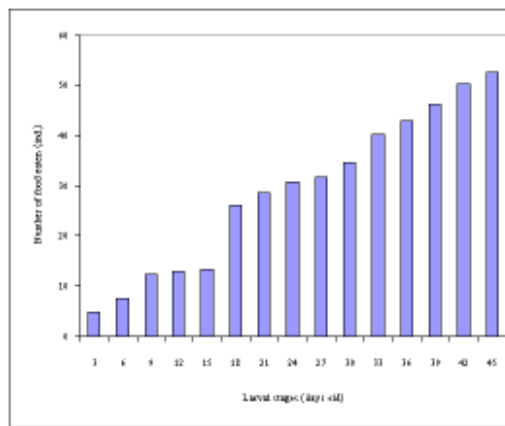


Figure 3. Number of food eaten to satiation of larval sand goby

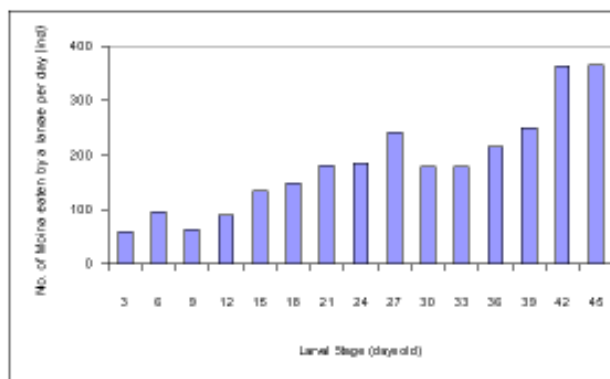


Figure 4. Number of food eaten per day by of larval sand goby

Discussion

The time required to empty the larval digestive tract of rotifer, *Artemia* and *Moina* were in the range of 1 hr 20 min - 3 hr. The digestive tract of older larvae was better developed than that of younger larvae, as it was found that the digestive period in older larvae was shorter than in the younger ones. Tawaratmanikul *et al.* (1988) reported that the time to digest *Moina* particles by giant catfish (*Pangasianodon gigas*) larvae aged 2-3 days, 5-6 days and 8-9 days were 3, 4 and 5 hours, respectively. Hassan (1990) measured digestion time in mullet, *Liza haematocheila*; the amount of rotifers or *Artemia* nauplii in the digestive tract decreased rapidly at the beginning of consumption, that to most of the food was digested within 4 hr and the digestive tract was empty within about 8 hr.

It was found that the time required to fill the larval digestive tract with rotifer, *Artemia* or *Moina* was in a range of 40 min. - 1 hr 50 min. depending on larval age i.e. for 3-18 days old larvae it was 80-110 minutes and the amount of rotifer to get satiation were 4.8-26 ind/larvae. For 21-27 days old larvae it was 60-80 minutes and the amount of rotifer and *Artemia* to get satiation was 28.5-31.6 ind/larvae, and for 30-45 days old larvae it was 40-60 minutes and the amount of *Moina* to get satiation was 34.6-52.4 ind/larvae. The time required to fill the larval gut, tended to decrease with larval age. On the contrary, the amount of prey required to fill the larval gut, tended to increase with larval age. The time required for feeding to satiation of larval sand goby is similar to that of other species. Amornsakun *et al.* (1998) reported that the time required to fill the gut of larval green catfish (*Mystus nemurus*) was in the range of 1 hr 30 min. - 2 hr and the mean numbers of *Moina* in the digestive tract of 3, 6, 9, 12 and 15-day-olds were 9.9, 21.2, 31.8, 24.2 and 68.8 ind/larvae, respectively. Vatcharakornyothin *et al.* (1988) reported that the time required to get satiation with *Moina* of freshwater catfish (*Clarias macrocephalus*) larvae aged 5-6 days, 8-9 days, 11-12 and 14-15 days were 105, 105, 105, and 75 minutes, respectively.

The times required to get satiation of sharp-tooth African catfish (*Clarias qariepinus*) larvae aged 2-3 days, 5-6 days, 8-9 days, 11-12 and 14-15 days were 150, 150, 150, 150 and 75 minutes, respectively. The satiation time of juvenile masu salmon, *Oncorhynchus masou* was less than 60 minutes, with a tendency to increase with increasing fish size (Nagata, 1989).

It was found that the larvae of age 3-45 days spent 3-4 hr each time to feed on rotifer, *Artemia* or *Moina* depending on larval stage. The mean numbers of rotifer eaten in a day by 3, 6, 9, 12, 15 and 18-day old larvae were 58.8, 95.4, 64.0, 88.8, 134.0 and 147.4 ind/larvae, respectively. Rotifer were eaten by fish larvae in the range of 58.8-147.4 ind larvae⁻¹ day⁻¹. The mean numbers of rotifer added *Artemia* eaten in a day by 21, 24 and 27-day old larvae were 181.6, 185.6 and 241 ind/larvae, respectively. Rotifer added *Artemia* were eaten by fish larvae in the range of 181.6-241 ind larvae⁻¹ day⁻¹. And the mean numbers of *Moina* eaten in a day by 30, 33, 36, 39, 42 and 45-day old larvae were 177.4, 179.4, 241.8, 249.6, 362.8 and 366.2 ind/larvae, respectively. *Moina* were eaten by fish larvae in the range of 177.4-366.2 ind larvae⁻¹ day⁻¹. This increases with larval age as shown in Figure 4. The numbers of prey consumed showed a similar trend to those of other fish. Amornsakun *et al.* (1998) reported that *Moina* were eaten by fish larvae of green catfish (*Mystus nemurus*) in a range of 61.56-421.74 ind larvae⁻¹ day⁻¹. Tawaratmanikul *et al.* (1988) reported that the studies on numbers of *Moina* taken in a day by giant catfish (*Pangasianodon gigas*) larvae for the 2-3 day, 5-6 day and 8-9 day old larvae were 64, 396 and 341 ind, respectively. Hassan (1990) reported the amount of food taken in a day by larval and juvenile mullet, *Liza haematocheila*. A 23-day old larva and a 28-day old larva consumed about 1,900 and 3,300 rotifers a day, respectively, and a 31-day old larva and a 42-day old larva consumed about 440 and 2160 *Artemia* nauplii a day, respectively. Bryant and Matty (1980) reported optimum *Artemia* feeding rate for carp larvae, *Cyprinus carpio*, to be 200-250% of their body weight on *Artemia* nauplii per day. It is very

important to determine the suitable amount of food consumed by a larva per day at each stage of its sequential growth. Suitably estimating the amount of food needed for a certain number of cultured larvae or juveniles will ensure better growth and survival as well as avoid unnecessary food wastage.

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