Survival rate ability of unfed eel *Anguilla b. bicolor* in different sizes and sources of eel caught

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Abstract. World consumption of eel nowadays still depend on mostly (80%) from Aquaculture industry. However, the eel seed of glass eel, elver either bigger sizes of eel juvenile, still also depend on the wild caught. The study aims to test the survival rate of unfed eel from different sources of seed and sizes. The eel collected from five riverine of catch area i.e. Dlangu of Purworejo (CA I), Larangan of Nusawungu (CA II), Ciberem of Kaliwungu (CA III), Patimu an creek (CA IV), and Ciwulan riverine of Tasikmalaya (CA V) which were caught in August 2018. The other eels were caught in July 2019 collected from Segoro Anakan (CA VI), Buton Cilacap of Indian Ocean Coast Line (CA VII), Gatel riverine of Nusawungu (CA VIII) and Pasir creek of Sidobunder Puring, Kebumen (CA IX). The eel sizes were grouped into four class of sizes i.e. glass eel (GE), small pencil (‘sp’), big pencil (‘bp’) and consumption size (Co) as a comparator. For the shipment trials, eel were transported from those caught area to Semarang (ranging between 180 to 240 km distances) by normal seeds package with oxygenated plastic bag. Unfed trials, the eel were kept in a limited water volume without aeration and the water replaced every day. Experiment was conducted during 30 days without feeding. The result shows that the sizes of eel i.e. GE, SP, BP, and Con can survive during shipment with 23 and 27 h duration time. Unfed treatment, the best survival rate found in ‘Co’ (52 %) followed by ‘bp’ (34 %), ‘sp’ (33 %) during 30 days without food and aeration. However, the GE found 100 % death during 18 days in unfed conditions. Eel seed sources comparison shows significantly different (α < 0.05) among caught area locations. These can be conclude that eel seeds of GE size can be keep during delivery transportation (shipment) without food given for 23 h, and can be kept prior to other purposes for approx. fortnight while ‘sp’ and ‘bp’ sizes for mostly one month.

1. Introduction

The annual global growth in fish consumption has been twice as high as population growth since 1961 to 2018 [1]. This is indicated that white meat preferences increased by time and possibly people’s knowledge improvements. Indonesian peoples during 2018 have had 50.69 kg fish per person (P-1) and during 2019 have been predicted to increase attaining 54.49 kg P-1 fish [2]. This attainment has been mostly twice compare to the last 10 years, where in 2009 the fish consumption only approx. 29 kg P-1.
Eel of *Anguilla* sp as a catadromous species is a popular fish for the worldwide dishes especially in Japan or commonly eastern Asia, some countries of Europe, America and Australia [4]. During 2008 to 2010 the world eel consumption have mostly (80%) depend from Aquaculture industries [5]. Average annual aquaculture growth declined to 5.8% during the period of 2000–2016 [1].

However, introducing eel aquaculture in Indonesia has had a constrained in a local fish market, where the Indonesian were not recognised the eels as a good dishes and not as popular as in European, American neither Japanese countries. Even though Silfvergrip [6] reported that Indonesia have ever as a targeted market of European glass eel (*A. anguilla*), but the purpose of imported the eel seeds still unknown due to different climate between Europe and Indonesia. However, during 2012 to 2017 have been develop a local eel culture industries especially in Central Java [4]. Unfortunately, they have closed and can’t continue in eel businesses due to in-continue eel market. These problems affected to supplier of eel seeds, they have to kept the seeds in a longer times.

In addition, culture industry of *Anguilla* sp. in Indonesia also facing difficulties in finding the seed either slow growth in racing them. Biomass absolute growth of *Anguilla b. bicolor* reared at different water current found relatively low (35.11 to 90.77%) during 100 days culture [4]. In rearing Pacific white shrimph *Liopeneus vannamei* using biofloc have specific growth rate between 2.01 – 2.68% d⁻¹ [7]. In this fact *L. vannamei* have much bigger in absolute growth attaining closely to 3 times (300%) than *A. b. bicolor*. However, the eel price is twice or even tree times higher than the shrimp in the market (exported), hence the eel culture industries in Indonesia is still have a magnetic power to run.

Studies on survival rate of *Anguilla sp.* have been conducted by some authors. Pederson conducted the study on long term survival of stocked eel *Anguilla anguilla* (L.), in wild of lake and cultured system. The result shows that during 5 years evaluations, the identified proportion of cultured and wild eels, the survival of the cultured batch was estimated at 42 and 57%. Luo et al. [8] used different water temperature for survival and growth rate of *A. marmorata* and *A. b. pacifica*. The results showed that *A. marmorata* and *A. b. pacifica* all died within 10 and 9 days at 8 °C, but survived normally at temperature of ≥ 18 °C. Politis et al. [9] tested the effect of salinity to European eel *Anguilla anguilla* larval mortality, the results shows that eel larvae kept in tanks with reduction by times on salinities treatments have higher of survival rate compare to control (without any reduction) salinity. Taqwa et al. [10] optimized the physiological status of *A. bicolor bicolor* glass eels through salinity and temperature acclimatization prior transportation. The results shows that medium at salinity of 6 ppt (%) and temperature from 16°C to 20°C showed the best physiological status of glass eels and still maintaining in a maximum survival rate. However, survival rate of different sizes eel during transportation and eel kept without feed given prior seedling have never been conducted. For this reasons, study on survival rate ability during shipment and unfed eel *A. b. bicolor* in different sizes and sources of eel caught will be give an information in minimizing the risk during shipment to seedling. Hereafter, the aims is to understand in eel seed survival rate ability during delivery transportation (shipment) and the maximum time for preparation in eel’s seedling.

2. Methodology

2.1 Sample Collection and Shipment

Sample of eels were collected from different estuaries (i.e. creek, riverines, marshes and impounding sea water Segoro Anakan) of southern Central Java estuaries and estuary of Tasikmalaya West Java in August 2018 and July 2019. The eels were grouped into four class sizes and caught with different fishing gears. Smallest size of eel which commonly drifted and swim up on surface water of the river named Glass Eel (GE) caught mainly using a lift net fishing device, this size stage normally have the weight range less than 1 g tail⁻¹. Small pencil size (SP with body weight range of 5 – 15 g) and big pencil (BP = 15 – 50 g) where normally they have hiding habit in a holes, hence they caught using bamboo trap device or pvc trap with the net underneath. Consumption size of eel (Con ≥150 g) wich normally have already attaining in maturation stage, commonly call as a grey eel, they tend to be migrate to ocean for
reproduction. For this sizes (of grey eel) started to swim down to the sea during declining of low tide. For this eel habit, they were caught using floating seine net to trap them up.

Figure 1. Caught area of eel from different area of Central Java (CA I – IV) and West Java (CA V) southern estuaries caught during 2018, and Central Java southern estuaries (CA VI – IX) during 2019, (map taken from: https://int.search.myway.com/search/maps.jhtml?n).

The eels which were caught in August 2018 i.e. at riverines of Dlangu – Purworejo (CA I), Larangan creek of Nusawungu (CA II), Ciberem riverine at Kaliwungu - Sidareja (CA III), Patimuan creek (Citandui, CA IV), and Ciwulan riverine of Tasikmalaya (CA V). The eels from those five areas were pooled at Wangon Banyumas to quarantine them prior shipment to Semarang (Central Java) (Figure 1). The other eels were caught in July 2019 collected from impounded sea water of Segoro Anakan (CA VI), marshes at Buton Adipala Cilacap coast line of Indian Ocean (CA VII), Gatel riverine of Nusawungu (CA VIII) and Pasir creek of Sidobunder Puring, Kebumen (CA IX). These group of eel were pooled at Nusawungu (see Figure 1) for quarantine and packaging. The eels were then weighed and counted the number, packaged using a transparent plastic bag with oxygenated water, ID number, salinity, pH, DO, temperature and time recorded prior shipment. Duration of shipment which normally conducted by eel collectors, where they have maximum ability of eel survived for 26 h with 80 – 100 % in SR. For this treatments, eels shipment duration used was tried to in the below of maximum time (less than 26 h) for group of eel from CA I to V (conducted in 2018) and above the optimum time (more than 26 h) for eel
from CA VI to IX (conducted in 2019). After attaining the destination, time of arrival, water quality, number of eel death (DR) were recorded prior to the next treatments.

2.2 Survival Rate
Styrofoam boxes with dimension 40 cm width, 73 cm length, and 27 cm height were used. The boxes were disinfected using chlorine and dried up prior use. Water volume depend on the amount of biomass and poured in approximately at a tip above dorsal fin of eel sizes to let aerial respiration [11]. Weighing, counting number of eel and conducted a morphometric examination of ano-dorsal (A/D in a glance) by using Fahmi and Himawati [5] method in order to determine the species tested. Hence the eel categorized as A. bicolor bicolor or A. sidat as mention by Kotelat [12] for the Java eel. Water was replaced in every 24 h, prior and after replacement; water parameters (i.e. volume, salinity, pH, DO, temperature) and eel behavior were recorded. An un-aerated water medium and without giving food to the fish were administered during 30 days experiment. Death rates recorded daily and survival rate were calculated at the end of experiment. The death fishes were observed morphologically and weighted in order to calculate the delta of weight loss.

3. Results and Discussions
The results after fast examination in color and dorsal anal fin length, shows that most of eel caught from CA I to CA IX have ano-dorsal ratio (A/D) less than 4 %. Fahmi and Himawati [5] found the eel from Cimandiri riverine of Southern West Java estuaries (Sukabumi) have A/D between 0 – 3.7 % recognized as Anguilla bicolor bicolor, 13.71 – 19.35 % as A. marmorata and 4.17 – 9.52 % as A. nebulosa nebulosa. Hence, the eel caught from CA I – IX recognized as A. b. bicolor with half grey color on dorsal, whitish bright on ventral area as mention by Fahmi and Himawati [5]. Only six of eel found have marble dotes which caught from CA II (2018) were recognized as A. marmorata (A/D > 13.5 %) and separated from the treatments.

3.1 Eel origin and Riverine Properties
Number of eel caught were varies between 16 – 100 eels from nine different estuaries. The sizes were classified into four classes, hence eels caught (on August 2018) from Dlanggu (CA I) and Citandui/Patimuan creek (CA IV) were mostly in big pencil (BP). Eel from Larangan (CA II) and Ciberem (CA III) were mostly in small pencil (SP), whilst Ciwulan (CA V) all of eel caught were in glass eel (GE) sizes. These due to merely just the devices used, small and big pencil sizes using bamboo/PVC trap and GE using lift net. During July 2019 eel caught from Klaces/Segoro Anakan (CA VI) in consumption (Con) sizes, Marshes (CA VII) and Gatel riverine (CA VIII) were in SP, and from Pasir riverine (CA IX) in BP (Table 1).

Table 1. Sizes, number of eel caught from nine riverines/estuaries, time of quarantine before shipping and shipment duration (in hours)

| No | t of Caught | Size/Loc. Code | Rvne/Estuary | Location | No of Fish | Mean w (g) | Σ w (g) | Q.b.S (d) | Sh (h) |
|----|-------------|----------------|--------------|----------|------------|-----------|---------|----------|--------|
| 1  | Aug. 2018   | BP-PR (CA I)   | Dlanggu      | Purworejo | 54         | 31        | 1,674   | 2.3      | 23     |
| 2  | Aug. 2018   | SP-KR (CA II)  | Larangan     | Nusawungu | 52         | 12        | 624     | 2        | 23     |
| 3  | Aug. 2018   | SP-KW (CA III) | Ciberem      | Sidareja  | 52         | 12.5      | 650     | 3        | 23     |
| 4  | Aug. 2018   | BP-PT (CA IV)  | Citandui     | Patimuan  | 54         | 30        | 1,620   | 4        | 23     |
| 5  | Aug. 2018   | GE-CW (CA V)   | Ciwulan      | Tasikmalaya | 48   | 0.25      | 12      | 3        | 23     |
| 6  | July 2019   | Con-SA (CA VI) | Klaces*)     | Kp. Laut  | 16         | 240       | 3,840   | 2.7      | 27     |
| 7  | July 2019   | SP-SIBT (CA VII)| Marshes     | Adipala   | 55         | 11        | 605     | 4        | 27     |
| 8  | July 2019   | SP-NW (CA VIII)| Gatel       | Nusawungu | 100        | 12        | 1,200   | 3.4      | 27     |
Table 1

| No | Caught | Estuary/ | Location | No of Fish | Mean w (g) | Σ w (g) | Q.b.S (d) | Sh (h) |
|----|--------|----------|----------|------------|------------|----------|------------|--------|
| 9  | July 2019 | PB-KB (CA IX) | Pasir Kebumen | 35 | 35 | 1,225 | 4 | 27 |

Notes: t-time, SP-small pencil, BP-big pencil, GE-glass eel. Con-Consumption size, *)-Impounding sea water of Segoro Anakan Nusakambangan - Cilacap, w-weight, g-gram, Q.b.S-Quarantine before Shipment, d-day, h-hours.

The biggest sizes (Con) of eel from CA VI have a weight varies from 170 – 310 g (Table 1) and caught using floating seine net during low tide migration. For this time of migration, the eel have attained a grey (maturation) stage and seems to follow degraded salinity from low to high salinity. Hereafter, the seine mouth has faced the current direction to trap the grey eels.

Table 2. Catch Area water parameters measurements conducted during August 2018 (CA I – V), and July 2019 (CA V – IX)

| Locus/ WP | CA I | CA II | CA III | CA IV | CA V | CA VI | CA VII | CA VIII | CA IX |
|-----------|------|-------|--------|-------|------|-------|--------|---------|-------|
| S (‰)     | 5.7  | 5.5   | 2.25   | 25.25 | 5.2  | 25    | 28     | 5.8     | 5.4   |
| t (°C)    | 27.7 | 28.7  | 29.5   | 27.62 | 26.7 | 27.7  | 29.2   | 27.8    | 27.8  |
| DO (ppm)  | 5.5  | 6.8   | 9.3    | 2.94  | 3.5  | 6.85  | 3.2    | 6.7     | 6.2   |
| pH        | 7.7  | 8.24  | 8.95   | 7.57  | 8.6  | 6.7   | 7.9    | 8.2     | 7.9   |

The eels caught were pooled separately in sizes and origin for Q.b.S in a rearing concrete with small volume of water and medial aeration were administered. The water medium used were merely fresh water (0.07 – 0.2 ‰) with mean of temperature 27.2 °C, DO 5.7 ppm and pH 7.1. Compare to the habitat origin where they were caught from (Tabel 2), water quality parameters during Q.b.S seems more stable. The duration of Q.b.S was varies in between 2 – 7 days and was depend on the devices used and placed where they caught. Larangan creek (CA II) have connection with Gatel river (CA VIII), whilst CA II have connected to Gerak dam for irrigation. At a certain time, the dam distribute the water for rice field and flow through to the CA II, hence the eels attracted to swim up counter current. This phenomenon mention by Verhelst et al [13], that shipping canals can be used an alternative opportunities for new migration routes of diadromous species, by connecting river basins or creating shorter migration routes to the sea. For a moment after the flow water ceased, the eels tried to hide in a hole, and the bamboo/PVC trap have a good caught. The glass eel normally swim up to up-stream during dark time, and the GE caught were kept in the jar (plastic bottle for drink water) without any aeration. However, all of eels caught have a good condition (SR 100 %) during quarantine prior to shipment.

3.2 SR on Shipment

Survival rate (SR) on shipment is a crucial time to any seeds delivery, this will be affected to death rate during shipment and the health recovery condition to the seeds prior their cultured. The time used during first shipment was 23 h for CA I to V (2018) and 27 h for CA VI – IX (2019). This trial was conducted base on some experiences of delayed eel seeds shipment to 26 h have SR approximately 95 – 100 %. The results shows that in term of shipment times have no different between shipment duration of 23 and 27 h, both times of shipment can kept the eel survived to 100 %. In term of sizes, the glass eel (GE), small pencil (SP) and big pencil (BP) can survived to 100 % during 23 h shipment (Figure 2), whilst seems only BP and consumption sizes have SR to 100 % during 27 h shipment (Figure 3).

However, sources of eels where they were caught shows a specific reaction to the time duration of shipment. The SP eel from Ciberem riverine (SP-KW/CA III) have higher SR (94.2 %) compare to bigger eel (BP) from Purworejo (BP-PR/CA I, 92.6 %) during 23 h of shipment (Figure 2). The similar sizes of SP eel from marshes (close to coastal area) at Buton – Adipala (SP-SIBT/CA VII) also have higher SR (92.7 %) compare to eel from Gatel Riverine of Nusawungu (SP-KR/CA VIII, 31 %) (Figures 1 and...
3). The low survival rate of CA VIII may be correlated to previous treatment during Q.b.S. For this quarantine periods, even though they have 3 – 4 d Q.b.S (Table 1), it was noted that they faced one day (7 h) in un-plug aeration. Other reasons, even though similar amount of biomass were packaged in the same size of oxygenated plastic bag, may be correlated to the number of eel packed was 100 tails (ts) of eel from CA VIII, 16 ts from Con-SA (CA VI), 55 ts from CA VII, and 35 ts from BP-KB (CA IX) (see Table 1 and Figure 3). The biomass need a certain amount of oxygen for their metabolic rate, but the number of tails fishes need more oxygen for their activities (movement, predation/feeding, defense, etc.). Taqwa et al. [10], reported that oxygen consumption of glass eel increased by increasing water temperatures and will reduced by the time and no correlation of oxygen consumption in different salinities. Moreover, the overall figures of 23 and 27 h shipments still gave a good opportunity to eel seeds of all sizes from GE to BP for further aquaculture purposes.

![Figure 2](image2.png)  
**Figure 2.** Different sizes SR of *A. b. bicolor* from different caught area during **23 h** shipment in August 2018

![Figure 3](image3.png)  
**Figure 3.** Different sizes SR of *A. b. bicolor* from different caught area during **27 h** shipment in July 2019

3.3 *Unfed SR*

![Figure 4](image4.png)  
**Figure 4.** Different sizes of eels survival rate without aeration and food given during 30 days on August – September 2018 observation.
Eel collectors normally keep the seeds in a minimum water condition. The water volume normally used with small water just a tip on a top of dorsal fin without any aeration. In a dense capacity, some collectors used aeration with 3 to 5 times of previous water volume. To maintained water quality they kept in small concrete tank without food given. When the collectors want to keep the eels a bit longer, they used tropical almond leafs (*Terminalia cattapa*) to prevent the eel from fungus infection. This situation due merely to the time needed to collect the eel seeds from fishers to a certain amount and can fulfill the order from consumers.

Results of unfed eel SR in 2018 observation shows that except glass eel from Ciwulan (GE-CW/CA V), most of the eels can survive during 30 days under unfed and un-aerated condition. The highest SR (96.3 %) found on the small pencil eel from Citandui (BP-PT/CA IV) followed by big pencil eel from Purworejo (BP-PR/CA I) with 88.0 % SR, small pencil from Ciberem (SP-KV/CA III) 73.5 % SR, and small pencil from Larangan creek of Nusawungu (SP-KR/CA II) with 57.7 % SR. For the glass eel from Ciwulan (GE-CW/CA V), only can survive 100 % during 7 days, 93 % SR during 12 days and all of them were pass away after that (Figure 4).

4. Conclusions

The eel with sizes: GE, SP, BP, and Con can survive during shipment with 23 and 27 h duration time. Unfed treatment, the best survival rate found in ‘Co’ (52 %) followed by ‘bp’ (34 %), ‘sp’ (33 %) during 30 days without food and aeration. However, the GE found 100 % death during 18 days in unfed conditions. Eel seed sources comparison shows significantly different (α < 0.05) among caught area locations. These can be conclude that eel seeds of GE size can be keep during delivery transportation (shipment) without food given for 23 h, and can be kept prior to other purposes for approx. fortnight while ‘sp’ and ‘bp’ sizes for mostly one month.

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