# Reproduction, growth, survival and vertebra abnormalities inheritance of hybrid balloon and normal red rainbowfish (*Glossolepis incisus*)

Tutik Kadarini, Muhamad Yamin, Siti Z. Musthofa

Research Institute for Ornamental Fish, Jl. Perikanan no. 13, Pancoran Mas, Depok, 16436, West Java, Indonesia. Corresponding author: T. Kadarini, tutikdarso@gmail.com

**Abstract**. The research of the vertebra abnormality inheritance in balloon red rainbowfish has never been conducted. The objectives of the study are to determine inheritance pattern, reproduction, growth and survival rate of hybrid balloon red rainbowfish and normal rainbowfish. The research was conducted in Laboratory of Research Institute for Ornamental Fish Culture, Depok, West Java, Indonesia. The scope of this research included hybridization between balloon and normal red rainbowfish broodstock, spawning, egg incubation, larval rearing for 40 days and seed rearing for 5 months. The hybrids were carried out by three different crossing between e.g., (1) balloon red rainbowfish ♀ x balloon red rainbowfish ♂, (2) normal red rainbowfish ♀ x balloon red rainbowfish ♂, (3) balloon red rainbowfish ♀ x normal red rainbowfish ♂. Each treatment was done in three replications. The average total length of balloon red rainbowfish was 5.214±0.255 cm, while normal red rainbowfish was 7.520±0.773 cm. A pair of matured adult fish were spawned naturally in a glass container (40 cm X 20 cm X 50 cm) filled with water (to 25 cm height). The fish were fed by bloodworm and commercial pellets (35% protein). The eggs were removed and incubated in a plastic container filled with 5-10 liter of water. The eggs hatched between 5-7 days after fertilization at water temperature of 25-31$^o$C. The 1-2 days old larvae were moved and reared in 70 cm x 80 cm x 70 cm concrete tanks (100 larvae container$^{-1}$). The 1-10 days old larvae were fed with *Rotifer* sp. and 20-40 days old larvae were fed with *Moina* and *Tubifex*. The fry fish of 40 days old were then reared in hapas net (size of 1 m x 1 m x 1 m) placed in ponds at density of 100 fish net$^{-1}$. The result shows that average of larvae survival rate were between 48.73 and 59.4% and fry survival rate were between 48.73 and 61.67%. Breeding of balloon x normal fish produced 48-54% balloon rainbowfish, but breeding of balloon vs balloon fish produced 71% of balloon rainbowfish. This results indicate that balloon trait of red rainbowfish did not interfere egg production and larval survival rate but decrease larval growth rate. It is also indicated that the balloon trait is controlled by one dominant allele and it is passed to offspring from both male and female parents of red rainbowfish.
**Key Words**: cross breeding, red rainbowfish (*Glossolepis incisus*), balloon fish, inheritance, survival rate, growth.

**Introduction**. Rainbowfish belong to the family Melanotaeniidae which is distributed in New Guinea and Australia, living in freshwater streams, lakes and swamps (Allen 1980). The first species of rainbowfish was discovered in 1907 (Ohee 2013), and currently there are approximately 95 species of rainbowfish which are successfully identified (Tappin 2010). Rainbowfish species are characterized by diverse colors on the body such as red, blue, yellow and orange and relatively small body size (< 14 cm total length - TL) (Allen 1980). One of the popular and valuable rainbowfish species is red rainbowfish (*Glossolepis incisus*). It is an endemic fish originating from Lake Sentani and its tributary streams in Irian Jaya, Papua, Indonesia (Tappin 2010). Male red rainbowfish color is bright red in all over its body and it is more attractive than the female which is yellowish green colloration.

Since 1986 IUCN Red List of Treatened Species lists the red rainbowfish as an endangered species with vulnerable status (IUCN 2012). Degradation of rainbowfish habitat especially by human activities leads to the verge of extinction of many species (Kadarusman et al 2010). Beside that, rapid population growth surounding the lake contributes to the increasing of household waste and pollution into the lake, which is threatening the existence of fish inhabiting the lake. Another threat was coming from the introduced fish species such as tilapia (Kadarusman et al 2010).

In rainbowfish culture, sometimes farmers find fish with morphological abnormality (Nugraha et al 2015). The vertebral deformity is known as a lead change in fish external morphology (Berillis et al 2015) so that the fish looks asymmetrical with "crooked" head. One of the vertebra abnormalities produces fish which is known as balloon rainbowfish. Besides in rainbowfish, the balloon abnormalities were also found in other fish such as "balloon kissing gourami" (*Helostoma temminkii*, Cuvier 1829), "balloon molly" (*Poecilia velifera*, Regan 1914), "blood parrot cichlid "(*Heros severus* x *Amphilophus citrinellus* hybrid) and ornamental goldfish (*Carassius auratus* L.) (Arbuatti et al 2013). The vertebra abnormalities are caused by natural environmental stressor, anthropogenic pollution, and hatchery rearing practices (Prochazka 2009) and also some other factors such as genetic, parasite, handling, and nutrient (Silverstone & Hammell 2002). Furthermore, according to Nugraha et al (2015), the deformity in rainbowfish was mostly contributed by poor management and poor water quality rather than inbreeding depression.

Generally, balloon rainbowfish has a shorter body and tail rod than that of normal rainbowfish and it looks like an inflated balloon (Musthofa & Kadarini 2012). The fish has a wide crooked-down mouth and has a bigger head and body. In aquatic trade, the fish is called as "*Glossolepis incisus*" balloon. Musthofa & Kadarini (2012) reported that the balloon fish standard length reduced to about 31.50% of the normal fish size. The difference phenotype of balloon rainbowfish compared to the normal fish causes the fish is considered as unique and attractive ornamental fish. To our knowledge, a research on vertebra abnormality inheritance in balloon red rainbowfish has never been reported. The purpose of this study is to determine inheritance pattern, reproduction, growth, and survival rate of hybrid balloon and normal red rainbowfish.

**Material and Method**. The study was carried out in March to December 2016 in Research Institute for Ornamental Fish, Depok, West Java, Indonesia.

***Broodstock management***. Broodstocks were separated by body shape and sex. Eighteen broodstock consisted of 12 (6 male and 6 female) balloon red rainbowfish (total length of 5.21±0.255 cm, weight of 3.843±1.669 g) and 6 normal (3 male and 3 female) red rainbowfish (total length of 7.52±0.773 cm, weight 3.843±1.669 g) were obtained from local farmers. Broodstock were aclimatized for 20 days aimed for gonad maturation in a round fibre container with diameter and height of 1.20 m and 1 m respectively. The container was filled with ground water to a 70 cm high and provided with aeration. The broodstock were fed with the mixture of commercial pellets (35% protein) and bloodworm (*Chironomus* sp.) twice a day at 08.00 a.m. and 15.00 p.m. The matured broodstock was distinguishable with unmature broodstock by the appearance of body color and the size of abdomen. Mature broostock was easy to spawn naturally in captivity.

***Mating***. Matured broodstock were characterized by color appearance in fish body. Matured male fish was indicated by red color which would be brighter (more vivid) and actively chasing female. Matured female fish was indicated by yellowish-green body, bulged belly and sometimes with redish genitalia (Figure 1). Mating fish was conducted in a glass tank (size: 40 cm x 20 cm x 50 cm size) containing 25 cm height of ground water and aerated. Each tank was consisted of a pair of gonadal matured male and female. During spawning, the fish fed by the mixture of 35% pellet and bloodworm (*Chirinomus* sp). The research was designed in a complete randomized design (CRD) with 3 treatments and 3 replications. Broodstock mating combination as a treatment is shown below:

(1) ♀ Balloon red rainbowfish x ♂ Balloon red rainbowfish;
(2) ♀ Normal red rainbowfish x ♂ Balloon red rainbowfish;
(3) ♀ Balloon red rainbowfish x ♂ Normal red rainbowfish.

Every 2 days, each pair of broodstock was spawned naturally. During a period of treatment, a female spawned up to 4 times. Spawning was triggered by adding substrate of raffia plastic bundle at dawn. The broodstock would release eggs gradually and lay on the plastic substrate. Egg observation was conducted in the morning by lifting the substrate from the container and then moved into an incubator container. Egg diameter was measured digitally using stereo microscope connected to a camera.

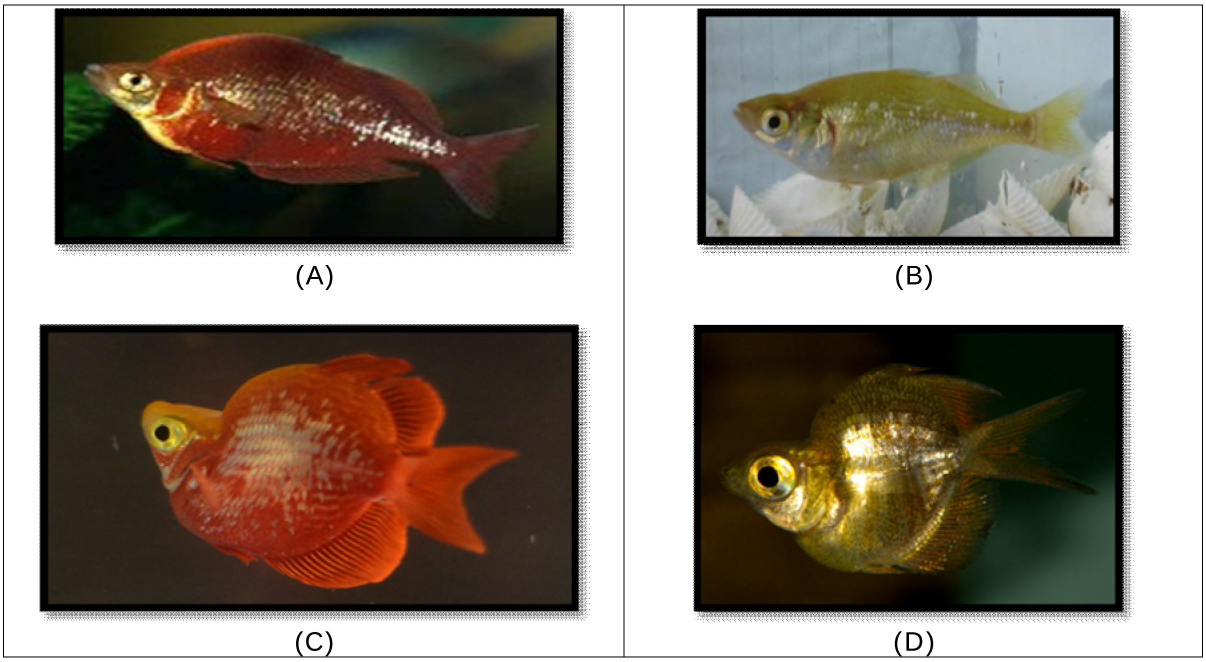


Figure 1. Brood fish used in the study: (A) normal male red rainbowfish; (B) normal female red rainbowfish (C); balloon male red rainbowfish; (D) balloon female red rainbowfish.

***Egg incubation***. Substrata containing eggs were moved into a plastic container filled with 5-10 L of water and aerated. Fertilized eggs were determined by transparent in color, and contrary unfertilized egg would be ivory. Duration of egg incubation to hatch into larva took at least 5-7 days (25-31$^{o}$C) (Kadarini et al 2013b). A few hours after being hatched, the larvae would be swimming on the water surface. After 1-2 days, the larvae were harvested, numbered and transported to rearing containers.

***Larvae rearing***. The 1-2 days old larvae were reared in a concrete tank placed outdoor up to 40 days old. One hundred (100) larvae were reared in each tank with size: 70 cm x 80 cm x 70 cm, and aerated. The 1-10 days old larvae were fed with infusoria and rotifers and for 20-40 days old larvae were fed with moina. After 40 days of rearing, the fry were harvested and moved into fry rearing net cages (Kadarini et al 2013a).

***Fry rearing***. The 40-days old fry were reared for 5 months in hapas (plastic net cage size of 1 m x 1 m x 1 m with water level of 60-70 cm. Four net cages were placed in a concrete tank of 2 m x 2 m x 1 m. Each tank contains 100 fish which were fed with a mixture of *Tubifex* sp. and commercial pellet (5-10% of body weight). Sampling were conducted on day-40 and day-150 old larvae. Sampling was held for the first time on the day-40 only in order to minimize mortality during sampling process. Balloon and normal fish can be distinguished from the body size, which in the balloon rainbowfish it was shorter than that of the normal rainbowfish.

***The parameters***. The observed parameters include number of eggs, fertilization rate (FR), hatching rate (HR) of larvae, percentage of balloon fish (abnormal) and normal fish, survival rate of larva and fry, larva and fry growth. Survival rate was the percentage of living fish both for larva and fry during preservation.

***Analysis***. Data was analyzed using ANOVA and Tukey test to distinguish inter-behaviour ($p > 0.05$) with Minitab includes egg number, fertilization rate (FR), hatching rate (HR) of larva, larva survival rate, balloon (abnormal) and normal fish percentage, fry survival rate, larva and fry growth.

## Results

***Spawning***. Spawning frequency, egg number, egg size, fertilization rate (FR), hatching rate (HR), and number of larva from each treatment of mating balloon and normal rainbowfish are presented in Table 1. From 4 times spawning trials on each treatment, it was obtained that spawning frequency of mating balloon fish ♀ x balloon fish ♂ was higher (93%) than other treatments (75%). Meanwhile, the number of egg on each treatment was 114.25±94.49, 157.76±98.05 and 96.97±39.73 respectively.

Fertilization rate (FR) is a number of eggs fertilized by male during spawning. Average FR of the treatment was between 95.61 and 97.17%. Meanwhile, Musthofa et al (2013) reported that fertilization rate of balloon red rainbowfish was 100%. Hatching rate (HR) is number of eggs hatched to be a larva after 5-7 days of incubation. Average HR from the three treatments were between 91.81 and 93.14%. The HR results are lower compared to HR reported by Musthofa et al (2013) that the balloon red rainbowfish fertilization rate was 100%. The average number of larvae produced from 4 times spawning were 91-151 larvae (Table ). The highest number of larvae was produced from mating of normal red rainbowfish ♀ x balloon red rainbow ♂, however there was no significant difference between the treatments ($p > 0.05$).

Table 1

Average frequency of spawning, number of egg, egg diameter and number of larvae from 4 trials spawning of mating normal and balloon rainbowfish

| *Parameters* | *Mating treatments* | | |
|---|---|---|---|
| | *♀ balloon red x ♂ balloon red* | *♀ normal red x ♂ balloon red* | *♀ balloon red x ♂ normal red* |
| Σ Spawning experiment | 4 | 4 | 4 |
| Spawning frequency (%) | 3.7 (93%)$^{a}$ | 3.0 (75%)$^{a}$ | 3.0 (75%)$^{a}$ |
| Number of egg | 114.250±94.490$^{a}$ | 157.760±98.050$^{a}$ | 96.970±39.730$^{a}$ |
| Egg diameter (mm) | 1.055±0.023$^{a}$ | 1.047±0.045$^{a}$ | 1.046±0.048$^{a}$ |
| Fertilization rate (%) | 96.670±3.080$^{a}$ | 97.170±2.660$^{a}$ | 95.610±4.250$^{a}$ |
| Hatching rate (%) | 92.080±7.230$^{a}$ | 93.140±6.250$^{a}$ | 91.810±7.320$^{a}$ |
| Number of larva | 106.000±81.930$^{a}$ | 151±88.150$^{a}$ | 91±34.600$^{a}$ |

Means±standard deviations in the same column with different superscript letters indicate significantly different result ($p < 0.05$).

***Larva and fry rearing***. The results of larval survival rate, fry survival rate and percentage of balloon rainbowfish from mating treatment of normal and balloon rainbowfish are presented in Table . Survival rate of 40 days old larva from each treatment were ranged from 49.73 to 59.4% and fry were ranged from 48.73 to 61.67%. There were no significant differences between larva and fry survival rate among the treatments ($p > 0.05$). Percentages of balloon fish produced from mating treatment of balloon rainbowfish ♀ x normal rainbowfish ♂, and between normal red rainbowfish ♀ x balloon red rainbowfish ♂ were 49.00 and 46.33% respectivelly. This was lower and significantly different ($p < 0.05$) from the percentage of balloon rainbowfish produced from mating treatment of balloon ♀ x balloon ♂ rainbowfish (71±6.43%).

Table 2

Larva survival rate and fry survival rate percentages of balloon rainbowfish resulted from crossed between balloon red rainbowfish and normal rainbowfish at 40 and 50 days old fry

| *Parameter* | *Brood stock mating combination* | | |
|---|---|---|---|
| | *♀ balloon red x ♂ balloon red* | *♀ normal red x ♂ balloon red* | *♀ balloon red x ♂ normal red* |
| Survival rate (%) of larva (40 days old) | 49.73[a] | 56.70[a] | 59.40[a] |
| Survival rate (%) of fry (5 months old) | 48.73[a] | 61.67[a] | 60.70[a] |
| Number of balloon rainbowfish (%) | 71±6.43[a] | 46.33±9.71[b] | 49±3.61[b] |

Means±standard deviations in the same column with different superscript letters indicate significantly different result ($p < 0.05$).

***Growth***. Average total length, standard length, body height and weight of 40 days old normal and balloon rainbowfish fry produced from crossing combination are presented in Table 3. The result indicated that the average of total length and standard length of balloon red rainbowfish were 1.470±0.059 and 0.980±0.070 cm respectivelly, or shorter than normal rainbowfish were 2.160±0.198 and 1.640±0.183 cm, respectively (Table 3). As well as body weight of balloon rainbowfish was lighter than normal rainbow fish. Meanwhile, body height of balloon rainbowfish had a higher body than normal rainbow fish (Figure 2).

Table 3

Average total length, standard length, body height and weight of 40 days balloon red rainbowfish and normal rainbowfish

| *Body parameter* | *Fish size (cm)* | |
|---|---|---|
| | *Balloon rainbow* | *Normal rainbow* |
| Total length (cm) | 1.470±0.059 | 2.160±0.198 |
| Standard length (cm) | 0.980±0.070 | 1.640±0.183 |
| Body height (cm) | 0.580±0.002 | 0.530±0.075 |
| Body weight (g) | 0.095±0.030 | 0.121±0.022 |

N: 20 fish.

Figure 2. Fourty days old red rainbowfish. Balloon red rainbow circled and normal red rainbow not circled.

Average total length, standard length, body height and weight of 5 months old normal and balloon fry rainbowfish produced from mating combination treatment is presented in Table 4. The total length of normal red rainbowfish was in range of 4.55-5.52 cm, longer than balloon which was in range of 3.63-3.91 cm. Meanwhile, the height was almost similar between balloon and normal red rainbowfish ranging from 1.12 to 1.151 cm and 1.14 to 1.55 cm respectively. The weight of normal rainbowfish was in range of 1.04-1.99 g, heavier than that balloon of 0.84-1.44 g.

Table 4

Total length, standard length, body height and weight of 5 months old normal and balloon rainbowfish produced from mating combination treatment

| Parameters | Treatment | | |
|---|---|---|---|
| | ♀ *balloon red* x ♂ *balloon red* | ♀ *normal red* x ♂ *balloon red* | ♀ *balloon red* x ♂ *normal red* |
| *Balloon* | | | |
| Total length (cm) | 3.91±0.47[a] | 3.88±0.29[a] | 3.63±0.45[a] |
| Standard length (cm) | 2.93±0.45[a] | 2.91±0.13[a] | 2.71±0.72[a] |
| Body height (cm) | 1.51±0.36[a] | 1.22±0.04[a] | 1.12±0.35[a] |
| Body weight (g) | 1.44±0.91[a] | 1.03±0.19[a] | 0.84±0.04[a] |
| Length-body height ratio | 2.59 | 3.18 | 3.24 |
| *Normal* | | | |
| Total length (cm) | 5.52±1.08[a] | 4.71±0.53[a] | 4.55±0.16[a] |
| Standard length (cm) | 4.48±0.92[a] | 3.82±0.49[a] | 3.63±0.25[a] |
| Body height (cm) | 1.55±0.51[a] | 1.38±0.04[a] | 1.14±0.17[a] |
| Body weight (g) | 1.99±1.50[a] | 1.19±0.27[a] | 1.04±0.12[a] |
| Length – body height ratio | 3.56 | 3.41 | 3.99 |

Number of fish measured was 20 fish for each treatment. Means±standard deviations in the same column with different superscript letters indicate significantly different result ($p < 0.05$).

**Discussion**. In the red rainbowfish cultivation, sometimes breeder found fish with spinal abnormality known as balloon red rainbowfish. The spinal abnormality leads to change its phenotype which is different from normal rainbowfish, i.e. shorter but higher in body of fish. Since its body shape is regarded as unique, in many ornamental fish markets, the ballon fish value is more expensive than normal ones. The spinal abnormality was caused by several factors such as nutrition, environment and genetic (Fernández et al 2008).

Genetically, the abnormality of spinal development causing reduction of total body length in fish is occured by mutation in gene locus (Haffter et al 1996; Colihueque & Araneda 2014). Furthermore, Haffter et al (1996) identified four dominant mutations giving rise to fish reduced body length which were lilliput (lil), smurf (smf), stöpsel (stp) and däumling (dml). From these four mutation types, lil and smf did not indicate any ventral abnormality while the body length reduction was caused by reduced growth. The ventral abnormalities are only indicated on stp mutation (vertebrae length reduction) and dml mutation (decreased number of centra). Moreover, it is suggested that both of these mutations did not cause a reduction in the number of ribs, nerves and thermal arch (Haffter et al 1996; Colihueque & Araneda 2014). Nevertheless, dml mutation caused delayed swim bladder formation.

Many factors might affect fish spawning such as season, types of substrate and tank, and quality of the broodstock (Kadarini et al 2012; Effendie 2002). From the three mating treatments, it was indicated that balloon and normal rainbowfish were able to spawn well on the controlled environmental treatment condition. Rainbowfish spawned throughout the year so that its spawning frequency could reach up to 24 times in a month (Mustahal et al 2014). Kadarini et al (2013a) reported that from 12 mass spawning trials of normal red rainbowfish (5 broodstocks tank$^{-1}$), the percentage of fish spawning rate reaches 83 percent. Musthofa et al (2013) further reported that from 20 spawning trials of balloon red rainbowfish broodstock, the percentage of spawning rate was up to 80 percent. From visual observation it was found that matured male fish has a brighter (vivid) red color on its body and also active in chasing female.

Spawning ability of crossed balloon x balloon fish was higher than crossed balloon x normal fish pair. The higher spawning frequency on mating treatment of female balloon x male balloon rather than other treatments were assumed due to the similarities in body shape and movement abilities which facilitate the spawning process of the pair. A normal rainbowfish had a longer, leaner body shape with swift swimming movement in contrast to balloon rainbowfish which had a shorter, wider body with slow swimming movement

(Figure 1). The similarities in body shape and movement patterns would affect the fish ability to adapt to its partner and conduct spawning. On the contrary, the differences in body shape and swimming movement between balloon and normal rainbowfish caused a disruption in the mating process.

***Egg incubation***. The average diameter of egg produced from normal and balloon rainbowfish was relatively similar. As well as egg incubation duration, it did not indicate any significant differences between the treatment in which the egg hatching period ranged between 5-7 days after incubation process and the hatching peak period occured in day 6 after fertilization. The egg diameter from each treatment ranged from 1.046 to 1.101 mm and was not significantly different between the treatments ($p > 0.05$). This result is in line with Musthofa et al (2013) who had been reported that an average diameter of balloon red rainbow egg was 1.033±0.023 mm. These conditions indicated that spinal abnormalities in the balloon rainbowfish and cross treatment did not disrupt the egg production and quality, and embryonic development as well. Furthermore, relatively same age fish reared in controlled container and feed allow the fish to live and reproduce normally. The result is in line with Abrehouch et al (2009) that fish egg diameter was not affected by the differences in the feed quality. Further, Kjersvik et al (1990) stated that egg diameter was not closely related to the quality of produced larva.

The important parameter in most studies on the quality of fish egg was fertilization and hatching rate besides stage development and the obtained larvae (fry) (Kjersvik et al 1990). From four times spawning trials, the number of produced larva from each treatment obtained a quite high in range starting from no egg to producing many larva (up to 117 larva). While the fertilization rate from each cross treatment was quite high ranging from 87.5 to 100% (data not shown). Based on fertilization rate and hatching rate, it was indicated that the egg quality produced by all mating treatments was not significantly different. This result is also in line with Kadarini et al (2013a) who stated that normal red rainbowfish fertilization rate was about 71-93% and hatching rate was 93.00-97.12%. According to Tappin (2010) the rainbowfish fertilization rate generally ranged from 70 to 80%. While the number of larva produced from all three treatments was relatively similar to Musthofa et al (2013) who reported that a pair of balloon red rainbowfish produces 0-68 larvae per spawning. This result is also in line with Heinimaa & Heinimaa (2004) which stated that the female size had no correlation to relative fecundity of wild Atlantic salmon (*Salmo salar* L.). The similar number of larva from each treatment indicated that the abnormality (balloon) only lead to fish growth disorder but it was not lethal to embryos and larva. Furthermore, newly hatched balloon red rainbowfish had a total body length of 3.8±0.01 mm (Musthofa et al 2013) and 4.26±0.003 mm for the normal red rainbowfish (Kadarini et al 2013a).

***Survival rate***. Survival rate of the mating treatment among balloon and normal red rainbowfish was divided into two stages, the first was larval survival rate (0 to 40 days old larvae) and fry stage (40 days old to 5 months). Larva survival rate obtained at 40 days rearing showed equal between each treatment that was ranged from 50 to 60%. This result was also not much different from Said's report (2004), that *Melanotaenia boesemani* and *Melanotaenia praecox* larva survival rate is 49%, but lower than Kadarini et al (2013a) who reported normal red rainbowfish larva survival rate was ranging from 68.70 to 81.28%. Some causing factors of low larval survival rate are unsuitable timing of natural feed and the presence of pests such as dragonfly larva that could bite the fish larva during rearing in outdoor.

After 5 months rearing starting from larval stage, it was found that fry survival rate did not show significant difference between each treatment (48.73-61.67%). We expected that low survival rate during fry rearing is due to differences in fish size and presence of moss in hapas which disrupt fish movement and reduce the light entering the water. Generaly, the survival rate result indicated that the spinal abnormalities were not lethaly to larva or fry fish.

According to Haffter et al (1996), from four dominant types of spinal mutations causing fish body shortening, it was only fish carrying a däumling mutation that was decreasing viability to 50% before reaching adulthood. Meanwhile, fish with three other dominant types of spinal mutations (lil, smf and stp) had a good viability.

***Growth***. During 5 months rearing, embryo and fry growth rate of balloon and normal rainbowfish had no significantly difference between each treatment especially in total length, body height and body weight. Balloon rainbowfish had a shorter body and lighter weight about 20-30 percent compared to the normal rainbowfish. Meanwhile, body height of rainbowfish tent equal to or 25% shorter than normal fish. Based on the analysis of lenght weight relationship, normal rainbowfish had allometric negative growth pattern therefore, the fish appears longer and slimmer. In contrast, balloon fish have allometric positive growth pattern, so the fish look fatter (Musthofa & Kadarini 2012). One of the possible factors causing slower growth rate in balloon rainbowfish was spinal abnormalities. Fish with vertebra abnormalities usually do not swim efficiently, less ability to get food, and more susceptible to physiological imbalance (Berillis et al 2015; Silverstone & Hammell 2002). Beside that, the abnormalities might also cause the balloon fish losing in food and space competition.

***Balloon trait***. In addition to genetics, several other factors causing spinal abnormality in fish were including nutrient, pathogen, pollutant and traumatic preservation (Silverstone & Hammell 2002). Unlike genetic abnormalities, these abnormalities could not be passed down to the next generation. Percentage of balloon fish produced from mating balloon and normal rainbowfish was 46.33-49.0% or reach about half of the population. In contrast, mating among normal parent produces 100% normal offspring rainbowfish (Kadarini et al 2011). These results indicated that balloon fish trait could be derived from both the male and female parent to offspring with equal opportunity. These results was also indicating that the parents fish were heterozygote carrying normal (recessive) and balloon (dominant) traits (Tave 1995). Furthermore, from mating treatment among female balloon and male balloon results offspring with balloon trait reach nearly ¾ population (71±6.43%) and ¼ population were normal fish (Figure 3). These result confirmed that balloon trait of rainbowfish was controlled by one dominant allele (Tave 1995).

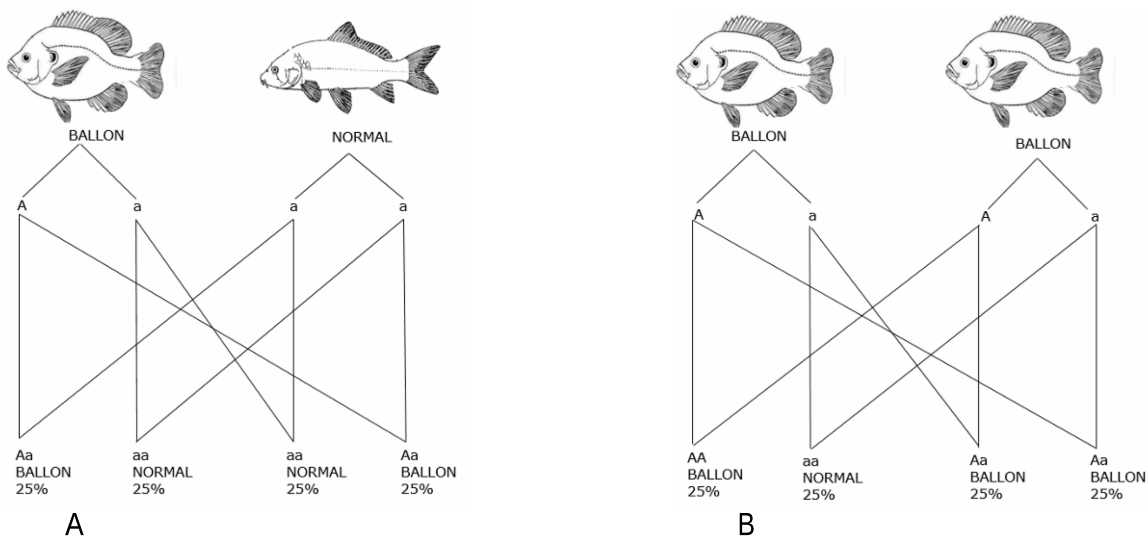


Figure 3. Mating combinations between normal x balloon rainbowfish (A) and ballon x balloon rainbowfish (B), and the phenotypes of the offspring produced by each mating (AA = balloon rainbow, Aa = balloon rainbow, aa = normal rainbow).

**Conclusions**. This study has successfully revealed that balloon trait of red rainbowfish did not cause interference in egg production or larval survival rate but it decreased the larvae growth rate. Balloon trait could be passed to offspring from both parents of red rainbowfish with equal opportunities. The balloon trait was controlled by a complete dominant gene allele.

**Acknowledgements**. We thank the RIOF staf; Sanusi for his assistance during the study in laboratory and Prof. Ketut Sugama for suggestion during completing the paper. This study was partly funded by APBN 2012.

**References**

Abrehouch A., Idaomar M., Ali A. A., Nhhala H., Talbaoui E. M., 2009 Broodstock feeding effects on spawning performances' (fertility, eggs and larvae quality) of the Mediterranean red porgy (*Pagrus pagrus*, Linnaeus 1758) during two years. African Journal of Food Science 3(8):193-200.

Allen G. R., 1980 A generic classification of the rainbowfishes (family Melanotaeniidae). Records of the Western Australian Museum 8(3):449-490.

Arbuatti A., Salda L. D., Romanucci M., 2013 Spinal deformities in a wild line of *Poecilia wingei* bred in captivity: report of cases and review of the literature. Asian Pacific Journal of Tropical Biomedicine 3(3):186-190.

Berillis P., Panagiotopoulos N., Boursiaki V., Karapanagiotidis I. T., Mente E., 2015 Vertebrae length and ultra-structure measurements of collagen fibrils and mineral content in the vertebrae of lordotic gilthead seabreams (*Sparus aurata*). Micron 75:27-33.

Colihueque N., Araneda C., 2014 Appearance traits in fish farming: progress from classical genetics to genomics, providing insight into current and potential genetic improvement. Frontiers in Genetics 5:251.

Effendie M. I., 2002 [Fisheries biology]. Cetakan Kedua, Yayasan Pustaka Nusatama, Yogyakarta, 163 pp. [in Indonesian]

Fernández I., Hontoria F., Ortiz-Delgado J. B., Kotzamanis Y., Estévez A., Zambonino-Infante J. L., Gisbert E., 2008 Larval performance and skeletal deformities in farmed gilthead sea bream (*Sparus aurata*) fed with graded levels of vitamin A enriched rotifers (*Brachionus plicatilis*). Aquaculture 283:102-115.

Haffter P., Odenthal J., Mullins M. C., Lin S., Farrell M. J., Vogelsang E., Haas F., Brand M., van Eeden F. J., Furutani-Seiki M., Granato M., Hammerschmidt M., Heisenberg C. P., Jiang Y. J., Kane D. A., Kelsh R. N., Hopkins N., Nüsslein-Volhard C., 1996 Mutations affecting pigmentation and shape of the adult zebrafish. Development Genes and Evolution 206:260-276.

Heinimaa S., Heinimaa P., 2004 Effect of the female size on egg quality and fecundity of the wild Atlantic salmon in the sub-arctic River Teno. Boreal Environment Research 9:55-62.

IUCN Red List of Threatened Species, Version 2012.2.3 Available at: http://www.iucnredlist.org/details/9268/0. Accessed: November, 2012.

Kadarini T., Kurniawan W., Solichah L., Wibawa G. S., 2011 [Larvae production of three species of rainbow fish (red rainbowfish, Boesemani and Melanotaenia)]. Prosiding Seminar Nasional Ikan VI & Konggres Masyarakat Iktiologi Indonesia III, pp. 559-562. [in Indonesian]

Kadarini T., Nur B., Nurhidayat, Sholichah L., Zamroni M., Wibawa G. S., 2012 [Technical instructions of rainbowfish culture (*Melanotaenia parva*)]. [BPPBIH] Balai Penelitian dan Pengembangan Budidaya Ikan Hias, Depok, West Java, 36 pp. [in Indonesian]

Kadarini T., Musthofa S. Z., Ferdiansyah J., 2013a [The different ratio of females and males to spawning pattern and survival rate of red rainbowfish (*Glossolepis incisus*) larvae to support the conservation of fish resources]. Prosiding Forum Nasional Pemuliaan dan Konservasi Sumberdaya ikan, Dirjen KP3K-UNPAD-MII, Article KSI-P1. [in Indonesian]

Kadarini T., Zamroni M., Pambayuningrum E. K., 2013b [Development of the kurumoi rainbowfish larvae (*Melanotaenia parva*)]. Jurnal Riset Akuakultur 8(1):77-86. [in Indonesian]

Kadarusman, Sudarto, Paradis E., Pouyaud L., 2010 Description of *Melanotaenia fasinensis*, a new species of rainbowfish (Melanotaeniidae) from West Papua, Indonesia with comments on the rediscovery of *M. ajamaruensis* and the endangered status of *M. parva.* Cybium 34(2):207-215.

Kjørsvik E., Mangor-Jensen A., Holmefjord I., 1990 Egg quality in fishes. In: Advances in marine biology. Blaxter J. H. S., Southward A. J. (eds), pp. 26:71-113.
Mustahal, Hermawan D., Gumilar G., 2014 [Larval production of parrot red rainbow *Glossolepis incisus* fish with different numbers of raffia's rope as substrate]. Jurnal Perikanan dan Kelautan 4(4):243-250. [in Indonesian]
Musthofa S. Z., Kadarini T., 2012 [Morphological abnormality of red rainbowfish, *Glossolepis incisus* from captivity]. Prosiding Seminar Nasional tahunan IX UGM Tahun 2012, Jogjakarta, Article GN-03. [in Indonesian]
Musthofa S. Z., Zamroni M., Kadarini T., 2013 [Reproductive viability of balloon red rainbowfish *Glossolepis incisus* in controlled habitat]. Prosiding Seminar Nasional Perikanan 2013, Teknologi Budidaya Perikanan, Sekolah Tinggi Perikanan, Jakarta, pp. 307-313. [in Indonesian]
Nugraha M. F. I., Pouyaud L., Carman O., Widyastuti U., Zairin Jr. M., Kadarusman, Avarre J. C., 2015 Genetic diversity of Boeseman's rainbowfish (*Melanotaenia boesemani*) reared in Indonesian farms compared to endangered natural populations. Tropical Conservation Science 8(3):796-812.
Ohee H. L., 2013 The ecology of the red rainbowfish (*Glossolepis incisus*) and the impact of human activities on its habitats in Lake Sentani, Papua. Doctoral thesis, Division of Mahematics and Natural Sciences of the Georg-August Universität Göttingen, 118 pp.
Prochazka E., 2009 Incidence of malformations in fish embryos/larvae (review). Available at: https://www.researchgate.net/file. Accessed: November, 2017.
Said D. S., 2004 [Hybrid viability on interspecies cross breeding of *Melanotaenia boesemani* and *Melanotaenia praecox*]. Limnotek 11(2):50-56. [in Indonesian]
Silverstone A. M. Hammell L., 2002 Spinal deformities in farmed Atlantic salmon. Canadian Veterinary Journal 43:782-784.
Tappin A. R., 2010 Rainbow fishes: their care and keeping in captivity. 493 pp.
Tave D., 1995 Selective breeding programmes or medium-sized fish farms. FAO Fisheries Technical Paper No. 352, Rome, FAO, 122 pp.

Received: 22 May 2018. Accepted: 28 June 2018. Published online: 06 August 2018.
Authors:
Tutik Kadarini, Research Institute for Ornamental Fish, Jl. Perikanan no. 13, Pancoran Mas, Depok, 16436, West Java, Indonesia, e-mail: tutikdarso@gmail.com
Muhamad Yamin, Research Institute for Ornamental Fish, Jl. Perikanan no. 13, Pancoran Mas, Depok, 16436, West Java, Indonesia, e-mail: yaminpaada@gmail.com
Siti Zuhriyyah Musthofa, Research Institute for Ornamental Fish, Jl. Perikanan no. 13, Pancoran Mas, Depok, 16436, West Java, Indonesia, e-mail: siti_zuhriyyah@yahoo.com

How to cite this article:
Kadarini T., Yamin M., Musthofa S. Z., 2018 Reproduction, growth, survival and vertebra abnormalities inheritance of hybrid balloon and normal red rainbowfish (*Glossolepis incisus*). AACL Bioflux 11(4):1173-1182.