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PRELIMINARY STUDY OF EEL FISH IN LAKE POSO, SULAWESI ISLAND, INDONESIA

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Abstract
Lake Poso in the Island Sulawesi, contains eel fish (*Anguilla marmorata*) that has a catadromic migration pattern. The 364 km^2 lake is connected to the sea by a single river that drain the water from an elevation of 512 m down to the sea along a 40 km stretch. Conservation of the eel is endangered by the active catching by local people using bamboo traps along the river mouth from Lake Poso during migration to the sea as well as by environmental change of the Poso River estuary that exhibit landward migration of the elver. These are the reasons for which this research was conducted. Reproduction aspects of the eels during the period of May to August spawning migration cycle was studied by investigating the gonads and liver. Preliminary results show that some of the eels gonad are immature containing cysts of gonias while other have early vitellogenic oocytes. Liver of the eels rich with glycogen shows active metabolism during vitellogenesis. Gonadosomatic index (GSI) values range between 0.33 to 3.83% and Hepatosomatic Index (HSI) from 0.29 to 1.35%.

Introduction
One of an important natural resource of Lake Poso, Sulawesi Island, Indonesia (ca. 120°36'E and 1°58'S) is eel fish. A series of studies is being conducted to reveal the relations between the eel's life cycle and its ecosystem. This paper limit discussions on the reproduction aspects which is a key factor in the conservation of this species. Lake Poso is a deep tectonic lake, maximum depth is 395 m, oval in shape in a north-south direction, mostly steep lake-banks, the surrounding hinterland composed of mainly metamorphic rocks and some sedimentary rocks, covered by primary forest which during the last three decades has been partially converted into open space and cultivated rice field. Following an east-west section throughout the lake's catchment shows an asymmetric basin profile, more steep and narrower in the eastern rim of the lake while the western part is build by higher mountain range and a broader and several small flat wetland or ecotones. The southern end of the basin consists of sedimentary rocks that clearly shows erosion remnants which through the rivers has filled the adjoining lake bottom.

Eels are indigenous species of Indonesia (Nontji, 1987), its distribution is along rivers that has an estuary facing deep sea. These eels have a catadromous migration pattern because they migrate to deep sea for hatching, then the leptocephalus will return to the estuary for growing up into the elver stage. This migration process is an important biological aspect in the life cycle of each organism. They are part of the reproduction processes which unfortunately is misused by the local population to catch them during this migration period. This type of catching practice has endangered the conservation of several species in rivers of the world.

European eels (*Anguilla anguilla*), Japanese eels (*A. japonica*), and American eels (*A. rostrata*) have been extensively studied since a century ago. The life cycle from

the pelagic larva stage to mature stage ready for migration has been reported since the beginning of this century (Colombo & Grandi, 1996), while the Indonesian eels have not much been published. For this reason the eels that lived and migrate from Lake Poso into the Bay of Tomini in the north will be studied to add scientific information on Indonesian eels.

Because of its high economic values, countries such as Japan, Europe, USA, and Hongkong have cultured eels intensively by catching the elver from nature. On the contrary, export of natural grown-up eels from Lake Poso was reported to Singapore and Hongkong. According to statistic figures from the Department of Fisheries they were 41.5 tons in 1990 that dropped to 29.1 tons in 1997. In the Poso River area the catch of grown-up eels was through large and strong bamboo traps facing upstream, build along river channel near the lake, to catch eel during migration to the sea. This way of practice certainly endangered the life cycle of this species.

Methodology

During field sessions, the eels were killed by decapitation and their body weight, total length, and gonad and liver weight were measured. Small pieces from liver and gonads were fixed for 24 h in bouin alcohol solution, dehydrated in an ethanol series, and embedded in paraffin. Cross sections 5-7 μm thick, stained with Periodic Acid Schiff (PAS) were observed with a Zeiss microscope.

Quantitative analyses of the gonad and liver used the Gonadosomatic Index (GSI) and Hepatosomatic Index (HSI) which is expressed as :

$$GSI = (\text{gonad weight} / \text{body weight}) \times 100\%$$

$$HSI = (\text{liver weight} / \text{body weight}) \times 100\%$$

In addition to these observations, secondary data from the Fisheries Department of the District of Poso has been utilized.

Results

During the 1998 field survey it was observed that mature eels started to migrate from Lake Poso to the sea in January as concluded from the total number of catch reported by local population that build their eel trap along the river mouth. These are strong bamboo fence build at the river mouth between Lake Poso and Sulewana waterfalls about 15 km downstream. Highest catch was observed during April and May totally 10.7 and 7.2 tons, with an average one night catch of 30 eels, each with a weight of 2.5-17 kg.

There are indications of decreasing yearly catch as reported by statistics of the local office of the Department of Fisheries, that of 41.5 tons in 1990 down to 30.5 tons in 1998. This decrease in total catch should get special attention in addition to the fact that during that same period the price has increased from Rp 5,000 to Rp 8,000. This could be a preliminary indication that there is a decrease in population because of too high catch during their migration to the sea.

Discussion with local fisherman provide information that eel migrate following the river current to the sea including the pass through the high and rough fall along the Sulewana waterfall. The mechanism of eel body during transport was observed by local people during their initial entry into their bamboo trap. It was observed that the eel rolled

themselves encircling their head in the middle with the tail outside while the mouth bite its tail for which they formed a wheel shape. This instinctive move was to protect their sensitive body parts from being hurt during travel. It was observed that after a while being trapped inside the bamboo trap the eel will open their wheel shape body and try vigorously to free themselves from the strong bamboo stick.

Migration activity of the eels to the sea will follow the high river discharge during rainy season which is highest in April and May. By choosing this high water flow the eels conserve energy by drifting following the current of the river. This specific time of travel was concluded from discussions with local fisherman and reports on total catch by the dozens of traps that has nearly close all possible water paths along the Poso River channel.

Along the estuary at lower part of the Poso River that flows amid the Poso City downstream, some catching activities by local population is by fish-hook which never came with high catch figures. This is because people in the Poso City have better primary jobs and this activity is done more or less as a sport or side-activity. Our field observations along the estuary is directed more toward the elver migrating upstream from the open sea.

Increasing number of glass eel population in the estuary was observed during May to June especially on dark moon period. Transparent or glass eels were observed in the shallow estuary until December as reported by the Fisheries Department. Contrary to these facts, there was a substantial decrease of glass eels observed in the estuary as reported in June to August 1998 which was only 66,000 glass eels compared to 785,000 observed during May to November 1997. These elver are potential sources for recruitment of eels in Lake Poso. Steps toward the culture of elver has been tried by the Fisheries Department but not successful yet and there are several obstacles to be overcome.

A population of larger elvers with a size of < 5 cm and with a pigment has been observed in the rivers that flows downstream into the Poso River. This was observed in the Kayamanya during August 1997 but during the May 1998 observations not a single elver was met. There was a great change of the river bed typology due to the construction of a new concrete wall along the river sides which was designed to straighten and increase the water flow. By this structure the elvers is backwashed to the sea during flooding time. Up till now it is not clear yet on the duration of the elvers stay along the estuary and at what length it started to migrate upstream to Lake Poso. Eels with a length of less than 50 cm has never been found in the river as well as the lake which need further observations.

A total of 46 eels with a length ranging between 57-140 cm and a range of weight between 333.8-6600.0 g has been measured (Table 1). The eel's gonad formed a lamella or a ribbon with a light red or pink color with one pair elongated on the dorsal abdominal.

The observed eel has developed as well as undeveloped gonads. The undeveloped gonad with a weight of less than 5 g was observed in eels of less than 73 cm in length, while the developed gonad was observed in eels with a length of more than 73 cm found in Lake Poso. Undeveloped gonad is characterized by a cyst or a group of oogonia less than 10 μm in size. Developed gonad was observed in female with many oocytes vitellogenic cells with a diameter of 150-170 μm. The oocytes cytoplasm of the cells is heterogen with well distributed cortical vesicular inclusion. The observed composition

and size of oocytes in the ovary is homogenous.

Based on histological analyses of the liver, some are very basophylic based on the magenta color with PAS coloring and contain a lot of glycogen which was found in eels with developed gonads. On the contrary eels with undeveloped gonads contain pale colored cells with little glycogen and a liver weight of less than 5 g.

Table 1. Body parameters, GSI, and HSI values of eels from Lake Poso.

Parameter	Range	Average
Body length, cm	57 - 140	97.77
Body weight, g	333.8 - 6,600	3,523.16
Gonad weight, g	2.0 - 253.0	89.46
GSI, %	0.33 - 3.83	2.22
Liver weight, g	1.0 - 66.5	33.44
HSI, %	0.29 - 1.35	0.78

Values of GSI and HSI less than 1% were found in eels with undifferentiating gonochoristic gonads.

Discussion

Eel fish is classified as gonochoric which means that at a stage they don't show a clear sexual distinction, at the juvenile stage the gonad does not show a clear male or female status. The gonad will further develop into some sort of ovarium where in half of the individuals it will transform into an ovarium and the rest become testis (Efendie, 1997). They show crenulated ribbon-like gonads that were classified as females and narrow lobed (scalloped) gonads as males (Frost, 1945; Bertin, 1956 cit Poole & Reynolds, 1996).

All eels that was collected in the Poso area was over 57 cm in length and its gonad has differentiated to ovarium and testis, compared to European eels which according to Colombo & Grandi (1996) observations, has differentiated after gaining a body length of 22 cm.

Developed gonads were only met at female individuals as proven by the oocytes vitellogenic, while spermatocytes was not seen in the male individuals. In European eels that are migrating to the sea the gonad consist of oocytes at the early stage of vitellogenesis with a GSI value between 1-2%, while the male eels contain testis with gonia cells with a GSI value of 0.1% (Dufour, 1994). It was also reported that the gonad development ceased during a certain stage while the migration to the sea does not occur. The next phase is unknown in natural stage (gonad maturity, spawning, or dead) because it occurs in deep sea. It was concluded that environmental factors are very dominant in the ripening processes and spawning.

From GSI values it can be concluded on the fish gonad developments stages. During migration in the Poso area the GSI value range between 0.33-3.83%. Values of less than 1% shows that the gonad has not developed which is also shown by histological analyses where only gonia cells are in the gonad. In eels where the gonad has begin to develop, the GSI value is above 1%. According to Bursawa-Gerard (1994) values of

GSI of 0.3-0.8% is considered immature while 1.2-2% is mature. Individual eels with gonads that has not developed found together with groups of developed gonads with high GSI values was also found in European eels (Fontaine, 1994).

Eels living in the other continent that is ready for migration to the sea for reproduction have a variation in GSI values. Silver European eels that is ready for migration has the lowest GSI value which is only 1.5-2%, while American, Japanese, and Australian eels is 3-5%, and highest in New Zealand eels (*A. dieffenbachi*) which is up to 9%. These differences might have a relation with the distance between living area and spawning, where *A. anguilla* are eels with the longest migration track (Todd, 1981 in Dufour, 1994).

The liver organ takes part in the reproduction process especially in the formation of oocytes. The cells of the liver of eels that started migration from Lake Poso shows active metabolism as shown by carbohydrate accumulation in the form of glycogen in the liver cells. The glycogen is needed as energy reserve during the gonad developments and migration activities because during migration eels do not have feeding activities. The liver organs take active part in the vitellogenesis process that is the egg or oocytes formation (Ng & Idler, 1983). In salmon and alose fish during endogenous vitellogenesis, the hepatocyte contain cytoplasm that is rich with glycogen and lipid, and the exogenous vitellogenesis process causes an increase in the specific gravity of the female liver that constantly decreases to the spawning site (Haryani, 1992; Medford & Mackay, 1983).

During migration activity of the liver organ of the eel also developed with an important high weight of 66.8 gr. and also shown in the ratio with body weight (HSI) up to 1.35%. This weight increase is caused by accumulation of glycogen and lipid that is prepared for reserve energy during migration and gonad developments. Wingfield & Grimm in Delahunty & de Vlaming (1980) found that the highest HSI values was found during pre-spawning stage and lowest in post-spawning stage in *Pleuronectes platessa* fish. In the field a 73 cm eel was found in the Poso River that contain gonad that has not developed and a liver that does not show metabolism activities with a HSI of only 0.2%. This shows that eels do not prepare energy reserve for migration purposes that occur without feeding. Fontaine (1994) explained that these eels "take risk" because they do not have good preparation for thousands of km travel to the deep sea with a length of time without feeding.

Conclusion

Eels from Lake Poso during the time of migration of the year in May to August consist of two groups based on their preparation for migration. The first group are individuals that contain gonad that have developed as shown by the oocytes vitelogenic cells, active metabolism of the liver organs, and a GSI and HSI of over 1%. The other group consist of eels that contain gonads that has not developed and consist only of gonia cells, not active liver cells, and low GSI and HSI values.

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