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SIZE AT SEXUAL MATURITY AND SEX
REVERSAL OF THE COMMERCIALY
IMPORTANT GROUPER,
Plectropomus leopardus
(SERRANIDAE)

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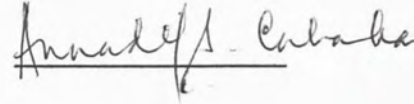

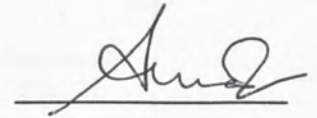
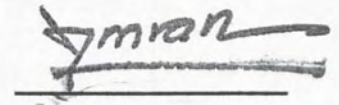
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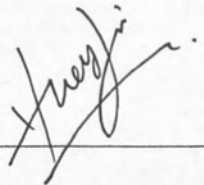
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DECLARATION

I would like to declare that this dissertation is my original writing, except the data, notes and facts that already stated with its resources and origins.

21 February 2005



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ABSTRACT

Serranidae or commonly called groupers or *kerapu* are economically important in Malaysia and in Southeast Asia in the Live Reef Food Fish Trade but scientific information on this family of coral reef fishes in Malaysia is poor. I studied the onset of sexual maturity and sex reversal of *Plectropomus leopardus*, a commercially important serranid that grows to a maximum size of 80 cm SL and is a protogynous species. Samples were from Kudat Fish Market during the period August to December, 2004. Standard measurements were taken on the samples and the gonads were examined macroscopically for sex and histologically for sexual maturity and sex reversal. Sex reversal of *P. leopardus* occurs earlier than expected at less than 60 % of SL and 80 % of SL, respectively. *P. leopardus* in Sabah attain sexual maturity at 38 cm SL and changes sex at 46 cm SL (58 % of maximum size). The earlier sex reversal may be an adaptation to the high fishing pressure on the *P. leopardus* populations in Sabah and requires a management response. More samples and further studies on stock, migration, and spawning aggregations are needed to gather a complete scientific understanding of the species for management. However, the reproductive information in this study could be used in a precautionary approach in establishing biological regulations (e.g., allowing exploitation of fish at least 50 cm SL) for the conservation and sustainable use of this marine resource.



ABSTRAK

Serranidae atau kerapu merupakan ikan yang mempunyai nilai ekonomi yang tinggi di Malaysia dan Asia Tenggara dalam Perdagangan Ikan Karang tetapi maklumat tentang famili ini dan iakan karang yang lain di Malaysia adalah sangat terhad. Kajian saya adalah mengenai kematangan seks dan perubahan seks pada ikan *Plectropomus leopardus*. Ikan ini mempunyai panjang yang maksimum 80 cm SL dan merupakan spesies protoginus. Sampel dikumpul dari Kudat dari bulan Ogos hingga Disember, tahun 2004. Pengukuran piawai telah dibuat atas sampel dan gonad telah dikaji secara makroskopi dan histologi untuk menentukan seks, kematangan dan perubahan seks. Perubahan seks bagi *P. leopardus* muncul lebih awal daripada yang dijangkakan (80 % kepanjangan maksima) iaitu kurang daripada 60 % SL. *P. leopardus* di Sabah mengalami kematangan seks pada panjang 38 cm SL dan berubah seks pada panjang 46 cm SL (58 % daripada kepanjangan maksima). Perubahan seks yang awal mungkin disebabkan ketekanan penangkapan *P. leopardus* yang tinggi di Sabah. Sampel yang lebih diperlukan untuk kajian yang selanjutnya dalam stok, migrasi dan bentuk pembiakan untuk mengadakan kefahaman pada spesies ini serta memudahkan pengurusanannya. Walaubagaimanapun, maklumat dalam kajian ini dapat memberikan cadangan dalam pendekatan untuk mengadakan regulasi biologi untuk pemuliharaan dan kemantapan dalam sumber alam marin.



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CHAPTER 1

INTRODUCTION

1.1 Background

Sabah is a rich maritime state with strategic geography features that suitable for fisheries development especially for the live fish trade. This is because more than three quarters of its boundaries surrounded by the sea. The South China Sea on the west coast, Sulu Sea on the northeast coast, and Sulawesi Sea on the southeast coast of Sabah. It has a longest coastline around 1,440 km and the total territorial water cover around 55,000 km².

According to the Sabah Fishery Department (2002), marine fish product has become most significant product in fishery sector of Sabah in year 2002. Marine fish product for year 2002 attained around 149 million tonne with 79.95% of the total fish product in year 2002. The wholesale value for marine fish product was RM 415 million with wholesale value for total fish production in Sabah was RM 756 million (Refer to Appendix A, Table 1.1).

The live fish trade in Sabah play a very important role not only in local market but also in others country. The live fish especially commercially important fishes such



as groupers not only found in the local market of Sabah but also export to others country such as Hong Kong, Singapore, Taiwan, and Japan (Tropical Research and Conservation Centre, 2001). Sabah Fishery Department (2002) reported that Japan is the country import the most fish from Sabah with figure 13, 053.10 metrics tons. The total value earned from exportation worth around RM 445 million in year 2002 (Refer to Appendix A, Table 1.2).

Although groupers are not the highest amount of marine fish that landing in Sabah but it is the most valuable among the others species. Total landing of groupers in year 2002 was 3970.69 metrics tons worth RM 52 million in whole Sabah. The highest amount of groupers landing in Sabah is Kudat with 1, 044.31 metrics tons. According to the statistics report of Sabah Fishery Department (2002), Kudat is the highest region that brought in around RM 34 million or 65.16% of total value of groupers in Sabah for year 2002 compare with the others region.

This study is focus on one of the commercially important groupers, *Plectropomus leopardus* (Family Serranide) (Refer to Appendix C, Photo 1.1). *P. leopardus* commonly called as coral trout or in the local language, *kerapu merah*, *kerapu bara* or *sunoh*. *P. leopardus* is one of the groupers that are always found in local market with various sizes. This fish is very popular in local market especially for seafood restaurant and also others country, it has a high market price compare with others groupers.

Production of grouper still depend on wild capture although grouper aquaculture has been develop almost two decades in sixteen different countries



include Malaysia. People still have to pay high prices for species that cannot be supplied by hatcheries. *P. leopardus* is one of the groupers that failed to be hatched. Nevertheless, people seem to be biased to the wild caught groupers than the hatchery groupers and willing to pay more to get the wild caught groupers.

This study on *P. leopardus* is based on the sample from Kudat in Sabah. Kudat is the second largest coral reef region in Sabah (Refer to Appendix B, Figure 1.1). Kudat's fish market is one of the most important live fish trades in Sabah because of the strategic location. Productivity of coral reef fish in Kudat is very high because there are large distributions of coral reef in Kudat especially around Banggi Island so fishing on coral reef fish is very active in Kudat.

Thus, coral reefs in Kudat have been damaged by unsustainable fishing practice such as blast fishing and cyanide fishing. Coral reefs are the important habitat of coral reef fish, by destroying the habitat, the abundance of coral reef fish will seriously decrease. Coral reef not only provides food for human, but it support over twenty five percent of known marine species. Destroying the coral reef mean to destroy the important biodiversity of the global and the most productivity ecosystem.

According to the survey by Tropical Research and Conservation Centre (2001), there are around 99% of reef fish species disappeared from coral reef in Sabah compared to non fishing coral reef zone. *P. leopardus* is one of the reef fish that seriously decrease around 97.26% in population. The numbers of *P. leopardus* that caught by fishers in Kudat decreased from 123 individuals in March, 1999 to 45 individuals in October, 1999 and closed operations from January, 2000 (Tropical



Research And Conservation Centre, 2001). This data showed that *P. leopardus* are facing condition of over fishing in Kudat. Others seriously over fishing groupers include *Cephalopholis argus* (Peacock grouper), *C. miniata* (Coral grouper), *Epinephelus polyphekadio* (Camouflage grouper), *P. laevis* (Saddleback grouper), *P. areolatus* (Squartail coral trout) and so on (Tropical Research And Conservation Centre, 2001) (Refer to Appendix A, Table 1.3).

This study will focus on the reproductive biology of *P. leopardus*. This study is important because there are none of this kind of study had been conducted in Sabah. Through this study, we can know the reproductive cycle of *P. leopardus* especially the maturity and the sex change of this fish. Beside that, with this study we will know the fishing pressure on commercially important *P. leopardus* and to avoid local extinction occur because of over fishing. There are a lot of studies that related to spawning aggregation, abundance and size structure, captive technique and other on groupers that conducted in others country (Russ *et al.*, 1996) but less in Sabah.

As we know, most commercially important coral reef fish such as groupers and wrasses are easily affected by fishing pressure because of its long life and reproductive behavior (Queensland, 2003). Over fishing may cause the reproductive behavior of these important coral reef fish to be changed. With great demand of large coral reef fish in live fish trade, large individuals may be fished out of the populations. This could be detrimental in the populations of fishes by taking out large individuals over a long period of time and may cause the loss of the genetic characteristic for large sizes fish. This condition will cause reproductive fitness of reef fishes decrease because lack of either female or male fish. There may be also local extinction occur on



this commercially important coral reef fish. Over fishing on coral reef fish will affect the balance of reef ecosystem and it will endanger the long term sustainability of fishing and other reef-dependent industries (The Coral Reef Alliance, 2003). To avoid over fishing and cause stock of reef fish collapse, conservative management must be taken as soon as possible to protect our reef ecosystem (Coleman *et al.*, 2000).

1.2 Study Objectives

There are two main objectives in this study. First is to find out the size of *P. leopardus* attain sexual maturity in Sabah. The assumption of first objective is *P. leopardus* commonly attain sexual maturity around 35cm (SL). The second objective of this study is to find out whether sex reversal of *P. leopardus* occurs when fish is at 80% of known maximum size. The maximum size using in this study is 80cm (SL) so the assumption of second objective is 64cm (SL).



CHAPTER 2

LITERATURE REVIEW

2.1 Coral Reef

Coral reef are one of the most colorful and complex ecosystem in tropical region. It grow in the neritic zone of ocean that are high temperature, high penetrate of sunlight for photosynthesis and currents and waves constantly renew nutrient supplies to the reef (Campbell and Reece, 2002).

Coral grow at different rates depend on water temperature, salinity, turbulence and the availability of food resources. The massive corals species are the slowest growing species but branching and staghorn can grow very fast. Because of slow growing character, damage of coral reef can be recovered only in long period.

Coral reef supports over twenty five percent of known marine live. In tropical seas, coral reef provide habitat for a great diversity of invertebrates and fishes with over four thousand species of fish, around seven hundred of coral and thousand of others plant and animal.



2.2 Coral Reef Fish

Coral reef fish are the fish that live associate with coral reef. Coral reef are home of thousand species of fish. The extraordinary beauties of the coral reef fish make the coral reef become the most attractive ecosystem in the world. The Great Barrier Reef in Queensland, Australia is the famous coral reef region in the world.

Reproductive of coral reef fish especially long live reef fish are very complex. Although some of the reproductive biology such as sex reversal, spawning aggregation that generally study in many country such as Great Barrier Reef in Queensland, Australia but further research is needed too.

2.2.1 Maturity of Coral Reef Fish

Coral reef fish will attain maturity stage when they reach certain sizes depend on their species. For example, female black grouper will mature only when they reach 32 inches long. *Epinephelus tukula* (potato grouper) reach maturity at 90 cm (SL) and fully mature female attain 95.5 cm (SL) (Yeh *et al.*, 2003).

Daniel Pauly (1984), fishes tend to grow very fast until they reach the first maturity stage. They will grow slowly after that because all the energy they gain have move to the development of their reproduction system. Table 2.1 show a few groupers species that have been reported about their standard length for first maturity of females.



Table 2.1 Standard length (SL) of sexual maturity in female groupers.

Species	SL (cm)
<i>Epinephelus alexandrinus</i>	27.0
<i>E. areolatus</i>	19.0
<i>E. aeneus</i>	40.0
<i>E. diacanthus</i>	12.5
<i>E. guaza</i>	36.0
<i>E. maculatus</i>	31.0
<i>E. microdon</i>	34.0
<i>E. rhyncholepis</i>	23.0
<i>Cephalopholis cruentatus</i>	14.0
<i>C. striata</i>	10.0
<i>Plectropomus leopardus</i>	30.0

(Source: Ha, 2003)

Female fish maturity stage can be clearly defined by whether the oocytes are vitellogenic or previtellogenic (Samoilys, and Roelofs, 2000) by using histological examination. Vitellogenic mean mature and previtellogenic is conditions before or nearly mature. There are five common stages in determine the maturity of female fish. The first stage is immature stage with no signal of spawning. Second stage is resting stage; third stage is ripe stage or mature stage. The last two stages are running ripe stage and spent stage. Tables 2.2 in Appendix A contain all the characteristic of gonadal development stages for *Plectropomus leopardus*.

There are another two stages after the female fish reach the fifth stage, the transitional stage and bisexual stage. The bisexual stage was very rare and has not been documented for *P. leopardus* before (Samoilys, and Roelofs, 2000).



When fish transform into male, there are two stages are defined, incomplete male and complete male. Incomplete male refers to fish that just success to change sex from female to male (Refer Appendix A, Table2.3).

Another method to determine the maturity stage is using the eggs in the fish's ovary but these require sample of eggs that taken from the fish. The diameter and appearance of the egg and the position of the nucleus in the egg are visual indicators of development (Ha, 2003).

2.2.2 Reproductive Mode of Coral Reef Fish

There are a few types of character that perform by coral reef fish in their life history. Fishes that born to be particular sex are call gonochoristic. It means that gonochoristic fish cannot change sex in their whole life, they will maintain to be one sex only.

Many coral reef fish such as groupers, wrasses and sea bream are able to change sex when they reach certain period of adult live. The term change sex can also term sex reversal. Fish that able to change sex will perform one particular sex either male or female and change to opposite sex for the rest of their live when they reach the maturity stage.

Hermaphroditic marine fish represent the fish that have both sexes in their life. Hermaphrotism is the condition for an individual to have both female and male reproductive function (Campbell and Reece, 2002). There are sequential and simultaneous hermaphroditism fish. In sequential hermaphroditism fish, fish that



change sex from female to male call protogynous hermaphrodites. Groupers are one of the examples for protogynous hermaphroditic fish. On the other hand, fish that change sex from male to female call protandrous hermaphrodites. The sexual maturity of sequential hermaphroditism fish mature in the different period while simultaneous hermaphroditism fish mature at the same time in one individual.

The causes of sex change have been studied in small and territorial reef fish such as labrids, pomacentrids and Anthenii serranids, sex change in these species is control by their social behavior (Tupper, 1999). In fresh water fish, sex change occur genetically depend on their age and size. In some grouper, sex change will occur only when they reach age ten, for *Epinephalus morio* (red grouper) sex ratio is not equal until age fifteen (Tupper, 1999).

Some species of wrasses and parrotfish separate into two stages of male, primary male and secondary male. Fish will bear to be male then change sex into female when they reach certain sizes and change again into male. Primary male refers to first time to be male fish and secondary male refers to the second time fish change sex from female to male.

Another interesting trait is some of the coral reef fish such as *Pseudochromis* species show sexual dimorphism in their coloration, size and body shape (Brons, 1996). Fishes with sexual dimorphism can easily identified their sexual either male or female because they are different in morphological form. Those species that show only differences in coloration are sexual dichromatism. The fish that show difference morphologic only when they breed are called temporarily dimorphic or dichromic. In



the other hand, fish that differences morphological according to their sex are call permanently dimorphic or dichromic. The species such as groupers and wrasses that do not have this type of characteristic are call monomorphic fish.

Gregory (2004), spawning aggregations is the behavior that commonly found in coral reef fish. There are around twenty one families of tropical coral reef fish form spawning aggregation. Group of fish from same species will group together and move to their spawning site during spawning season. In family Serranidae, not all groupers spawn in group. Many large coral reef fish form spawning aggregation during spawning season such as groupers (Serranidae), snappers (Lutjanidae), parrotfish (Scaridae) and surgeonfish (Acanthuridae) (Society for the Conservation of Reef Fish Aggregations, 2000). Among commercially important species that form spawning aggregations, grouper populations have drastically declined in the Caribbean and *Epinephelus itajara* and *E. striatus* are now listed as endangered spesies by the IUCN (Heyman *et al.*,2002) .

2.3 Groupers

The word grouper is from Portuguese “garoupa” means perch-like fishes. Groupers are the members from one of the largest teleost fish family, Serranidae. Members of family Serranidae include sea basses and hamlets. There are more than three hundred species of Serranid over the world (Florida Marine Research Institute, 2001).

Groupers are long live, large and chunky fish. Large groupers may be live over 50 years old. Some species of groupers can even live over 120 years. Because of long



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