PARASITES AS POTENTIAL STOCK MARKERS FOR TUNA IN INDONESIAN WATERS

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ABSTRACT

Tuna fish are highly migratory species. Clarifying their stock structures and migration patterns is important for tuna fisheries management. The purpose of this research was to examine the parasites of bigeye tuna (Thunnus obesus) and yellowfin tuna (Thunnus albacares) to determine which parasites may be potential stock markers for assessment of tuna migration patterns. Bigeye tuna and yellowfin tuna were collected (measured between 28-48 cm fork length) from 9 sites across Indonesia and from 2 'outlier sites' (The Maldives and Solomon Islands). Organs including gills (filaments and branchial arches), stomach wall, liver, pyloric caeca, and intestines were examined. Seven types of didymozoids were distinguished including 3 Didymosulcus spp., 4 Kollikeria spp. and one acanthocephalan (Bolbosoma sp.). The results suggest these fish parasites are potentially useful markers for assessment of tuna migration pattern, contributing information needed for fisheries management in Indonesia.

Keywords: Tuna; parasites; stock markers; Indonesia

INTRODUCTION

Indonesia's pelagic fisheries resources are important to the nation's economy and as a domestic food resource. Two species of tuna important to Indonesia and to neighbouring countries in the Indian Ocean (IO) and Western and Central Pacific Ocean (WCPO) regions are yellowfin tuna (YFT), *Thunnus albacares,* and bigeye tuna (BET), *T. obesus.* Recent stock assessments for these species suggest YFT in both regions and BET in the IO are marginally exceed the MSY, but that BET in WCPO are exceeding the MSY and the catches may be unsustainable (Davies *et al.*, 2014; Harley *et al.*, 2014; IOTC-SC 16, 2013). However, the assessment neglected the stock structure. The existing assessments based on the assumptions of single panmictic spawning populations of YFT and BET within the IO and WCPO. However, some recent studies suggested there may be discrete meta populations across the range (Dammannagoda *et al.*, 2008; Nugraha *et al.*; 2011, Wells *et al.*, 2011; Fraile *et al.*, 2013; Swaraj *et al.*, 2013). The results from tuna tagging programs in the IO and WCPO also suggest that the movement/mixing rates of YFT and BET may not be as high as previously thought (Hoyle *et al.*, 2013). If populations are discrete, or mixing rates are low within a panmictic population, some populations (or sub-regions) could be susceptible to local over-exploitation and improper management decisions.

The use of parasites as biological tags in population studies of marine fish has increased (MacKenzie *et al.*, 2008) because parasite data are relatively inexpensive to collect and the method was globally accepted to identify stock (Lester, 1990; Begg & Waldman, 1999). If the parasite fauna of fish from two areas was similar, so we construed that the fishes either have grown in a similar environment or have a common history. Where the fauna is different, the histories of the fish are different according to the time scale of the parasites present: recent history for parasites with short residence times in the fish, long-term history for parasites that have remained in the fish for an extended time (Lester, 1990). Methods used to analyse such parasite data are becoming increasingly sophisticated (MacKenzie & Abaunza, 1998; Perdiguero-Alonso *et al.*, 2008).

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The Didymozoidae is a major family of trematodes which have radiated in pelagic fishes, especially tunas (Scombridae) (Pozdnyakov & Gibson, 2008). Adult didymozoids found mainly in the tissues of their hosts rather than in the gut lumen. They must therefore be sought specifically through the examination of the tissues where they reside. Another key feature of the family is that the adults retain eggs in the uterus (typically, it is thought, to be dispersed only when the parasite dies), which has the effect of making most didymozoids bright yellow. Many didymozoids form pairs and in some cases there is sexual differentiation into males and females; it is best to keep such pairs together and separate from other individuals so that they can be described as a pair. Many didymozoids are thread-like and may reach lengths in excess of a meter (e.g. Noble, 1975). Such species are challenging to work with. They can only be collected by slow and pain staking dissection of the surrounding tissues. This research aims to investigate parasites as a potential marker to examine the population structure and rates of mixing of YFT and BET across the Indonesian archipelago and connectivity to populations in adjacent ocean regions.

MATERIALS AND METHODS

BET and YFT were sampled from at 9 locations across Indonesia, namely Padang, Prigi, Palabuhanratu, Bitung, Gorontalo, Kendari, Ambon, Sorong, and Jayapura (Figure 1). They were obtained directly from fishing vessels at time of landing, from local fish markets, and from distribution companies when the catch where the origin could be traced. Gills and viscera were removed, placed into individual plastic bags with a label giving site location, date and time of capture and caudal fork length (FL), and then frozen for later laboratory examination. Additional samples of BET and YFT were collected from two 'outlier' locations, the Maldives and the Solomon Islands.
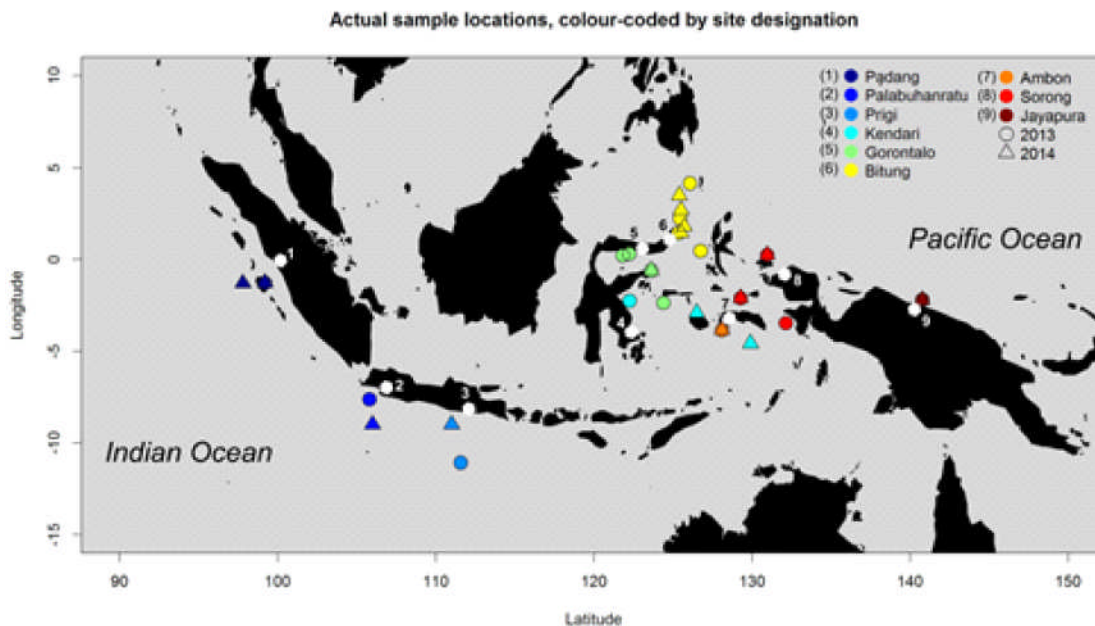

Figure 1. Map showing the Indonesian sampling ports (white symbols) and respective catch locations as understood from the fishermen.

In the laboratory gills and viscera were thawed and dissections carried out according to the methods of Lester *et al.* (2001). The gill arches were opened and the external and internal gill surfaces examined under a dissecting microscope to find didymozoids. The viscera were separated into stomach, pyloric caeca, intestine and liver. Each organ was placed in an appropriately-sized petri dish and examined progressively under a stereomicroscope. Separation of organs allowed for a clearer examination and also for the accurate recording of the site of infection. Any parasites found were removed and preserved in 70% alcohol for identification using stereo and compound microscopes and keys and other identification guides for parasites.

RESULTS AND DISCUSSION
Results

Ten types of parasites were found in the organs of BET and YFT: 3 types of *Didymosulcus*, 4 types of *Kollikeria*, *Hirudinella ventricosa*, *Bolbosoma sp.* and *Rhadinorhynchus sp.* (Tables 1). Of the 10 types, 8 appear to be suitable as biological tags. These include the 7 didymozoids (*Didymosulcus* spp. and *Kollikeria* spp.), and an acanthocephalan (*Bolbosoma* sp.).

Table 1.   Various parasites identified from organs of BET and YFT

BIGEYE TUNA AND YELLOWFIN TUNA		
Parasites	**Type**	**Organ**
Didymosulcus sp.	type 1	Gill
Didymosulcus sp.	type 2	Gill
Didymosulcus sp.	type 3	Gill
Hirudinella ventricosa		Stomach
Kollikeria sp.	type 1	Stomach wall
Bolbosoma sp.		Stomach wall
Rhadinorhynchus sp.		Stomach wall
Kollikeria sp.	type 2	Liver
Kollikeria sp.	type 3	Pyloric caeca
Kollikeria sp.	type 4	Intestine wall
Rhadinorhynchus sp.		Intestine wall
Bolbosoma sp.		Intestine wall

The 3 types of *Didymosulcus* found in gill arch and filament. *Didymosulcus* type 1 was comma shaped and found in pairs, embedded in the filaments of a gill arch (Fig. 2). Type 2 were elongated (Fig. 3) and Type 3 were more rounded (Fig 4).
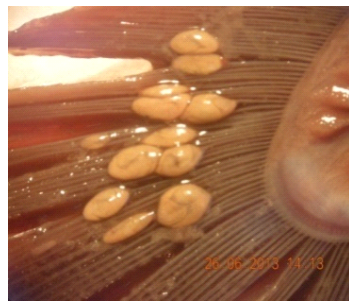

Figure 2. *Didymosulcus* type 1, a didymozoid *in situ* in the gills.
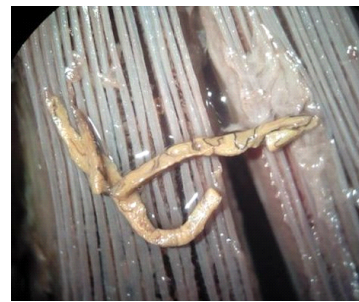

Figure 3. *Didymosulcus* type 2, a didymozoid *in situ* in the gills..

Figure 4. *Didymosulcus* type 3, a didymozoid from the gills.

Figure 5. *Kollikeria* type 1, a didymozoid from the stomach wall.

Figure 6. *Kollikeria* type 2, a didymozoid *in situ* in the liver.

Figure 7. *Kollikeria* type 3, a didymozoid from the pyloric caeca.

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Figure 8. *Kollikeria* type 4, a didymozoid from the intestine wall.

Figure 9. Giant worm, *Hirudinella ventricosa* from the stomach.

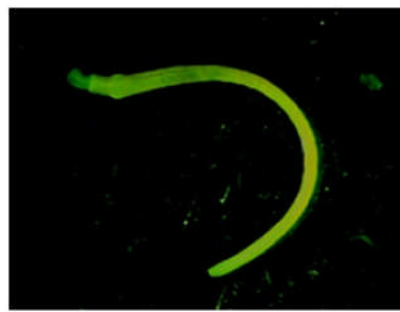Figure 10. Adult *Rhadinorhynchus* sp. from the intestinal lumen.

Figure 11. Juvenile *Bolbosoma* sp. from wall of intestine.

Four types of *Kollikeria* were found in the viscera. Type 1 from the stomach wall was a globular female within which was a small male (Fig.5). Type 2 were generally found in groups in the liver (Fig. 6). Type 3 were a large species with an elongate shape found in the pyloric caeca (Fig. 7). Type 4 were a small species found in the intestinal wall (Fig.8).

In addition to didymozoids, the giant worm *Hirudinella ventricosa* (Fig. 9) and 2 genera of Acanthocephala were found in the stomachs. Adult *Rhadinorhynchus sp.* were found in the intestinal lumen (Fig.10). Immature *Bolbosoma* sp. were generally embedded in the wall of the intestine (Fig. 11). They had a distinct bulge near the proboscis covered with a broad band of small hooks. A second band occurred on the body between the bulge and the proboscis.

Discussion

Preliminary identifications of the parasites were done using morphological characters (Pozdnyakov & Gibson, 2008). Future DNA sequencing may show whether the same species of parasites inhabit in both tuna species, or indeed whether the same species of didymozoid lives in different places in the same fish.

The genus *Didymosulcus* is specific to the family Scombridae and almost specific to tuna. They are considered a potentially dangerous parasite for species of tuna, little tuna and mackerel around the world (Williams & Williams, 1996), though these and the other parasites are all harmless to humans.

Didymozoids such as *Didymosulcus* and *Kollikeria* spp. are thought to release eggs and degenerate when the host fish matures. The probable life cycle involves eggs released from fish being eaten by a pelagic snail. Tiny cercariae develop in the snail and are eventually released into sea water. A cercaria is thought to be eaten by a planktonic copepod, the copepod eaten by small fish and then the small fish is eaten by a tuna.

Seven types of didymozoids and the acanthocephalan *Bolbosoma* sp. were embedded in host tissue and are considered suitable as biological tags. Parasites have proved useful as biological tags for discrimination of fish stocks and evaluating migrations because during migrations fish move with their parasites (Sinderman, 1961; Gibson, 1972; Wickings & MacFarlane, 1973; Mackenzie, 1983, 1986; McGladdery & Burt, 1985; Butorina & Shedko, 1989; Mackenzie, 1990; Moser & Hsieh, 1992). As noted by Bailey *et al*. (1988) and Lester (1990), the geographical variation of the distribution and abundance of parasites is an excellent source of information for examining movements and population structures of marine fishes.

The most suitable parasites are those embedded in the tissues rather than those 'free' in the lumen of the gut. Those in the lumen could have a limited

residence time in the fish compared with those embedded in tissues. Other stock discrimination studies have focused on juvenile anisakid nematodes or juvenile trypanorhynch cestodes which appear to be more or less permanent within the fish once the fish is infected. These were rare or absent from the fish dissected in this study. The residence time of didymozoids is unknown but those in tuna are thought to release their eggs and degenerate only when the fish matures. If only juvenile tuna are examined as in this study, it could be assumed that once a fish has been infected by a didymozoid the fish will stay infected until examined. Thus the didymozoid parasites here could be considered long-term residents in the fish.

CONCLUSION

There is seven types of didymozoids (3 *Didymosulcus* spp. and 4 *Kollikeria* spp.) and an acanthocephalan (*Bolbosoma* sp.) appear suitable as biological tags since their long residence time in the fish. Information on the distributions of these parasites may help to discriminate between tuna stocks in Indonesian archipelagic waters and thus provide information useful to those managing Indonesia's tuna fisheries.

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