THE SELECTION OF PARASITES FOR USE AS BIOLOGICAL TAGS IN POPULATION STUDIES OF BLUEFIN TUNA

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SUMMARY

This paper describes a systematic approach to the selection of parasites for use as biological tags to trace bluefin tuna, *Thunnus thynnus* (L.), caught in different parts of the North Atlantic, to their nursery areas of origin. A number of selection criteria are proposed for assessing the value of any parasite for this purpose. The dominant components in the parasite fauna of piscivorous pelagic teleosts are indicated by referring to published host-parasite lists. It is recommended that special attention be paid to trypanorhynch cestode larvae and juvenile acanthocephalans, which are likely to infect juvenile, rather than adult, bluefin and to have long life spans.

RESUME

Le présent document décrit une méthode systématique de procéder à la sélection de parasites destinés à servir de marqueurs biologiques pour définir le lieu d'origine du thon rouge, Thunnus thynnus (L.), capturé dans divers secteurs de l'Atlantique nord. Un certain nombre de critères sélectifs sont proposés pour évaluer l'utiliter d'un parasite à cet effet. Les principaux composants de la faune parasitaire des téléostéens pélagiques ichthyophages sont indiqués par référence aux listes publiées sur les parasites/hôtes. Il est conseillé de prêter une attention spéciale aux larves de cestode trypanorhynch et aux acantocéphales à l'état juvénile, qui probablement se fixent sur les thons rouges juvéniles, de préférence aux adultes, et ont un cycle vital prolongé.

RESUMEN

Se describe un planteamiento sistemático de la selección de parásitos que actúan como marcas biológicas, para seguimiento de ejemplares de atún rojo *(Thunnus thynnus)*(L.),capturados en distintas zonas del Atlántico Norte, para conocer su lugar de origen. Se proponen varios criterios selectivos, para considerar el valor de cualquier parásito respecto a este propósito. Los componentes dominantes de la fauna parasitaria de teleósteos pelágicos piscívoros, se relacionan en listas publicadas de huésped-parásito. Se recomienda que se preste especial atención a las larvas del cestodo tripanorhynchus y acantocéfalos juveniles, que al parecer tienen más tendencia a infectar a los juveniles que a los ejemplares adultos de atún rojo, y poseen un ciclo vital más extenso.

INTRODUCTION

The purpose of this paper is to offer a guide to the selection of parasites which are likely to make good biological tags for following migrations of bluefin tuna, Thunnus thynnus (L.), in the North Atlantic. The approach adopted is that of MacKenzie (1982), who recognised four main types of fish population study: stock separation, seasonal migrations, recruitment studies and adult age-dependant migrations. These four types differ in the particular aspects of migration which they investigate and in the groups of parasites which are likely to provide the best biological tags.

Anon. (1979) and Walters (1980) described two probable stocks of North Atlantic bluefin. One spawns in the Gulf of Mexico and immature fish range from the Gulf along the eastern seaboard of the United States. The other spawns in the western Mediterranean basin and immature fish are found in this area and in adjacent waters of the eastern Atlantic. The problem addressed in this paper is that of tracing adult bluefin caught in different parts of the North Atlantic to their eastern or western areas of origin. This is probably best considered as a recruitment study, but may also be considered as a study of seasonal migrations, since adult fish of this wide-ranging species presumably return to the same spawning area annually.

SELECTION CRITERIA FOR A RECRUITMENT STUDY

The following criteria are proposed for selecting parasites of potential use as biological tags for a recruitment study of bluefin tuna.

1) The parasite should have significantly different levels of infection in the subject host in different parts of the study area. (This does not apply where genetic differences between populations of the same parasite species are being investigated.)
2) No ectoparasite which is easily detached, leaving no evidence of its past presence on the host, should be considered, as these may be lost during capture and handling.
3) The method of examination should involve the minimum of dissection. A high degree of site-specificity on the part of the parasite is an advantage. Large numbers of host specimens usually have to be examined and time can become a limiting factor.
4) The parasite should be easily detectable and identifiable, otherwise the chance of missing an infection may be too great to justify its use.
5) The parasite should have no marked pathological effects on the subject host. A highly pathogenic parasite may cause selective mortalities or behavioural changes in infected fish which will reduce its value as a tag.
6) The parasite must infect young fish on the nursery ground. Ideally the fish should not be susceptible to further infection as adults. If they are, research may be aimed at identifying parts of the study area within which infection by the parasite cannot occur either because environmental conditions are unsuitable or because of the absence of suitable hosts for other stages of the parasite's life cycle.
7) The parasite must have a life span extending well into the fish's adult life. For long-lived species like bluefin, this means that the life span of the parasite in the subject host must be several years.

In general, parasites with direct single-host life cycles, such as protozoans, monogeneans and most crustaceans, do not make the best tags for recruitment studies because of the possibility of continuing cross-infection from one fish to another after they have left the nursery area. The best tag parasites for recruitment studies are more likely to be found amongst helminth parasites which have different developmental stages in at least one other host. Larval forms which have the fish as a second intermediate, transport or paratenic host are likely to have the longest life spans.

SELECTION CRITERIA FOR A STUDY OF SEASONAL MIGRATIONS

Criteria 1 to 5 above apply equally to studies of seasonal migrations as to recruitment studies, but 6 and 7 do not apply.

Since the time scale for a seasonal migration study is less than one year, the range of parasite species from which tags may be selected is not restricted to those with long life spans. Apart from criteria 1 to 5 quoted above, the basic requirement is that a parasite can infect the subject host in one area only within the migratory range. For bluefin this means a parasite which can infect adult fish in one or other of the spawning areas but not in both, or which can infect them only in some other well-defined area of the North Atlantic. The greatest disadvantage in using a parasite with a short life span as a tag is that the

proportion of fish infected tends to decrease continuously as parasites die off and are not replaced after the fish have left the infective area. Even if the parasite has a long life span, if it is infective to adult fish then the infection will be cumulative because the same fish may pass through the infective area each year. Such parasites can be useful for showing the timing and direction of migration but are less reliable for quantifying the proportions of different stocks in mixed populations.

THE PARASITE FAUNA OF PISCIVOROUS PELAGIC TELEOSTS

The dominant components in the parasite fauna of this group of fish can be deduced from their diet and by referring to the host-parasite lists of Migrelli (1938), Silas (1962), Silas and Ummerkutty (1962), Mamaev (1968), Baudin-Laurencin (1971), Bussieras and Baudin-Laurencin (1973), Chen and Yang (1973), and Korotaeva (1975).

Piscivorous fish ingest larval helminths along with prey species which serve as intermediate hosts, and also adult helminths, some of which can transfer directly from prey to predator. The diet of many large pelagic fish includes cephalopods, which serve as intermediate or paratenic hosts for many helminths. These fish therefore carry many species of helminths, particularly mature forms. Parasitic copepods are also common parasites of this group of fish. As juveniles, large pelagic teleost species may feed extensively on crustaceans, thus acquiring infections with the larvae of many species of cestodes. Monogeneans appear to be more common parasites of larger than of smaller species of pelagic teleosts. Tunas appear to be common hosts for both juvenile and adult acanthocephalans.

DISCUSSION

Surprisingly little is known about the parasite fauna of Atlantic bluefin. Silas (1962) and Tiews (1963) listed the species of parasites known from this host. Between them these authors named seven species of parasitic copepods, seven monogeneans, six digeneans, one cestode, one nematode and one protozoan. Carli and Sara (1976) have since added another species of digenean but, judging by the parasite faunas of other scombroid fish, the list is still far from complete, particularly with regard to endoparasitic helminths and protozoans.

Walters (1980) discussed the use of two parasites as biological tags for bluefin. The monogenean Nasicola klawei (Stunkard) appears to be the more promising of the two, but certain aspects of its biology require investigation. No intermediate hosts are involved in the monogenean life cycle, but N. klawei has been reported from other species of tuna on both sides of the Atlantic and in the Pacific (Stunkard, 1962; Bussieras and Aldrin, 1967; Bane, 1969; Bussieras, 1972). According to Walters, the main infective area of N. klawei for bluefin is in tropical waters of the western Atlantic, but he examined only 16 Mediterranean bluefin. If it could be shown conclusively that young fish of the eastern stock are not infected and that reproduction of N. klawei is inhibited outside tropical waters, this parasite could prove to be a useful tag.

The parasitic copepod Euryphorus brachypterus (Gerstaecker) [= Elytrophora brachyptera Gerstaecker] appears less promising. Walters considered it possible that only bluefin originating from the Mediterranean and adjacent waters of the eastern Atlantic might carry this parasite. However, Kabata (1979) reported records of E. brachypterus from at least seven different species of fish and described it as occurring in all oceans inhabited by tunas. Individual copepods of this and related species are capable of movement from one fish to another and Lüling (1953) observed that E. brachypterus caused considerable damage to the gill tissues of bluefin. Euryphorus brachypterus must therefore be considered to be of doubtful value as a biological tag.

By applying the proposed selection criteria and taking into consideration the composition of the parasite fauna of piscivorous pelagic teleosts, it may be concluded that the parasite groups which are most likely to provide effective biological tags for bluefin tauna are larval trypanorhynch cestodes and juvenile acanthocephalans. Both groups of parasites have obligate crustacean first intermediate hosts, so that large pelagic teleost species will tend to pick up infections at an early stage in their life history, before they become predominantly piscivorous. Many species of cestode larvae in fish hosts are known to have life spans extending to several years and some live for as long as the infected fish (see Chubb, 1980). The plerocerci of two species of trypanorhynchs - Lacistorhynchus sp. and Grillotia angeli Dollfus - are considered to have life spans of more than 10 years in fish hosts (MacKenzie, 1981 and unpublished results). No information has been found on the life spans of encysted juvenile acanthocephalans in fish hosts. Since these are assumed to be resting stages during which no growth or further development occurs (see Nicholas, 1967; Crompton, 1970) they may well have long life spans comparable with those of larval cestodes. Unlike the plerocercoids of

some other groups of cestodes, the main diagnostic features of the adult worm are clearly differentiated in fully formed trypanorhynch plerocerci. Both trypanorhynchs and acanthocephalans are characterised by the possession of armed proboscides which are usually invaginated in the encysted larval or juvenile forms. These can be everted by placing the excysted worm in fresh water on a microscope slide under cover slip pressure. A specimen can then be specifically identified by its proboscis armature, in combination with other diagnostic features. Adult trypanorhynch cestodes are exclusively parasites of elasmobranch fish. Adult acanthocephalans are parasites of a wide variety of aquatic and terrestrial vertebrates.

Several species of trypanorhynch larvae have been reported from scombroid fish in the North Atlantic (Nigrelli, 1938; Dollfus, 1942; Silas, 1962; Nikolaeva, 1968; Nikolaeva and Parukhin, 1968; Bane, 1969; Baudin-Laurencin, 1971; Bussieras and Baudin-Laurencin, 1973). Some of these have been reported from both sides of the Atlantic, but the following species appear to have been reported from one side only. From the eastern Atlantic and Mediterranean: Nybelinia lingualis (Cuvier) and Gymnorhynchus gigas (Cuvier). From the western Atlantic: Nybelinia bisulcata (Linton), Nybelina lamontae Nigrelli, Gymnorhynchus uncinatus (Linton), Otobothrium crenacolle Linton and Pterobothrium heteracanthum Diesing.

Baudin-Laurencin (1971) and Bussieras and Baudin-Laurencin (1973) reported juveniles of the acanthocephalan Bolbosoma vasculosum (Rudolphi) from Thunnus albacares (Bonnaterre) and Euthynnus alletteratus (Rafinesque) from the tropical eastern Altantic. Baudin-Laurencin also referred to the occurrence of B. vasculosum in the genus Thunnus in the Mediterranean.

In conclusion, it is recommended that in the search for biological tags for Atlantic bluefin tuna special attention be paid to trypanorhynch cestode larvae and juvenile acanthocephalans found in juvenile fish. These are usually found encysted in the visceral cavity and in the gut wall. Preliminary investigations by Walters (1980) suggest that the monogenean Nasicola klawei may prove to be a useful tag. It is probable that others can be found amongst the many parasite species which have yet to be recorded from bluefin.

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