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The Eels *Anguilla marmorata* and *A. japonica* in the Pearl River, China, and Hong Kong

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Abstract

Anguilla marmorata live in small numbers in the wide muddy Pearl River (Zhujiang) on the southern coast of China and in clear fast-flowing streams of Hong Kong. Females grew to 28 kg and 180 cm and perhaps 17 years old. Females migrated to sea during October-December at average weight of 11 kg, average length 150 cm and average estimated age 15 years, with ovaries which were about 3% of the body weight, ova of about 0.2 mm diameter, and body fat content of about 22%. Large eels are extremely valuable in the Hong Kong restaurant trade.

Anguilla japonica live in low-lying muddy waters. Commercially caught eels were mostly 3-5 years old and 40-70 cm long, and females migrated to sea during October and November.

Introduction

In southern China, two species of *Anguilla* occur: *A. marmorata* (Figs. 1, 2) is scarce; *A. japonica* is moderately common.

The main river entering the sea in southern China is the Pearl River (Zhujiang) which is the name given to the delta of the combined West River, North River and East River (Fig. 3) and consists of a network of muddy river channels, with flat ricefields in between. To the sides are scrub-covered hills rising to 1,000 m which have clear streams. The temperature of the Pearl River at Canton

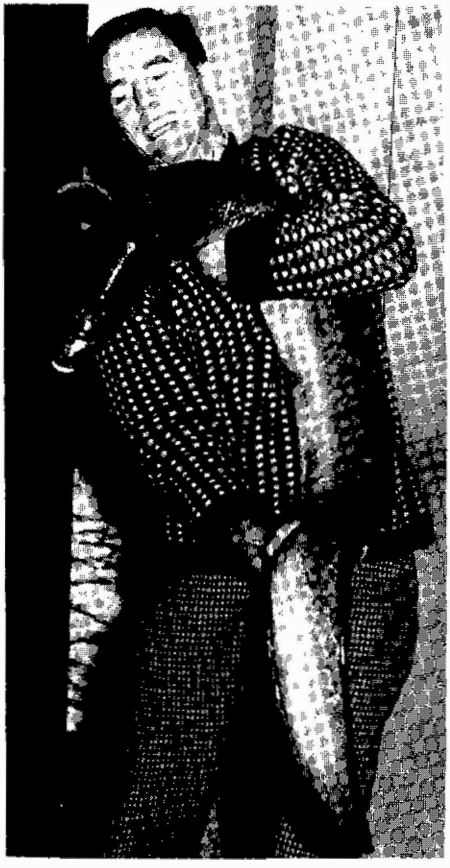

Fig. 1. *Anguilla marmorata* migrating female 17 kg.

(Guangzhou) is 12-29°C during average years (B.S. Chen pers. comm.). Hong Kong is mostly mountainous and flat land is found only around Yuen Long and Tai Po (Fig. 3).

This study is based on specimens and data collected during 1967-69.

Anguilla marmorata

A. marmorata, Quoy and Gaimard 1824, is a large mottled species and is the most widely distributed *Anguilla* species, its distribution extending through Africa, Madagascar, Indonesia and the Philippines, China, southern Japan, the Pacific Islands, Tahiti and Marquesas Islands. Despite its wide distribution, this species has not been studied in detail. The brief studies of *A. marmorata* that do exist are related to: world distribution (Schmidt 1925; Ege 1939); the Philippines (Herre 1923; Tabeta et al. 1976); southern Japan (Abe 1963; Nishi and Imai 1969); Taiwan (Tzeng 1987); China (Wu et al. 1964); Sulawesi (Celebes) (Castle and Williamson 1974); Tahiti (Schmidt 1927); and South Africa (Jubb 1961; Crass 1964).

The species inhabits clear fast-flowing streams and large rivers. In Luzon, Philippines, the species occurs up to 1,530 m altitude (Herre 1923) and in southern Africa one specimen was caught 1,000 km up the Zambesi River (Jubb 1961).

The Chinese name for *A. marmorata* is "faa maan" meaning "spotted eel." Large migrating female *A. marmorata* are called "dai seen wong" meaning "big eel king."

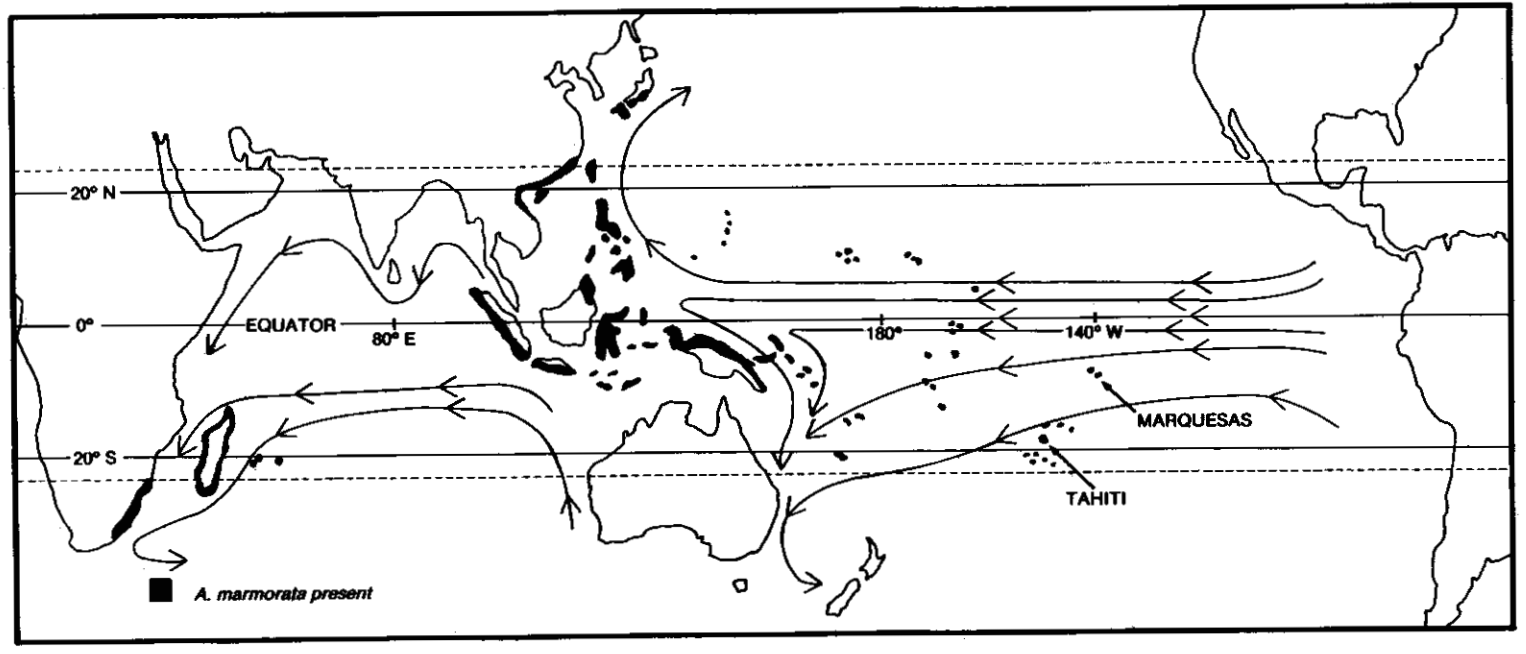

Fig. 2. Distribution of *A. marmorata*. The species occurs from South Africa to the Marquesas Islands in mid-Pacific.

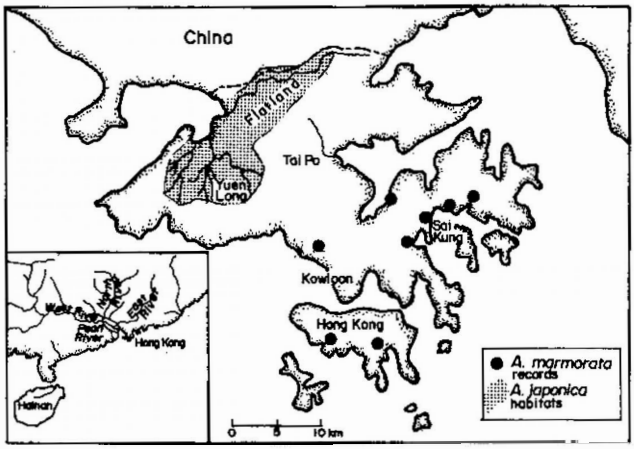

Fig. 3. Southern China showing the Pearl River and Hong Kong, and areas inhabited by *A. marmorata* and *A. japonica* in Hong Kong.

Each autumn during the 1960s about 100 large migrating female *A. marmorata* caught in the Pearl River were exported alive to Hong Kong to earn foreign currency. These "big eel kings" were sold for a high price in eel-gourmet restaurants. Now (1993) the economy of China is better and very few of these eels are exported. An effort was made to learn their biology, mainly from eels caught in the Pearl River in 1967-69 by commercial fishers using nets and then imported into Hong Kong. A few eels were caught in Hong Kong streams on baited hooks. Measurements, otoliths, etc. were obtained at restaurants when eels were being cut up.

The following were investigated (n=number of eels sampled): vertebral counts as in Ege (1939) (n=5); teeth pattern (n=3); length (n=12); weight (65 eels); age from otoliths placed in creosote on a black background (n=8); sex (n=65); gonad stage (n=15) and egg diameter (20 ova from each of 3 eels).

Also recorded was fat content (2 eels) of a segment from the anal region (which in *A. anguilla* has a fat content close to the whole body average [Thurow 1957]): three 50 g samples from each eel were weighed, dried, refluxed with 40-60 BP petroleum ether for 12 hours in a Soxhlet apparatus to extract the fat; the ether was evaporated off, the fat weighed and the results of the three samples averaged.

The exact locations in the Pearl River at which the large eels were caught is not known. One eel had been caught 250 km up the West River in Kwangsi (Guangxi) Province. In Hong Kong small numbers of *A. marmorata* were found in clear streams in mountainous areas. The eels live in holes in the sides of deep pools, which occur at intervals along the streams. There are reliable reports of small numbers of *A. marmorata*, including specimens up to 14 kg, being caught in reservoirs and small rivers of Hong Kong (at the locations marked in Fig. 3) during 1940-69. Due to urbanization and building of dams, the habitat of *A. marmorata* in Hong Kong is disappearing fast. We conclude that *A. marmorata* occur in low numbers in coastal areas of southern China.

To catch eels in Hong Kong, villagers used hooks baited with frogs or hairy-paw crabs *Eriocheir sinensis* in the summer wet season; in the winter dry season when water levels were low they heaped powdered oyster shell into the mouth of an eel's hole; this stupified the eel, which came out of its hole and could then be caught.

All the specimens examined (n=65) were determined to be female. No males were seen. (Presumably males are small and not exported) Immature female *A. marmorata* are mottled olive-yellow and blackish-brown on the dorsal and lateral surfaces of the body and head, and on the whole of the body behind the anus; the ventral surface ahead of the anus is pale. Migrating eels were darker.

Vertebral counts averaged 105.4 (Table 1). The upper jaw teeth pattern is the same as shown in Ege (1939).

The stomach contents of two immature eels examined (97 cm, 115 cm) from Hong Kong both consisted of a frog and a crab (*Eriocheir sinensis*). The fat content of *A. marmorata* was 10% in an immature female and 22% in a migrating female (Table 1).

The weight-length relationship based on 12 eels listed in Table 1 was $W = 0.00047\ L^{3.4}$ where W is whole weight in g and L is total length in cm.

Five eels had otolith rings clear enough to estimate their age (Fig. 4, Table 1). Of these, a 1 kg female was estimated to be 10 years old and four large migrating females (132-165 cm) were 15 and 16 years old. The narrow growth zones at the otoliths' centers but widely-spaced outer growth zones suggest that female eels grow slowly up to about age 10 years (1 kg, 70 cm) and then grow very rapidly. No validation of these age estimates was possible, however.

Table 1. Details of 15 female *Anguilla marmorata* examined in detail.

Stage: Immature or migrating	Length (cm)	Weight (kg)	Date of capture	Vertebrae (no.)	Age from otoliths (years)	Ovary weight (g)	Ovary weight (% body wt)	Ova diameter mean ± S.D. (mm)	Fat content %
Immature[a]	73	1.1	31 Aug. 1967	106	?	1	0.1		
Immature[a]	73	1.1	11 Sep. 1967	107	10	1	0.1		
Immature[a]	91	2.0	15 Dec. 1967	106	?	2	0.1		
Immature[a]	97	2.5	06 Aug. 1968	103	-	-	-		
Immature[a]	115	4.2	10 Nov. 1968	105	-	-	-		10
Migrating[b]	-	12.6	18 Oct. 1967	-	-	-	-		
Migrating[b]	-	15.3	21 Oct. 1967	-	-	600	3.9	0.22 ± 0.04	
Migrating[b]	159	14.4	06 Nov. 1967	-	15		-	-	
Migrating[b]	146	10.6	07 Nov. 1967	-	?	304	2.9		
Migrating[b]	-	15.4	07 Nov. 1967	-	-	580	3.8	0.21 ± 0.03	
Migrating[b]	132	7.6	16 Nov. 1967	-	15	250	3.3	0.22 ± 0.03	
Migrating[b]	165	13.6	16 Nov. 1967	-	16	415	3.3		
Migrating[b]	156	15.7	16 Nov. 1967	-	15		-	-	
Migrating[b]	150	12.7	25 Nov. 1967	-	-	405	3.2		22
Migrating[b]	156	16.9	11 Dec. 1967	-	-		-	-	

[a]Captured in Hong Kong.
[b]Captured in the Pearl River.

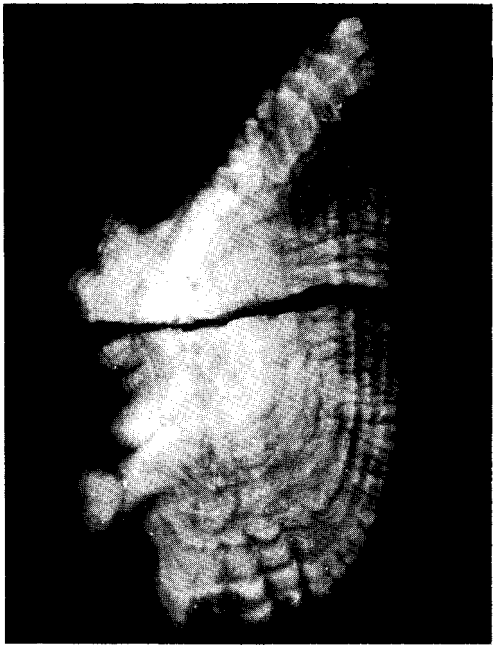

Fig. 4. *A. marmorata*. Otolith of migrating female 156 cm 15.7 kg., of estimated age 15 years, caught 16 November 1967.

The heaviest eel seen was 20 kg (female); the oldest was a 16-year-old (female). A fish merchant's notebook recorded that the largest eel he had ever purchased was a specimen 28 kg in weight and 180 cm long caught in the West River in Kwangsi Province in 1957. An eel of this size might be about 17 years old.

The ovaries of five eels 73-115 cm long were immature. The ovaries of 10 migrating eels 132-165 cm long were large (Fig. 5), weighing about 3% of the body weight and full of eggs of about 0.2 mm diameter (Table 1).

The weights and months of capture of a random sample of 60 migrating female eels are shown in Fig. 6. (The date of capture was estimated by deducting three weeks from the date of an eel's arrival in Hong Kong, to allow for transport time, etc.). These data suggest that female *A. marmorata* migrate to sea mainly during October-December. Perhaps smaller migrating females existed which are caught but not exported. Of the large migrating females sent to Hong Kong, the range of weights was 5-28 kg (average 11 kg); the range of lengths was 115-180 cm (average 150 cm); and range of estimated ages about 13-17 years (average 15 years).

The life history of *A. marmorata* appears to be similar to that of *A. anguilla, A. rostrata* and *A. japonica.*

From interviews with eel merchants, it was ascertained that *A. marmorata* are regarded as a delicacy by the Chinese and are very expensive. Certain restaurants specialize in cooking "big eel king" feasts. After a restaurant purchases an eel, the eel is exhibited alive in a tub of water on the sidewalk outside the restaurant. Eel enthusiasts speak to the proprietor, reserve a certain weight of the eel

Fig. 5. *A. marmorata*. Ovaries of migrating female 169 cm, 14.4 kg. Ovaries marked with arrows. Above: whole body cavity with two ovaries; below: one ovary.

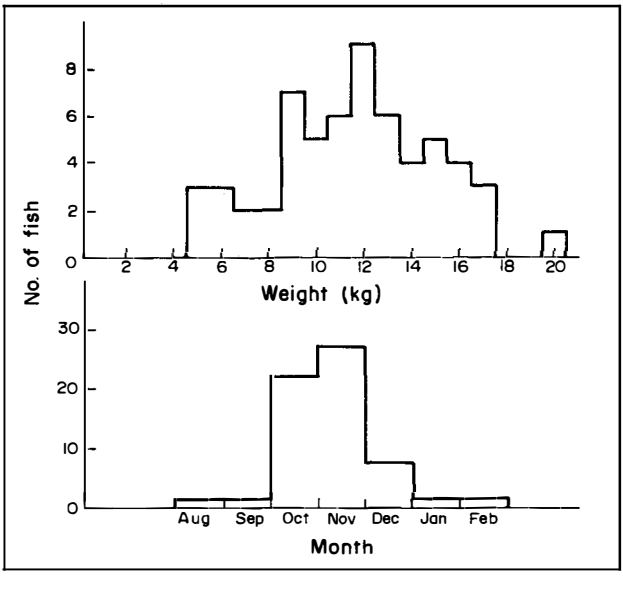

Fig. 6. Weights and month of capture of 60 migrating female *A. marmorata* sampled at random from among those caught in the Pearl River and imported into Hong Kong during August 1967 - February 1968.

and order a full-menu feast, with the eel as the highlight. The head and the tail are especially expensive. A typical 12 kg eel retailed for US$ 1,000 in 1992. When all the eel has been reserved, the proprietor phones his customers to announce that the "big eel king" has now been completely reserved. A day for the feast is then decided upon. The eel is killed in the morning and the feast is served that evening.

For a biologist to buy even one big eel is impossibly expensive. All measurements, otolith samples, etc. must be obtained at restaurants on the morning an eel is killed. Friendly restaurant owners are essential.

Anguilla japonica

A. japonica is a small plain-colored species and lives in coastal areas of China, Taiwan, Japan and Korea.

A. japonica is commoner in the southern China coastal area than *A. marmorata* and inhabits muddy rivers, low-lying ditches and brackish muddy inlets. About 70 t of live *A. japonica* were imported from the Pearl River into Hong Kong each year during the 1960s. In Hong Kong, small numbers of eels are caught in muddy rivers around Yuen Long and Tai Po (Fig. 1). Pigmented elvers of average length 6.5 cm (range 6.0-6.8 cm) were caught in May hiding in filamentous green algae in Aberdeen Harbour, Hong Kong. According to Zhang et al. (1986), *A. japonica* are common in the Pearl River area, and glass eels enter rivers during November-March.

Most eels caught in the Pearl River were 3-5 years old and 40-70 cm long and the oldest eel examined was 7 years old (otoliths of 121 eels examined). The largest eel seen was a female of 84 cm weighing 1.2 kg.

The main season of catching *A. japonica* in the Pearl River was October and November.

The fat content of migrating female eels caught in October and November averaged 16% (four 50 g samples from five eels minced together).

Vertebral count averaged 115.7, range 112-119 (120 eels examined). The count frequency was: 112 vertebrae (1 eel), 113 (5), 114 (21), 115 (27), 116 (27), 117 (27), 118 (10), 119 (2).

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