Study on the Stomach of Yellowfin Tuna (*Neothununs albacora* (Lowe))in the South China Sea [1)]

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Tuna long lining constitutes of one of the most importent deep-sea fisheries in Taiwan, the catch in 1967 totaling 38,861 metric tons (mt) : albacore 16,937mt., yellowfin tuna 13,784 mt., bigeye tuna 7,935 mt., bluefin tuna and others 929mt.(Fisheries Yearbook Taiwan Area,1968).

Since 1954, the Laboratory of Fishery Biology, Taiwan Fisheries Research Institute has studied Taiwan tuna resources, compiling information on length measurement, age determination, maturation of gonads (Song, 1969), sex ratios, ratio of catch per hook, and number and tonnage fishing boats by fishing area. However, no work has been done on the food and feeding habits of tuna. This paper reports the results of such a study on the yellowfin tuna, *Neothunnus albacora* (Lowe), which is abundant throughout the year (albacore is very abundant in December but is found only occasionally from January to November).

In 1963, adult yellowfin appeared to be most abundant in the central and western Pacific Ocean, less common in the northern, eastern and southern Pacific,based on data summarized by Rothschild (1966) from Japanese longline catches for the years 1953 to 1963. They inhabit the upper layer of the ocean to a depth of about 150m, the limiting environmental factor in the horizontal distribution being low temperature (18-28°C) and low oxygen (Murphy and Pella, 1966).

Hotta, Ogawa and Karitani (1965) reported on food and feeding habits of tunas. The present sutdy of the stomach contents of yellowfin tuna is the preliminary work, method modified from data in an earlier report(Tseng, 1969).

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Methods

To clarify the seasonal fluctuation of food based on stomach analyses of yellowfin tuna from the South China Sea, the months of February, May, August, and November are considered to represent winter, spring, summer and autumn, Respectively. Fish stomachs were collected from Kaohiung Fish Market in the middle of each month using random sampling methods (Table 1). Stomachs were carefully dissected and contents washed into a dish. Before analyzing the food items, all stomach contents were shifted into a 1000cc measuring cyclinder for 24 hours before reading their settling volumes (biomass). The average seasonal food volume (standing crop) is given in Table 2 and Figure 1. In the general analysis, food organisms were identified to the lowest taxonomic category practicable, then counted and recorded. Data for each season were calculated following procedures used by Tseng (1969): the average percentage, by number of each type of organism in the complete stomach contents; the average number of organisms in the stomachs; and the percentage of stomachs containing the organism. Emphasis is laid upon percentages by number rather than upon volume. While this method is not altogether satisfactory because the size of the different food elements varies considerably, it provides the best general indication of the relative importance of the various components because tuna feed selectively.

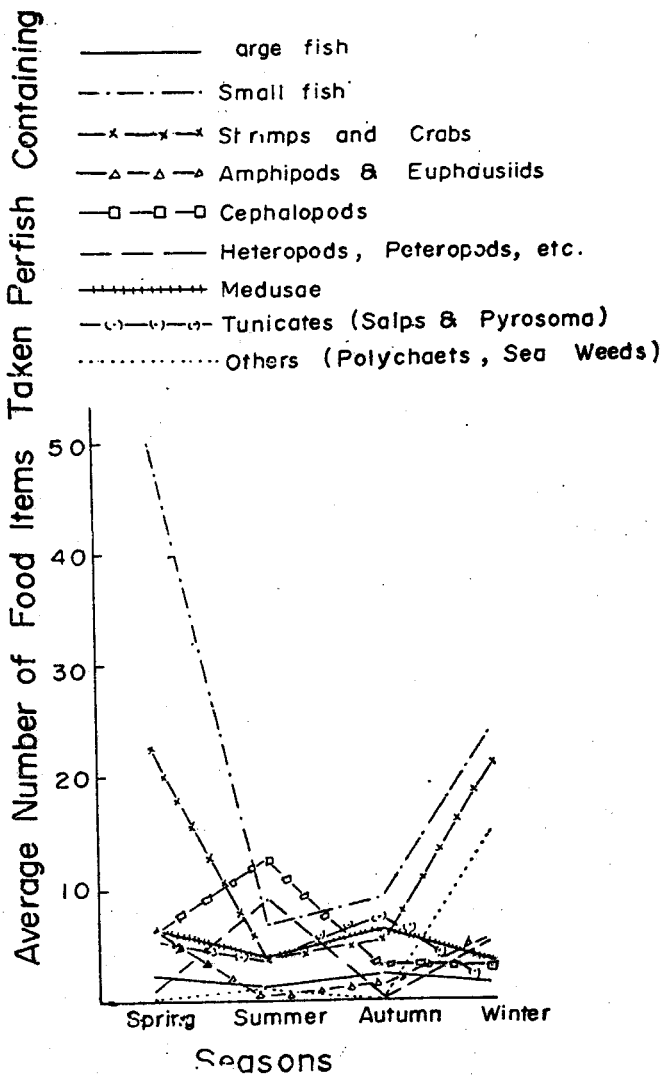

Fig.1. Average number of food items taken per fish containing seasonallg.

TABLE 1---Number of Tuna Stomachs Examined in Each Season.

Fishes	Season (Month)				Total
	Spring(March)	Summer(July)	Autumn(September)	Winter (December)	
Yellow-fin	5	2	4	10	21

TABLE 2---Average Seasonal Food Volume (Settling Volume) of Tuna Stomach in cc.

Food	Season (Month)				Total
	Spring(March)	Summer(July)	Autumn(September)	Winter (December)	
Food Volume (cc)	256	475	198	146.5	1075.5

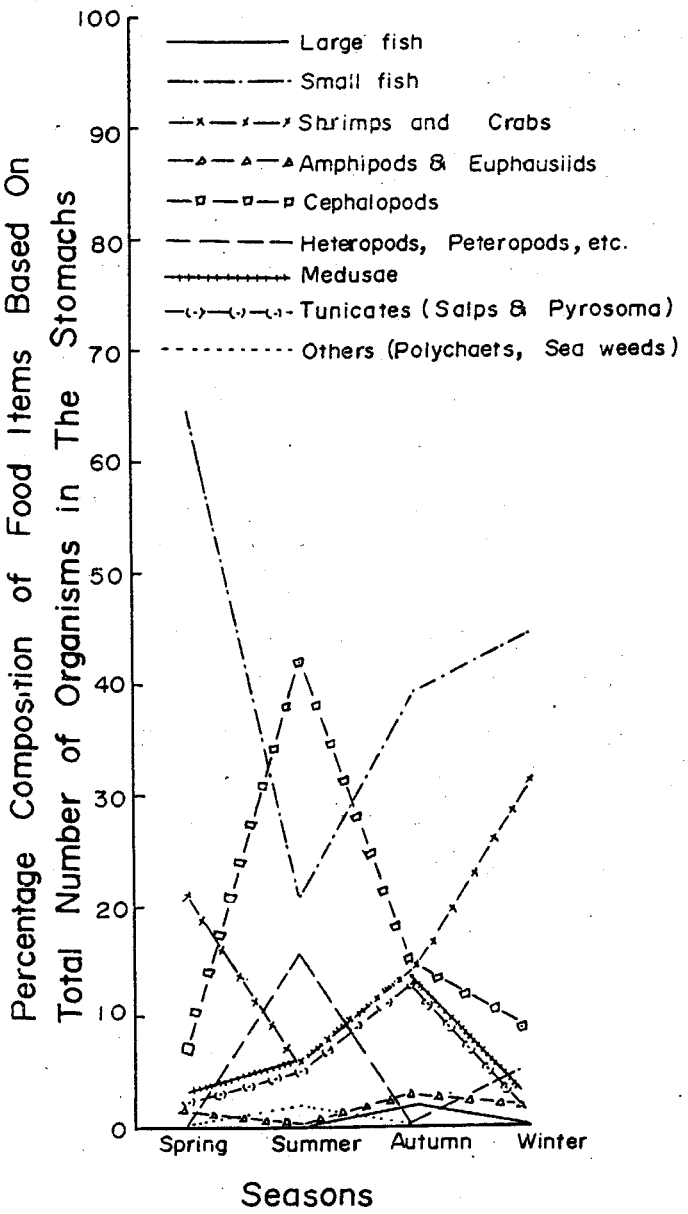

Fig.2. Tthe kinds and proportions of food items aken by yellowfin tuna.

Results

Tunas reportedly feed on a wide vriety of organisms (Hatta, Ogawa and Karitani,1965). The yellowfin tuna,whose food is dissussed herein, were caught in the South China Sea around 10°N latitude, from November 1968 to August 1969. The largest mature specimens were caught in spring, the smallest in winter.

Identification was based on a description and illustration by Abe (1963).

Analysis of food--Food composition: Fig 2 shows the kinds and proportions of food items taken by yellowfin tuna. Among them, fishes including mackerel, jacks and other small forms, predominate.Crustaceans, including shrimp, crabs, amphipods and euphausids, rank second. Squids, the most common mollusk, third. Of less importance are tunicates, medusae, polychaetes and

nemertean worms. Otoliths and squid beaks are occasionally very common. As some of the stomach walls of the fishes found among the stomach contents were partly digested, it is likely that the small shrimps, crab larvae, medusae, salps, amphipods, euphausids, and nemertean worms came from the tunas' prey rather than directly from the tunas.

variation in seasonal distribution of the more important food organisms is illustrated in table 3-6. In the five stomachs analysed in the spring (March) (Table 3), most common were large swimming fishes, such as *Ostraciidae* and *Gonostrona*, and small fishes, such as round herrings(*Dussumieriidae*) sardines (*Clupeidae*), anchovies (*Engranlidae*),as well as many unidentifiable fishes and otholiths. Shrimp were second abundant, squids third.Amphipods, euphasids, salps, and medusae were also present. In the two stomachs analysed in summer (June) (Table 4), squids (cephalopods) were most common. Small fishes such as anchovies were second in abundance, of large fishes only found one, *Nibea albiflora* occurred in one stomach. Shrimp, medusae, heteropods, pteropods, salps and nemertean worms were also present. Small crustaceans, such as amphipods and euphausids were absent. In the four stomachs analysed in autumn (September) (Table 5), the dominant food item was fishes, such as anchovies and sardines, large fishes included a mackerel 50 cm long and jacks from 20 cm to 23 cm in length. Squids ranked second, including one with a mantle length of 20 cm. Medusae, nemertean worms, salps, shrimp and crabs were also found. One *Pyrosoma* was found in one stomach. Small organisms such as polychaetes, heteropods, pteropods and amphipods were absent. In the ten stomachs analysed in winter (December) (Table 6),anchovies and other small fishes dominated; a large jack 22 cm long was found in one stomach. Shrimp were second in abundance. Crabs and amphipods were present but not abundant as were squids, other fishes, nemertean worms, and polychaetes.

Fig. 3 shows graphically the seasonal occurrence of food in the stomachs of yellowfin tunas. Small fishes such as round herring, sardines, anchovies and others were most abundant in spring, autumn and winter, but not in summer. Decapod crustaceans, mainly penaeid shrimp and crabs, were second in abundance in spring and winter. Squids (cephalopods) dominated in summer, but were less abundant in spring, autumn and winter. Small crustaceans principally amphipods and euphausids were found in spring, autumn and winter, but not in summer. Small mollusks such as heteropods and pteropods were fairly abundant in summer and winter, but rare in spring and absent in autumn.Medusae were equally distributed seasonally,

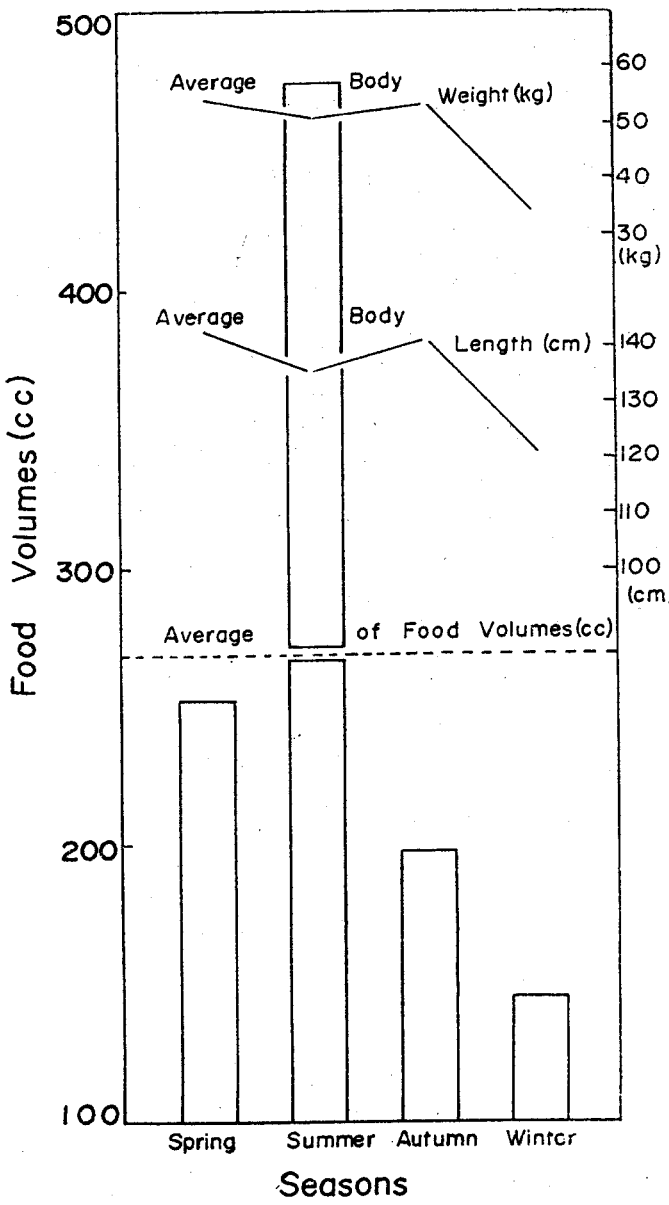

Fig.3. The seasonal occurrence of food in the stomachs of yellowfin tunas.

the average number in each stomach being around five. Two kinds of tunicates were found, of which salps predominated, only *Pyrosoma* was found, in winter. Tunicates were most abundant in summer, lessabundant in winter, least abundant in spring, and absent in autumn. Such food items as polychaetes, nemertean worms and sea weeds were abundant in winter, rare in summer and absent in spring and autumn.

Feeding habits: The food and feeding habits of yellowfin tuna are similar to those of closely related *Scombridae*, such as *Scomber tapeinocephalus* (Tseng, 1969). King and Ikehara (1956) reported that the food and feeding habits of yellowfin tuna were similar to bigeye tuna (*Tkunnus obesus*), in both of which squids composed paproximately 30% of the food. in the present study (Table 7), an average of 62% of identfiable items in yellowfin tuna stomachs consisted of fish, shrimp and squids. yellowfin tunas are voracious discretionry feeders. Because they swim rapidly they feed preferentially on large, alive marine animals, such as squids and fishes. Regarding selectivity of food organisms (Fig.4), yellowfin tuna in the South China Sea apparently feed mainly on fishes, such as mackerel, jacks, anchovies other small fishes and shrimp during spring, autumn, and winter, on squids and fishes in summer. According to Song (personal communication), female yellowfin tuna feed less during spawning season. From Table 9 we found that among 5 experiments yellowfin tuna seemed most like to eat milk fish bait than jack fish bait.

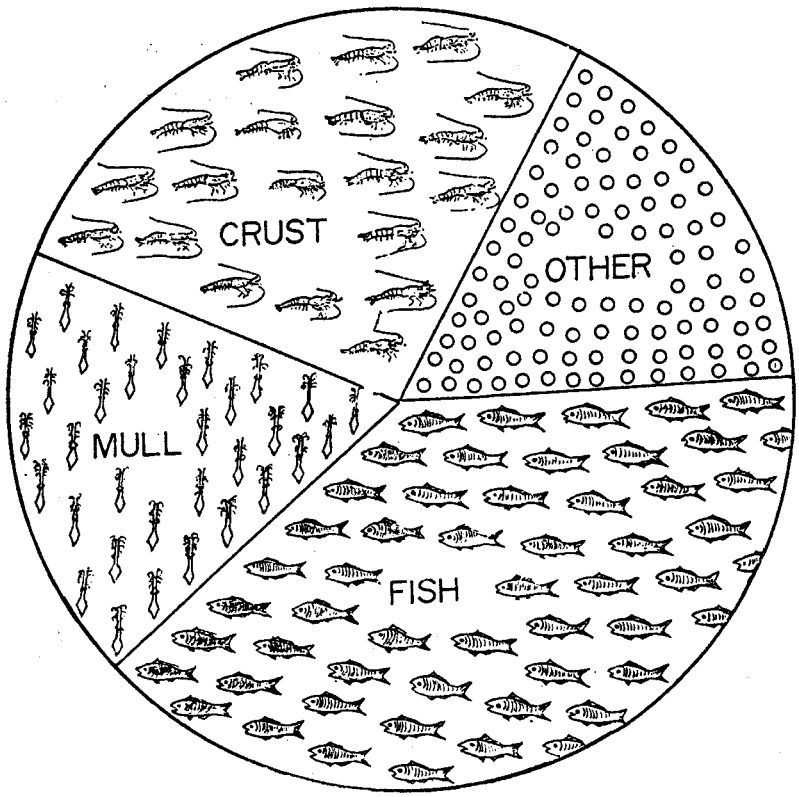

Fig.4. Summary of the food habits of yellowfin tuna from the South China Sea, whole year.

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TABLE 3- Winter Food of Tuna from South China Sea Based on Analyses of *10* Stomachs.

Organism	Percentage Frequency of Occurrence Among Fish Examined	Average Number Taken Per Fish Containing the Item	Percentage Composition of Food Items Base on Total Numeber of Organisms Found in the Stomachs.
Fishes			
Scombridae	*0*	*0*	*0*
Carangidae	*10*	*1*	Trace
Other fishes[1)]	*100*	*2*	*9*
Fish larvae, eggs[2)]	*40*	*23*	*35*
Mollusca			
Cephslopods	*80*	*3*	*9*
Heteropods	*40*	*3*	*5*
Pteropods	*10*	*1*	Trace
Other mollusca[3)]	*10*	*1*	Trace
Crustacea			
Amphipoda	*10*	*5*	*2*
Crabs	*10*	*2*	*1*
Euphausiids	*0*	*0*	*0*
Shrimps	*40*	*19*	*20*
Medusae	*30*	*3*	*3*
Polychaets	*10*	*14*	*5*
Tunicates			
Salps	*20*	*1*	*2*
Sea weeds	*10*	*1*	Trace

1. including other fish and otolith in pair.
2. includes fish eggs, fish larvae and other eggs.
3. including squids and its jaw

TABLE 4 Spring Food of Tuna from South China Sea Based on Analyses of 5 Stomachs

Organism	Percentage Frequency of Occurrence Among Fish Examined	Average Number Taken Per Fish Containing The Item	Percentage Composition of Food Items Based on Total Number of Organisms Found in the Stomachs
Fishes			
Ostraciidae	20	1	Trace
Gonostrona	20	1	Trace
Other small fishes [1]	100	50	65
Fish larvae, eggs [2]	0	0	0
Mollusca			
Cephslopods	80	6	7
Heteropods	0	0	0
Pteropods	0	0	0
Other mollusca [3]	20	1	Trace
Crustacea			
Amphipods	20	5	1
Crabs	40	5	3
Euphausiids	20	1	Trace
Shrimps	80	17	18
Medusae	40	6	3
Polychaets	0	0	0
Tunicates			
Salps	40	5	2
Sea weeds	0	0	0

1. including other fish and otolith in pair.
2. indudes fieh eggs, fish larvae.
3. including squids and its jaw

TABLE 5-Summer Food of Tuna from South China Sea Based on Analyses of 2 Stomachs.

Organism	Percentage Frequency of Occurrence among Fish Examined	Average Number Taken Per Fish Containing the Item	Percentage Composition of Food Items Based on Total Number of Organisms Found in the Stomachs.
Fishes			
Nibea	50	1	Trace
Other small fishes[1]	100	6	19
Fish larvae, eggs[2]	50	1	2
Mollusca			
Cephalopods	100	13	42
Heteropods	100	2	6
Pteropoda	50	6	10
Other mollusca[3]	50	1	2
Crustacea			
Amphipods	0	0	0
Crabs	0	0	0
Euphausiids	0	0	0
Shrimps	50	4	6
Medusea	50	4	6
Polychaets	50	1	2
Tunicates			
Salps	50	3	5
Sea weeds	0	0	0

1. including other fish and otolith in pair.
2. includes fish eggs, fish larvae.
3. including squids and its jaw.

TABLE 6-Autumn Food of Tuna from South China Sea Based on Analyses of 4 Stomachs.

Organism	Percentage Frequency of Occurrence Among Fish Examined	Average Number Taken Per Fish Containing the Item	Percentage Composition of Food Items Based on total Number of Organisms Found in the Stomachs.
Fishes			
Scombridae	25	1	1
Carangidbe	25	1	1
Other small fishes[1]	100	8	8
Fish larve, eggs[2]	25	1	1
Mollusca			
Cephalopods	100	3	15
Heteropds	0	0	0
Pteropoda	0	0	0
Other mollusca[3]	0	0	0
Crustacea			
Amphipods	50	1	3
Crabs	50	3	7
Euphausiids	0	0	0
Shrimps	75	2	7
Medusae	50	6	14
Polychaets	0	0	0
Tunicates			
Salps	50	5	0
Pyrosoma	25	1	1

1. including other fish and otolith in pair.
2. includes fish eggs, fishlarvae
3. including squids and its jaw.

TABLE 7-Annual Averge of Food of Tuna from South China Sea Based on Analyses of *23* Stomachs

Organisms	Percentage Frequency of Seasonal Occurrence Among Fish Examined	Average Number Taken Per Fish Containing the Item	Percentage Composition of Food Items Based on Total Number of Organisms Found in the Stomachs.
Fishes.			
Scombridae	*25*	*∠ 1*	Trace
Carangidae	*50*	*∠ 1*	*1*
Ostraciidae	*25*	*∠ 1*	Trace
Gonostrona	*25*	*∠ 1*	Trace
Nibea	*25*	*∠ 1*	Trace
Other small fishes	*100*	*17*	*29*
Fish larvae, eggs	*75*	*6*	*8*
Mollusca			
Cephalopods	*100*	*7*	*12*
Heteropods	*50*	*1*	*1*
Pteropoda	*50*	*2*	*2*
Other mollusca	*75*	*1*	*1*
Crustacea			
Amphipods	*75*	*3*	*4*
Crabs	*75*	*3*	*4*
Euphausiids	*25*	*∠ 1*	Trace
Shrimps	*100*	*11*	*19*
Medusae	*100*	*5*	*8*
Polychaets	*50*	*4*	*3*
Tunicates			
Salps	*100*	*4*	*7*
Pyrosoma	*25*	*∠ 1*	Trace
Sea weeds	*25*	*∠ 1*	Trace

TABLE 8-Seasonaly Distribution of Food Items in the Stomachs Content of Tuna.

Organisms	Winter	Spring	Summer	Autumn
Large fish				
Scombridae	x	-	-	x
Carangidae	x	-	-	x
Ostraciidae	-	x	-	-
Gonostrona	-	x	-	-
Nibea	-	-	x	-
Small fish	xx	xxx	xx	xx
Other fish larvae, fish egg	xx	-	x	x
Crustacea				
Shrimps	x	xx	x	x
Crabs	x	x	-	x
Amphipods	x	x	-	x
Euphausiids	-	x	-	-
Medusae	x	x	x	xx
Large mollusca				
Gastropoda	xx	xx	xx	xx
Small mollusca				
Heteropoda	x	-	x	-
Pteropoda	x	-	x	-
Other mollusca	x	x	x	-
Tunicates				
Salps	x	x	x	x
Pyrosoma	-	-	-	x
Sea weeds	x	-	-	-
Nematoda	xx	xx	x	xx
Polychaets	x	x	x	-

Remarks : The symbol xxx denotes great abundance, xx denotes common occurrence and x denotes uncommon or rare occurrence.

Table 9-The Bait Testing for Tuna Long -Line.

Fishes / Fish Baits	Yellowfin Tuna	Big-eye Tuna	Albacore	Marlins	Sharks and others	Total catch	Total Hooking Rate
Milk fish (1st Exp.)	*25*	*23*	*4*	*28*	*26*	*106*	(2.47%)
Jack (2nd Exp.)	*25*	*7*	*1*	*3*	*8*	*44*	(2.93%)
Milk fish (3rd Exp.)	*59*	*10*	*0*	*24*	*17*	*110*	(4.26%)
Jack (4th Exp.)	*4*	*1*	*0*	*7*	*6*	*18*	(3.05%)
Milk fish (5th Exp.)	*8*	*3*	*0*	*4*	*5*	*20*	4%