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DISTRIBUTION AND ABUNDANCE OF GIANT CLAMS (FAMILY TRIDACNIDAE) IN THE SOUTH-CENTRAL PHILIPPINES

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A population survey of giant clams (Family Tridacnidae) was conducted in certain coral reef areas of the Central Visayas, Western Visayas, Cagayan Islands and Palawan from February 1984 to October 1985. The largest species of Tridacna (T. gigas and T. derasa) were found to be either extinct or greatly reduced in numbers probably because of overcollection. The smaller species of Tridacna, although of variable densities, appear to be holding their own in general. Hippopus porcellanus may also be endangered. The status of H. hippopus is uncertain, but it occurred at some reefs in the Central Visayas, Cagayan and Palawan regions.

Giant clams are the largest bivalves in the world, the largest individuals of Tridacna gigas (Linn.) attaining a length of 137 cm and a weight of over 200 kg (Rosewater, 1965). These clams are obligatory inhabitants of shallow marine waters and are restricted to certain areas in the tropical Indo-Pacific region. All seven living species of the family Tridacnidae have been reported from the Philippines (Rosewater, 1965, 1982).

In the Philippines and elsewhere giant clams have formed part of the diets of coastal peoples. They have also been harvested commercially for their adductor muscles, considered a delicacy in some Asian countries, and for their shells. Dried adductor muscles are reported to fetch as much as US $82-143/kg in urban areas such as Hongkong (Munro and Gwyther, 1981). Giant clam shells have such uses in homes, restaurants and hotels as animal feeding troughs, ashtrays, washbasins and decoration (Wells, 1981). Because of the uncontrolled exploitation, the two largest species, T. gigas and T. derasa (Röding), are probably already extinct in certain parts of their range, such as western Indonesia (Salm, 1981). T. gigas has recently suffered extinction at four islands in Micronesia according to Heslinga et al. (1984). Both species are considered vulnerable by IUCN (1983). Hippopus porcellanus Rosewater, a Philippine endemic, is almost exclusively found in the Sulu Sea (Rosewater, 1982), where it is now apparently rare.

Widespread concern that some species of giant clams are threatened with extinction has resulted in noteworthy efforts to protect existing stocks in coral reef reserves (International

Union for the Conservation of Nature, 1983). In addition to protection, it is believed that restocking of coral reefs with animals spawned and reared initially in hatcheries can help prevent the extinction of these species. Captive breeding is now going on at a number of laboratories. A clam hatchery at the Micronesian Mariculture Demonstration Center at Koror, Palau has been successfully breeding T. derasa (Heslinga et al., 1984). The Orpheus Island field station of James Cook University, the University of Papua New Guinea, the Fisheries Division, Ministry of Primary Industries, Fiji, the University of the Philippines Marine Science Institute and the Silliman University Marine Laboratory have been conducting cooperative mariculture studies on giant clams since 1984 with financial support from the Australian Center for International Agricultural Research (ACIAR).

This paper on the distribution and abundance of giant clams in the south-central Philippines is part of the ACIAR-supported mariculture program. Earlier studies on giant clam abundance include those of Hardy and Hardy (1969), Hester and Jones (1974), Bryan and McConnell (1976), Hirschberger (1980) and Brown and Muskanofola (1985).

MATERIALS AND METHODS

The population survey was conducted from February 1984 to October 1985 in four regions: the Central Visayas, Western Visayas, Cagayan Islands and Palawan (Fig. 1). Twenty-five coral reef sites were surveyed in the Central Visayas, eight in the Western Visayas, ten in the Cagayan Islands, Sulu Sea, and 21 at Palawan. The sites in each region were at least 500 m apart. They were in shallow water, the average depth varying from 0.5 m to 5 m (average depth taken as the mean of maximum and minimum depths).

For most sampling sites a single observer using mask and snorkel or SCUBA was employed; two observers were used only in the few sites in the Central Visayas surveyed with the quadrat method. Sampling in shallow water (less than 2 m deep) usually required only the use of mask and snorkel. The observer swam in a straight line about one meter from the bottom. A calibrated flowmeter was used to determine the area of a sampling site. Clam species observed and individual lengths, water depth, temperature and percent live coral cover were recorded on a slateboard.

The sampling sites varied in area from 300 to 7,000 sq m, with the mode at 500 to 1,000 sq m, except for two sites in the Central Visayas of 100 sq m, which were surveyed by the quadrat method. The flowmeter method, which requires only one person, has been shown to yield comparable survey results to the widely accepted belt transect method (unpubl. data). It was assumed that the effective width of the observer's vision was about one meter,

making the distance travelled equal to the area surveyed.

Because sampling sites varied in area, clam density is expressed in number per hectare for direct comparison of survey results. The formula for determining relative species density (RD) was that of Brower and Zar (1977: 65):

$$RD = \frac{\text{total number of individuals of a species}}{\text{total number of individuals of all species}} \times 100$$

RESULTS AND DISCUSSION

Species Observed.

In and outside of the sampling sites, four species [T. crocea (Lamarck), T. maxima (Röding), T. squamosa Lamarck and Hippopus hippopus (Linn.)] were observed in the Central Visayas; three species (T. crocea, T. maxima and T. squamosa) in the Western Visayas; five species (all four Tridacna species and H. hippopus) at Palawan; and seven species (all species mentioned above plus T. gigas and H. porcellanus) at Cagayan. However, only five of the seven species were observed in the sampling sites (Table 1). T. gigas and H. porcellanus were absent in the sampling sites in all regions, while T. derasa and H. hippopus were absent in the sampling sites in all regions except Palawan. Only one individual (an adult) of H. porcellanus, three individuals (all juveniles) of T. gigas and ten individuals (all juveniles except one) of T. derasa were seen outside of the sampling sites at Cagayan. Empty shells of all species, except H. porcellanus, were also observed in all regions surveyed.

It is almost certain that, although T. gigas and T. derasa still exist at Cagayan and Palawan, they are now extinct in the Central and Western Visayas. Their occurrence in areas in these two regions not covered by the present survey is very unlikely, as none were seen in an earlier intensive survey of coral reef resources (see UP Marine Science Center, 1979).

Earlier authors (e.g. Hester and Jones, 1974; Hirschberger, 1980; Brown and Muskanofola, 1983) have described the association of tridacnid species with various habitats on reefs: T. crocea, embedded in massive corals; T. maxima, firmly anchored to coral heads; T. squamosa, attached by weak byssus to living coral or coral rubble; T. derasa and T. gigas, on sand flats and coral heads in lagoons, often associated with Acropora rubble; and H. hippopus, in shallow sandy areas and reef flats. Our own observations essentially confirm most of these observations. T. squamosa, T. derasa and T. gigas were found on reefs dominated by Acropora. T. squamosa was also found on reefs with high species richness, sometimes in coral rubble. H. hippopus and H.

porcellanus occurred on sandy portions of reefs.

Most of the clams observed were at 0-3 m depth; only a few were observed at depths greater than 5 m. In isolated observations before the present survey, we recorded live individuals of T. squamosa (in excess of 20 cm long) and two live T. gigas (1+ m in length) at a depth of 18 m. These two species may occur occasionally in deeper water. Brown and Muskanofola (1985) reported 15.5 m as the maximum depth of T. squamosa and 13.5 m for T. maxima at Karimum Jawa.

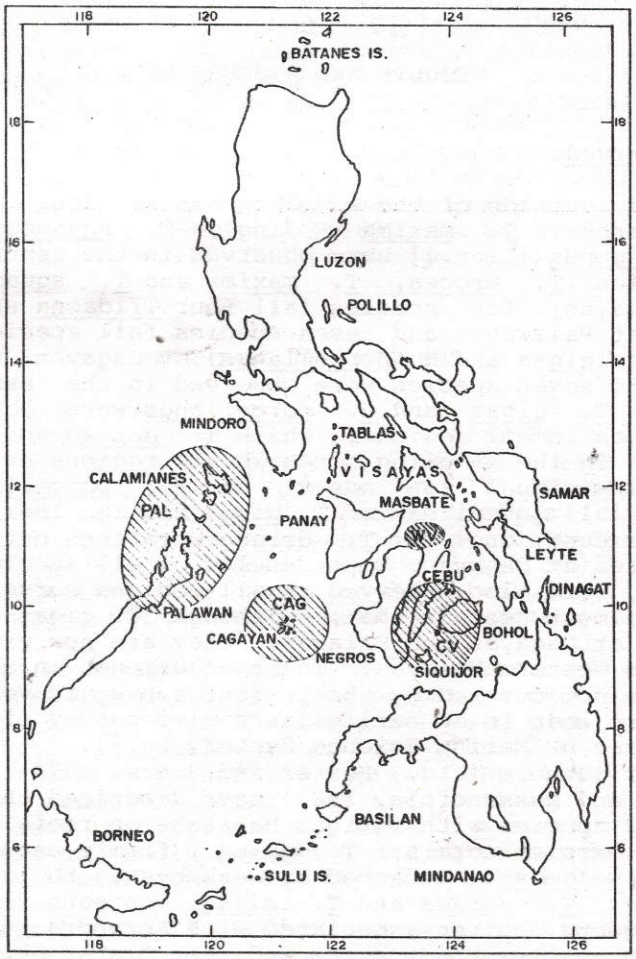

Figure 1. Areas surveyed for giant clams. Central Visayas (CV), Western Visayas (WV), Cagayan Islands (CAG), Palawan (PAL).

Length-Frequency Distribution.

Of the three species (T. crocea, T. maxima , T. squamosa) common to the four regions, only T. squamosa showed regional differences in size, the population in the Western Visayas being composed mostly of large individuals. One-way ANOVA using ten randomly picked individuals for each of the three species from each region showed statistical significance at the 5% level only for T. squamosa ($P<0.05$, $F=4.7133$, $df=3.36$).

The larger size of T. squamosa in the Western Visayas is probably the combined result of lower exploitation pressure on, and protection of, the stocks. The reefs explored are situated in the Visayan Sea, a prime fishing area, where people prefer fish to clams for food. Also, since 1982, one of the reefs surveyed has been closed to fishing, having been declared a marine park.

Abundance.

Abundance can be assessed in two ways: either (a) by the relative species density (RD), or (b) by the population density, here expressed as the number of clams per hectare. The RD is useful, as it indicates the predominance of a species in any one region but not in relation to all four regions, as the level of survey effort for the regions was not uniform. Population density, however, allows a comparison of the relative importance of the species common to all regions.

The RD's of five species are summarized in Table 1. In the Central Visayas, T. crocea make up more than 50% of all clams seen, with T. maxima and T. squamosa equally sharing the balance. In the Western Visayas, T. squamosa is the most dominant species, making up about 71% of all the clams observed. At Palawan,

Table 1. Relative species density (RD) for giant clams surveyed from June 1984 to October 1985. CV, Central Visayas; WV, Western Visayas; PAL, Palawan; CAG, Cagayan Islands.

REGION	T. crocea	T. maxima	T. squamosa	T. derasa	H. hippopus	TOTAL
CV	52.68	25.81	21.51	0.00	0.00	100
WV	12.41	16.28	71.32	0.00	0.00	100
PAL	97.88	0.79	0.81	0.11	0.41	100
CAG	40.31	56.92	2.77	0.00	0.00	100

T. crocea make up about 98% of all individuals observed, the remaining 2% consisting of individuals of the other four species, all of which can be considered uncommon in the region. At Cagayan, T. crocea and T. maxima make up 97% of all clams observed, T. squamosa about 3%.

The population densities (clams per hectare) for five of the seven species in the four study regions are shown in Table 2. Not included in this table are the densities of T. gigas and H. porcellanus, both of which must be considered rare. That T. gigas was common at Cagayan in the past is indicated by the presence of empty shells on the sea bottom and on the walls of the Roman Catholic Church building.

Table 2. Summary of data on distribution and population density of giant clams in the Central Visayas (CV), Wes Visayas (WV), Cagayan, Sulu Sea (CAG) and Palawan (PAL) regions, Philippines. Tc, Tridacna crocea; Tridacna derasa; Tm, Tridacna maxima; Ts, Tridacna squamosa; Hh, Hippopus hippopus.

Region	Number of Sampling Sites	Area Explored (ha)	Total Number of Clams Observed	Number of Clams per Hectare					
				Tc	Td	Tm	Ts	Hh	All species
CV	25	3.0	93	16.33	-	8.00	6.67	-	31.00
WV	8	0.7	129	22.86	-	30.00	131.43	-	184.29
CAG	10	0.5645	253	180.69	-	255.09	12.40	-	448.18
PAL	21	2.1	7051	3286.19	3.81	26.67	27.14	13.81	3357.62

T. derasa is represented by a very low population density at Palawan of about four individuals per ha. It was so rare at Cagayan that it was not seen in any of the sampling sites there. T. crocea, T. maxima and T. squamosa had variable population densities in the four regions. H. hippopus had a low density (about 14 clams per ha) at Palawan, the only region where it was observed in the sampling sites. The Central Visayas has the lowest density among the four regions for all species combined.

The low population density of T. derasa at Palawan and Cagayan and of T. gigas at Cagayan is probably due to overcollection. The low density of 7-8 clams per ha. for T. maxima and T. squamosa in the Central Visayas can also be attributed to intense exploitation and possibly to reef destruction. The fairly high density of T. squamosa in the Western Visayas is mainly due to protection. However, the reasons for the extremely high population density of T. crocea at Palawan

Table 3. A comparison of tridacnid clam population densities (clams per hectare).

Region	Philippines (this study)	Karimun Java, Indonesia[a]	Helen Reef, Palau, Western Caroline Islands		
			a	b	c
No. of transects or sampling sites	8 - 25	15	12	17	8
Total area surveyed (ha)	0.56 - 3.0	1.35	4.38	2.48	1.547
Density T. crocea	16.33 - 3,286.19	85.93	not counted; ubiquitous	not counted; ubiquitous	not counted, presence noted; density considered constant
T. derasa	3.81	-	23.06	2.02	4.52
T. gigas	-	-	18.72	1.61	2.59
T. maxima	8.00 - 255.09	200.00	135.84	253.63	201.68
T. squamosa	6.67 - 131.43	45.93	-	0.81	1.94
Hippopus hippopus	13.81	-	13.24	8.87	40.72

[a] Brown and Muskanofola, 1985
[b] Hester and Jones, 1974
[b] Bryan and McConnell, 1976
[c] Hirschberger, 1980
[b] Counted in 4 stations with area of 0.92 ha.

are unknown, since this species is little exploited, if at all. One environmental factor favoring a high population density may be the availability of coral heads, into which this species burrows.

The Central Visayas, where giant clams are heavily exploited for food, has the lowest population density for all species combined among the four regions. The high density figure for the Western Visayas is not representative for the whole region, as the sampling sites were situated mostly on a protected reef. The higher density estimates for species other than T. gigas for Cagayan and Palawan probably reflect the reduced collecting of these species in these regions.

The population densities of tridacnids in the Philippines

may be compared with those at Karimum Jawa, Indonesia (Brown and Muskanofola, 1985) and at Helen Reef, an atoll in the South Palau District, Western Caroline Islands (Hester and Jones, 1974; Brian and McConnell, 1976; Hirschberger, 1980). For direct comparison, their densities (clams per 100 sq m) were recalculated (Table 3). T. derasa and T. gigas were not present at Karimum Jawa, and were the most uncommon species in the Philippines and on Helen Reef (Table 3). Their reduced densities on Helen Reef are due to uncontrolled exploitation (Hirschberger, 1980). This may also be the case in the Philippines. Both species should therefore now be listed in Appendix II of the Convention for International Trade in Endangered Species (CITES), as proposed by Wells (1981).

T. crocea and T. maxima seem to be maintaining their populations in the three Indo-Pacific areas studied. Likewise, the population of H. hippopus has remained stable on Helen Reef. However, this species is apparently absent at Karimum Jawa and patchy in distribution in the Philippines. T. squamosa is represented by fair numbers at Karimum Jawa and in the Western Visayas, Philippines, but has low densities in other Philippine regions studied and at Helen Reef.

CONCLUSION

T. gigas and T. derasa are either extinct or threatened with extinction in the four Philippine regions surveyed. The reason for their local extinction or threatened status is probably uncontrolled exploitation. T. squamosa and T. maxima, although variable in densities in the four Philippine regions, are generally stable. T. crocea, which had relatively high densities in two of the four regions, is definitely not endangered. H. porcellanus is very rare and may be endangered. The status of H. hippopus is uncertain, as its distribution is extremely variable.

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