

BEHAVIOURAL STUDIES ON THE GREEN TURTLE (*CHELONIA MYDAS*) IN THE SEA

BY JULIE BOOTH & JAMES A. PETERS

Wreck Island, Capricorn Group, Australia; and Smithsonian Institution

Abstract. Underwater observations of green turtles near Fairfax Island, Bunker Group, Australia, disclosed female behaviour patterns to avoid copulation, including a striking adpressed hind limb position; resting in a female sanctuary area; avoidance swimming; face-to-face confrontation, followed or accompanied by biting; and a 'refusal' position, with the female assuming a vertical position, her limbs widely outspread and plastron facing the male. Copulation activity precedes egg laying on Fairfax. Copulation lasts as long as 6 hr. Females outnumber males, who engage in multiple copulations. The 'escort' is a group of one to five males attendant upon mated pairs. Hatchlings feed on various invertebrates. Cleaner fishes groom adult female turtles.

Although green sea turtles, *Chelonia mydas* (Linnaeus), spend but a small part of their life on the shore, biologists have accumulated masses of data on emergence from the sea, egg laying, orientation, migration of hatchlings from the nest to the sea, and so on. Aside from observations on mating made at the surface (Carr 1952; Frazier 1971; Hendrickson 1958), however, little is known about their behaviour in the submerged part of the life cycle. The senior author of this paper has spent many hours in the water with sea turtles off the beach of Fairfax Island, Bunker Group, Australia, where she observed and photographed their behaviour both prior to and subsequent to egg laying. All of the unique data in this paper are derived from her season with the turtles in 1967, although a few of the photographs were taken at later dates. The junior author has contributed only to the organization and preparation of the manuscript.

Methods

The primary method used was to swim with the turtles. A special paint compound (to be described more fully elsewhere) was developed that could be brushed on the shell of a turtle while underwater, and permitted identification of individuals over periods of a few weeks. The paint usually rubbed off or washed away in that length of time, although individuals could sometimes be recognized by the presence of paint even though the numbers could not be determined. At the beginning of the work the turtles were very easily upset by the presence of a swimmer in the water, but many of them gradually accepted the senior author after many hours of her constant presence. Mated pairs

were much more easily approached than single individuals, and paint was often applied then or to beached females while they deposited eggs.

Results

Sexual Behaviour

Courtship. The female is completely in control of whether mating occurs or not, because the males are almost continuously sexually aggressive during the breeding season, constantly patrolling off shore and in the lagoon, attacking any large object in the water. The female is not in a continuous state of receptivity, however, and has developed several mechanisms for avoiding copulation. There seems to be a vaguely hierarchical sequence of avoidance reactions by the females, and we arrange them here in apparent increasing order of significance. An unreceptive female will both swim and lie quiescent with the hind flippers carefully folded together in the position shown in Plate XVIII, Fig. 4 (top). Whether this is properly interpreted as a sign of rejection or not is uncertain, but the position is commonly assumed by females just returning from egg deposition or immediately after termination of copulation. Any female outside the 'female reserve' (see below) is certain to be approached by a male, and the male will mount immediately, if permitted. If she is not receptive, she swims away at a comparatively rapid pace, but, if pursued closely, she will circle quickly to face the male (also noted by Hendrickson 1958). Since the male prefers to approach her from behind, he swims out and around her circle, with the pair thus following an elliptical path through the water. She does not hesitate to bite him in the head or neck if he gets too close, and older

males are usually badly scarred from this and combat with other males. If her rejection is complete, she will usually use the vertical 'refusal' position (see below), which almost always concludes courtship. If she is caught in water too shallow to permit assumption of the refusal position, she will often beach herself. The males generally will not follow her, and even one which has successfully mounted but not yet penetrated the female will disengage rather than be dragged ashore, so beaching is a successful avoidance procedure. Males that have successfully engaged in copulatory penetration will remain in position even though the pair may be washed ashore. At least one female has been seen to leave the water on the lagoon side of the island and drag herself across the sandspit back to the water on the seaward side, to avoid pursuing males.

As noted above, females not interested in courtship will bite a courting male on occasion and can inflict a deep gash. But occasionally biting plays a role in the courtship, with the male nipping gently at her neck, pinching the skin lightly and releasing it. This type of bite can be seen in Plate XV, Fig. 1B. The female will sometimes respond by biting him in what appears to be a playful or certainly non-aggressive manner, and such an exchange of bites is almost invariably a prelude to copulation.

The unreceptive female rejects a courting male by assuming the 'refusal' position. As the male swims along behind her, she will turn toward him and assume a vertical position in the water, with the plastron facing the male, and all limbs wide-spread (Plate XV, Fig. 1A). Males treated in this way usually swim off and leave that female undisturbed. Acceptance of the refusal sign seems to be correlated with the availability of females, and a male that has accepted the refusal signal will sometimes return after cruising around the lagoon without locating a receptive female, or after finding all other females already mating. After such a cruise he is less likely to accept the signal again. This was verified several times by clinging to the tail of a male as he was repelled by a female, circled the lagoon, and returned to the original female with reinforced vigour. In the instance shown in Plate XV, Fig. 1A, the male pressed his attack until the female was forced back, and he seized the soft skin of her throat in his beak (Plate XV, Fig. 1B).

Sexually aroused males will pursue any large swimming object in the water, including skin

divers, but they generally respond to the same signal from a diver as from an unresponsive female, relieving an observer of the danger of harm from the heavy limbs. Occasionally the 'large swimming object' in the water is another male, but no male under attack by a second male has ever been seen to assume the 'refusal' position of a female. He will attempt to escape by frantic splashing, wild lunges, and bursts of speed. If caught, he generally manages to dislodge the aggressor by turning completely upside down.

Mating. During the 1967 season, the first turtle activity of the year to be recorded was a mating pair observed on 30 September. No females had been observed laying prior to that time, nor were there any tracks on the beach before 23 October. Matings were observed regularly, and almost daily, until 10 October. After that, copulation was seen on 16, 27 and 30 October, 3 November. No mated pairs were recorded after that date. The first record of egg laying is for 23 October. Thus, practically all observed matings took place prior to the period of maximum laying activity. A total of fifteen matings involving thirteen females was observed. No female marked while laying was seen mating on a later date. Since the mating activity reaches its peak before laying begins, and few matings are seen at the peak of laying, it seems very probable to us that fertilization takes place shortly before egg laying and in the same season, although we cannot substantiate this from dissections of the female genital tract.

The longest continuous observation of a mated pair was 6 hr. Copulation had already begun when this pair was first observed. Two females were each seen to mate twice in the lagoon at Fairfax, with intervals of 4 and 5 days. Only one male was seen to participate in more than one mating, with an interval of 4 days for the two records, but it is almost unquestionable that one male must copulate with a series of females during the mating season. During the 1967 season it was noted that females always outnumber the males in the Fairfax lagoon, sometimes as many as forty to one, and never lower than ten to one. Mounting of females may often occur near the surface of the water, but is not restricted to that area, nor is that necessarily the most frequent place for copulation. It has been observed on the sea bed, and mated pairs tend to keep to the bottom in murkier parts of the lagoon at Fairfax Island.

Several authors have noted either by observing from the shore (Harrison 1954; Hendrickson 1958) or from a low-flying airplane (Carr & Giovannoli 1957) that an unmated female is often accompanied by one to several males, referred to as 'attendant males' by Hendrickson (1958) and Carr & Giovannoli (1957). Such attendant males are also very commonly observed at Fairfax Island, but it does not seem to have been previously recorded that copulating pairs may often be accompanied by one to five males, here termed the 'escort'. The escort sticks close to the mated pair, circling about them, until finally one will attempt to dislodge the copulating male. The individual is usually fended off by the mated male, whose grip is extremely tenacious, but occasionally the attacker gains a foothold. This usually results in unbalancing the female, and all three will flop about until holds are broken. A female freed in this way will be approached immediately by members of the escort, but within the limits of the 1967 observations, she will only accept the original male. The escorts will leave a mated pair for an unattached female, and the senior author was so approached on several occasions (Plate XV, Fig. 1C). If she assumed the 'refusal' position of an uninterested female the escort would abandon the attack and returned to the mated pair. One male, easily recognized by the presence of a broad yellow stripe on his black-tipped tail, was observed repeatedly during the mating season, always either courting a female or as a member of an escort. The senior author became so familiar to him that she was able to grasp and attempt to dislodge his front flipper while he was copulating, but was quite unable to move it even slightly. The primary defence a mated male has against attacks from competing males from the escort is the strength of his grip on the shell of the female. While the attentions of the escort are generally directed at dislodging the mated male, that is by no means the sole method of attack. The sequence of photographs in Plates XVI and XVII (Figs 2 and 3) show a member of the escort who slowly and deliberately swam up to a mated pair and severely bit the tail of the copulating male. Severe damage to other parts of the male are often the result of escort attacks. Biting is the primary method of attack and is used by the female of a mated pair to defend against the escort. Spoczynska (1971) has remarked on the development of the biting habit in captive hatchlings of *C. mydas*, indicating that the young have the same pro-

clivities as the adults, although it may be only a feeding reaction in the juveniles.

Female Reserve. There is a section of the lagoon just east of Fairfax Island which is V-shaped, with the arms opening to the north, and variable in depth, from approximately 2 to almost 10 m. The bottom of this area is occupied only by resting females, lying on the sand. Unmated males appear to avoid the area, and do not attempt to mate with females within its limits. This area has been termed the 'female reserve.' Many females may rest there at one time. The males patrol around the area and may swim across it at or just below the surface. As soon as a female leaves the reserve, however, she is immediately courted by the circling males. Mated pairs may enter the reserve, and a pair resting on the bottom of the reserve is open to attack by a member of the escort, even though these unattached males will ignore other unmated females in the area. It is as yet unclear how the sanctity of the area is maintained.

Hatchling Behaviour

Feeding Behaviour. The feeding behaviour of hatchlings and young individuals was observed at Heron Island Research Station by tethering two individuals on nylon cord and watching them eat. These animals were kept until they were 4½ months old. They were seen catching and eating comb jellies and other ctenophores, pelagic tunicates, *Physalia*, *Verella* and *Porpita*. When these invertebrates were not available, the turtles would dive and attempt to bite chunks out of the oral discs of sea anemones.

Predators on Hatchlings. Hatchlings making their way to the sea after emergence from the nest are subject to heavy predation on the beach, and many terrestrial species will feed on them. Among the known predators previously mentioned in the literature (Bustard 1968; Frazier 1971) which will also take hatchlings on the beach at Fairfax Island are rats, gulls, white-breasted sea eagles and hermit crabs. Once the hatchlings have entered the sea, they are eaten by rock crabs and several species of fish. The black-tipped sharks, *Eulamia spallanzani* (Le Sueur), patrol the beaches on the lagoon side as well as seaward during the period of the hatch and thrash the water into a foam as they compete for the members of a hatch entering the water. The stomachs of several sharks caught on a line baited with a baby turtle were examined and showed from eleven to thirty hatchlings. The sharks examined were only up to about 1.5 m

PLATE XV

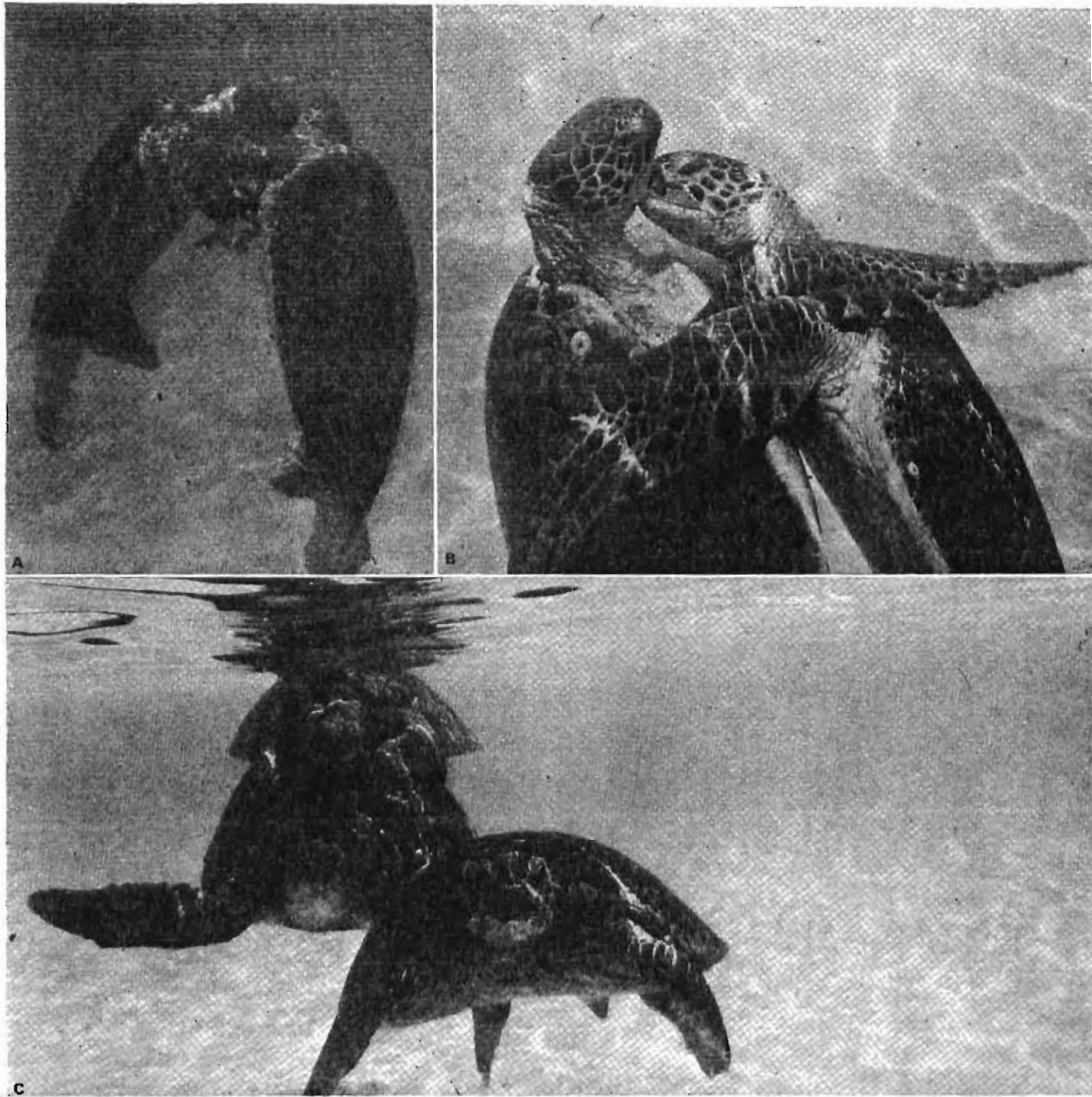


Fig. 1. (A) The 'refusal' position of the female, seen from the side with the male not completely accepting the signal. (B) The male, on the right, has not accepted the refusal position of the female, on the left. She is carried backward by the force of his charge, as he bites the skin in the gular area. (C) A mated pair, showing the grip on the grip on the carapace of the female, with the second male from the 'escort' approaching the photographer, who repelled him with the female 'refusal' position.

PLATE XVI

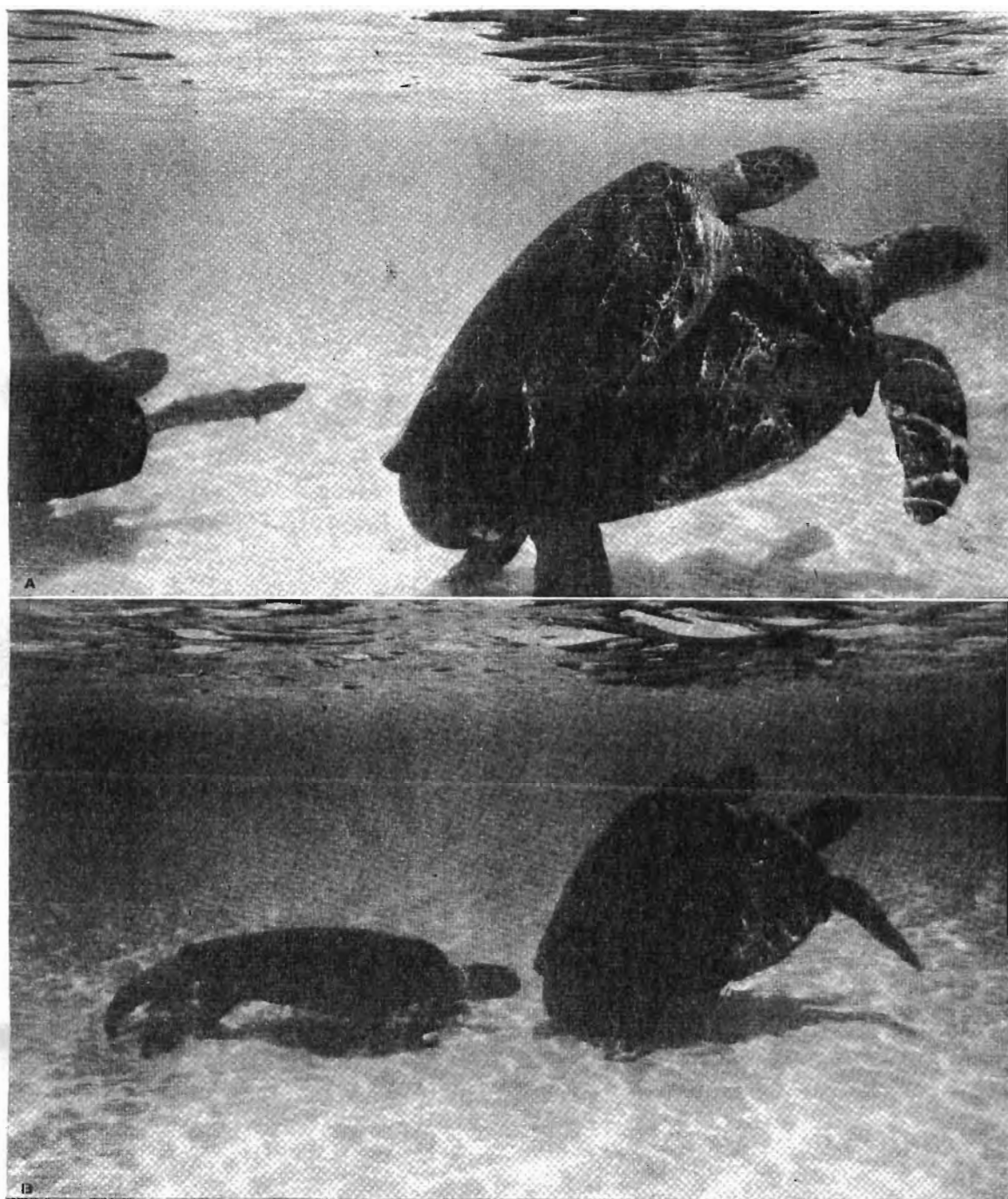


Fig. 2. A member of the escort at the left in (A) approaching the mated pair in (B).

PLATE XVII

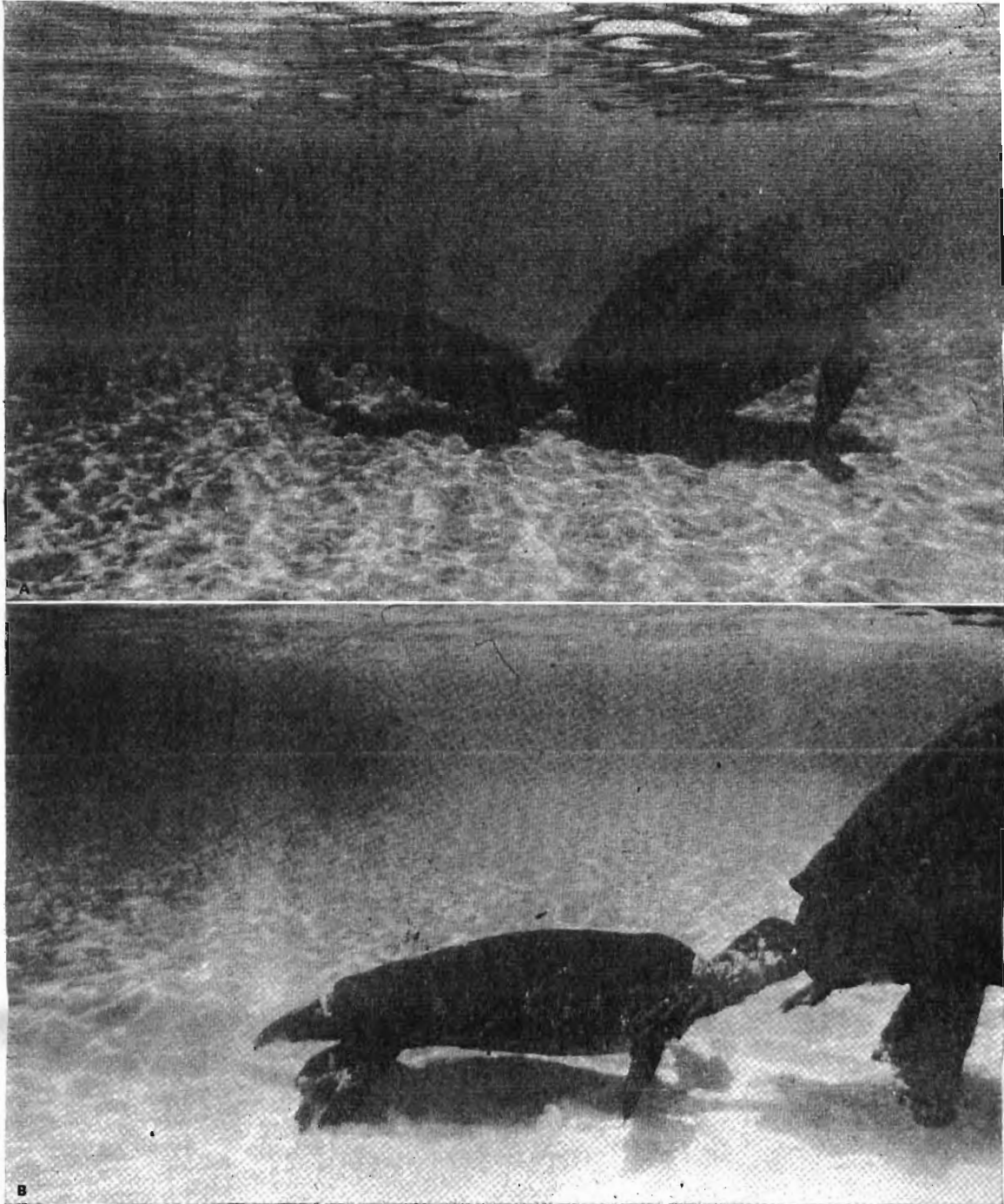


Fig. 3. A member of the escort touching the tail of the copulating male with his nose in (A) and biting the tail in (B).

PLATE XVIII

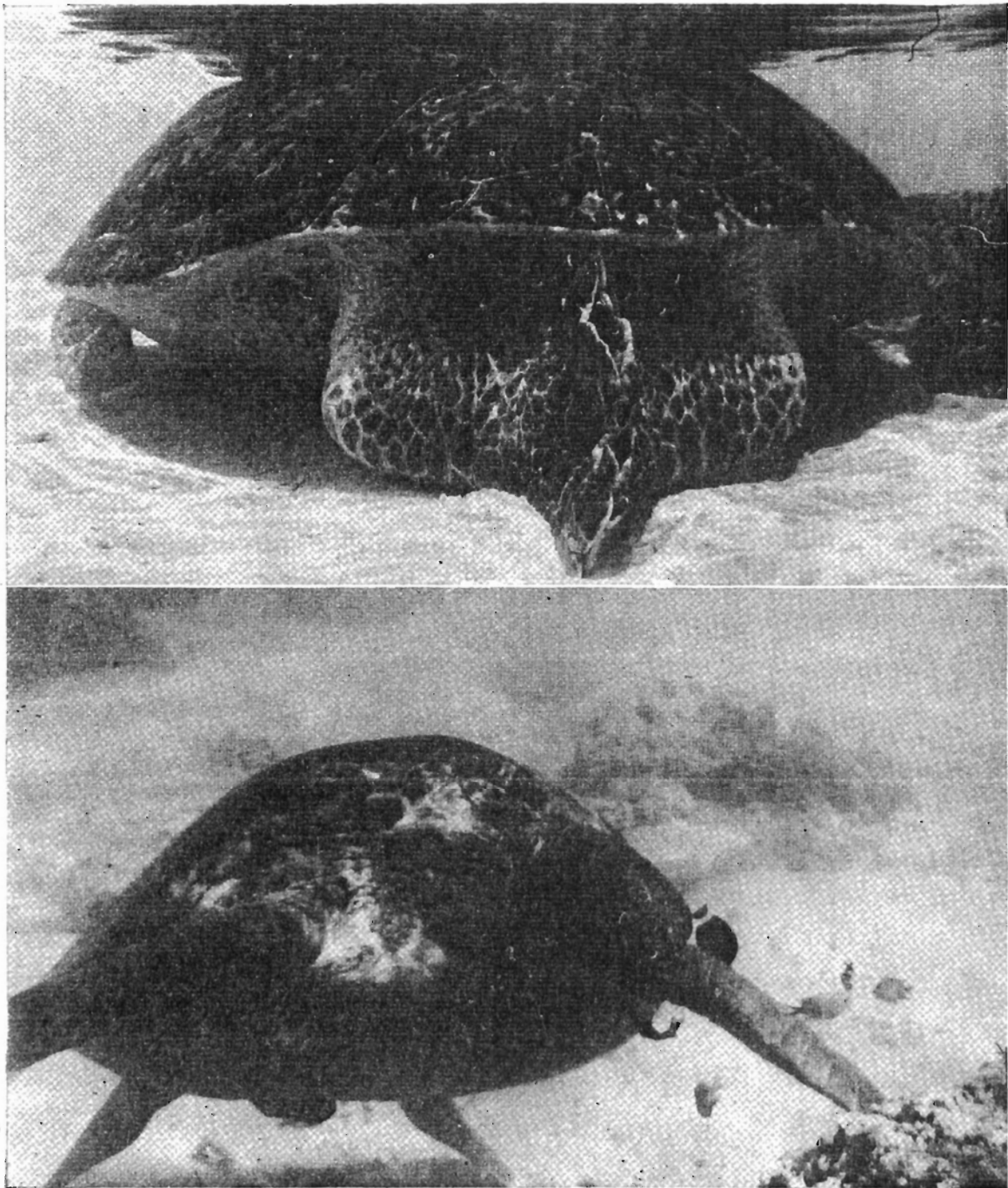


Fig. 4. (Top) A female *Chelonia mydas* at rest in the 'female reserve', with hindfeet in the position characteristically assumed after either laying eggs or copulating. (Bottom) A female in the 'female reserve' being groomed by cleaner fishes. The two principal species of fishes involved can be seen working on her neck and forelimbs.

in length, because larger ones could not be landed on this tackle.

Sedentary Habits and Movements

There is a small, sedentary population of turtles in the lagoon at Fairfax Island the year round. This includes hawksbills and loggerheads as well as green turtles. All species spend most of the time outside the breeding season resting in caves or under coral ledges. The male mentioned above, with the distinctively marked tail, is a permanent resident of the lagoon, and has been observed there throughout the year, when the female reserve is empty. He has been seen attempting to turn over rocks on the lagoon floor, presumably seeking food.

This sedentary population makes up a very small percentage of the breeding population, of course. Although many turtles were marked when laying eggs, few of them showed up later in the female reserve or elsewhere in the lagoon. This would indicate a continuously changing population during the breeding season. One female, F-32, was first marked in the lagoon at Fairfax Island on 15 October, while swimming about. She was then seen by other observers at Lady Musgrave Island, 5 km away, on 16 to 18 October. On 21 October she was back at Fairfax, and was seen resting in the female reserve. She was not seen laying eggs during this season but might have done so after the paint had worn off her shell, preventing recognition.

The prevailing winds in the lagoon are from the south-east. When the winds shift to the northern points of the compass, the lagoon turtle population shows a rapid decrease, regardless of wind velocity or condition of the sea. When the wind changes to any other direction, whether calm or with winds at gale force, the number of turtles in the lagoon sharply increases. It is suspected that they go under protective ledges of coral or well out to sea beyond the reef at the times of decrease.

Miscellaneous Observations

Commensals. Just as are some fish, green turtles are groomed by cleaner fishes (Plate XVIII, Fig. 4, bottom). The first observation of this was made when a large female was seen in a stationary position midway between the surface and bottom in a large coral pool near the reef edge, with two species of fish grooming her. About a dozen *Abudefduf sexfasciatus* (Lacépède) were plucking algal growths from her head and plastron, while several moon wrasses, *Thalassoma lunare* (Linnaeus), were picking at small barn-

acles attached to the skin of her neck. The female would arch her neck first to the right, then to the left, apparently to stretch and tighten the skin and provide access to the barnacles for the fish. This behaviour was subsequently observed many times, and stomach analyses of the wrasses showed the presence of barnacles.

Luminescence. During a night observation of a copulating male, the placement of the plastic-coated measuring tape along the curve of the carapace produced a strong line of luminescence. Any additional contact with the carapace also triggered luminous flashes. The source of the luminescence was not discovered.

Egg Deposition on Fairfax Island

While this paper is concerned primarily with activities of the green turtle in the sea, the senior author has extensive observations of females on the beach, and we briefly summarize them here. Both green turtles and loggerheads lay eggs on the island, with activity reaching its peak in December and January and then tapering off. Hawksbills have never been seen to lay eggs on the island, although they are almost constantly present in the resident population. In the records for the 1967 season, the first egg deposition occurred on 23 October, and observations continued almost daily until 27 December. All females seen laying were marked, and individuals with paint traces were recorded as repeats, even if the number could not be determined. During the period a minimum of 175 turtles laid eggs. Maximum counts on any 1 day were eighteen on 15 November, and sixteen on both 5 and 18 December. On both the 15 November and the 5 December two of the females had laid previously. In the eight cases where it was possible to identify an individual who had laid eggs on different days, the longest time span between the first and last observation was 24 days. Part of the area used by laying females was repeatedly washed away by cyclones during the 1967 breeding period and built up again afterwards by the action of the sea.

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