THE DIAMOND-BACK TERRAPIN
IN NORTH CAROLINA

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VALUE AND LOCAL FISHERY

Of marine and estuarial turtles only the diamond-back terrapin has had significant commercial history in North Carolina. Occasionally the valuable green turtles are taken, particularly the smaller ones, or “chicken turtles”; but the green turtle is here near the northern limit of its normal range. Pope (1939) says, however, that it was abundant in the North Carolina sounds before it was “decimated by turtle-hunters during the nineteenth century.” The generally large loggerhead turtles are much more common but are not a market item. Some persons locally eat and esteem them. The loggerhead is the only sea turtle that habitually lays eggs on the beaches of our region. Its interest to North Carolina is for the material it readily affords for scientific studies of development and growth. The smaller Kemp’s gulf turtle or “bastard turtle,” sometimes, unfortunately, called “hawksbill,” is found occasionally but is not valued. The true hawksbill, or tortoise-shell turtle, valued for its heavy covering of richly colored shell, has rarely been recorded from the Carolinas. The largest of all turtles, the trunk turtle or leatherback, is rare in our waters and without known commercial value in this country.1 We are not concerned here with the freshwater snapping

1. In Fishery Statistics of the United States, 1945, green turtle was reported from Florida (12,800 pounds, valued at $1,120) and Louisiana (9,300 pounds, valued at $1,395). Loggerhead turtle was reported as a commercial product from Florida in the small amount of 15,000 pounds, valued at $1,645, and Virginia, 7,400 pounds, valued at $400. The hawksbill was marketed from New Jersey in the amount of 800 pounds, valued at $8. However esteemed “green turtle soup” may be, it is evident that sea turtles are commercially insignificant.
turtles, used for "snapper soup," or with strictly freshwater terrapin, or "sliders," although the latter are sometimes improperly substituted for diamond-backs (Coker, 1906, and Pope, 1939).

The diamond-back terrapin is primarily an estuarial species, occurring along the entire Atlantic and Gulf coasts in brackish water and even occasionally in the rivers above the reach of salt water. It is our only turtle characteristic of brackish waters. It is not found in the sea. All evidence gained from observation in nature and from breeding experiments indicates some dependence upon fresh water. There is as yet no fully satisfactory explanation of its restriction in distribution to brackish water and to only the lower reaches of the fresh waters of certain rivers. Possibly it is a matter of feeding habit, its accustomed food being such as is dependent upon the presence of salt water and the flow of tidal currents. Hay (1904) reported that terrapin have been found in the Potomac as far up as within four miles of Washington. The terrapin themselves are not dependent upon salt water surroundings. I and others have had them live and thrive in captivity, in pens supplied only with water from an artesian well, but in such case they were fed with salt water fish. On the other hand, I have tried to keep them in Mississippi River water in Iowa, where they were fed only freshwater foods; the terrapin survived only a few months (Coker, 1920).

At one time large diamond-back terrapin were per pound the most valuable food product from coastal waters (in the retail market). Measurement of size is by the length of the under-shell, called the plastron. It is a large individual, and always a female, that has the undershell 6 inches in length. Such terrapin might sell at $50 or $60 a dozen. Hildebrand and Hatsel (1926) reported the Boston market price as one dollar per inch of bottom shell; this gives a rate of $72 per dozen for 6-inch terrapin. Larger terrapin up to 7 or 8 inches would bring higher prices. The length of 8 inches on the bottom shell is rarely exceeded and the maximum is believed to be about 9 inches. A leading dealer in the Baltimore market told me of selling two terrapin to a regular customer, whom he named, for $25. Value in the connoisseur market depends not only upon the size but also upon appearance.

Standards of appearance are not precisely describable, but are based primarily upon recognition of the so-called "Chesapeake" type, with the top shell (carapace) flaring behind (widest behind the middle), the head small and relatively pointed, coloration rich and usually dark, the concentric markings on the plates (scutes) of the carapace evident. A terrapin of equal size to the "Chesapeake" but with more nearly parallel sides, larger head, generally lighter or dull color, and smoother shell, would bring a substantially lower price. This would be branded a "Carolina" type, although, as will be seen below, both types occur in North Carolina and probably in the Chesapeake.
What has been said about market values was more generally applicable before World War I. The war, with its immediate inhibitions in respect to luxury foods, and prohibition, with its discouragement of gourmanderie, came together, but the latter long outlasted the War. At any rate, the use of terrapin stew as the gourmet’s delight has never come back in full force and the fancy market for terrapin seems not to have had a complete revival. By those who know, however, the superior flavor of the meat of select terrapin is not generally questioned. Consequently, there remains the possibility that diamond-back terrapin will sometime come back into high favor, if not to its former place of topmost esteem. In the North Carolina fishery at this time the terrapin is without significance.

Emphasis has been placed upon size in respect to price. Larger terrapin have greater weight, of course, but the higher value of large terrapin is based not so much upon poundage as upon presumed quality. It has always been assumed, whether correctly or not but probably correctly, that quality of meat and its flavor improves with age and size. Either younger or smaller terrapin, although highly toothsome, are relatively inferior in flavor. All male terrapin, being small, are thus excluded from the selects. The largest male of record in the terrapin experiments at Beaufort was reported as having a length on the bottom shell of 4½ inches, and the largest wild male found measured 4⅔ inches. The average undershell length of males was about 4 inches, a substantial proportion being smaller. It is doubtful if any male ever attains the “legal” minimum length for capture and sale—5 inches.

It is a long time since there was in North Carolina a particular fishery for terrapin (Coker, 1906). Occasional individuals are taken by chance in seine hauls or sighted in passing. At the time of the beginning of the experiments in terrapin breeding at Beaufort (1902), there was only one man in the Beaufort region known particularly as a “terrapin hunter.” Working in a small skiff he would pole his boat through the creeks and marshes, looking with keen eyes for a terrapin under water or a head projected above the water and capturing terrapin now and then with his dip net. In his own

2. Not everything served as “terrapin stew,” or even as “diamond-back stew,” is made from diamond-back terrapin. “Sliders,” and sometimes even “chicken,” may be substituted for the more expensive diamond-backs.

3. In the Government statistics for 1945 (Anderson and Power, 1949), diamond-back terrapin were reported as marketed from the following States:

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<tr>
<th>State</th>
<th>Pounds</th>
<th>Value</th>
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<tr>
<td>Maryland</td>
<td>370,000</td>
<td>$108,000</td>
</tr>
<tr>
<td>Virginia</td>
<td>27,500</td>
<td>6,875</td>
</tr>
<tr>
<td>North Carolina</td>
<td>2,700</td>
<td>675</td>
</tr>
<tr>
<td>South Carolina</td>
<td>500</td>
<td>125</td>
</tr>
<tr>
<td>Georgia</td>
<td>7,500</td>
<td>5,625</td>
</tr>
<tr>
<td>Florida</td>
<td>5,400</td>
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Obviously, the price per pound to fishermen is figured at 25 cents, except for Georgia (75 cents) and Maryland (about 29 cents).
words, and in good Elizabethan and original coastal English, he spent his life "perusing the creeks and propping the marshes." In earlier times in North Carolina the "drag-net" was employed in taking terrapin. In South Carolina I have been told of dogs trained to hunt terrapin in the marshes. Another method was to sail small boats through "creeks" or sloughs in the marshes, knocking occasionally on the bottom of the boat and looking for any nearby terrapin to raise its head above the surface of the water, presumably to look for the source of the sound. According to local informants terrapin are now fairly numerous in the Beaufort area, being taken frequently in shrimp nets used in inside waters. They are usually liberated for lack of local markets.

Terrapin caught by chance or as the result of search were taken to a dealer. Paid for at small prices, these were kept alive in boxes or barrels or, rarely, in pens, until shipping time in the fall. Even undersized terrapin, including the males, called "bulls," and the small females, known as "hens," were not excluded from shipment to bring profitable if not fancy prices, say $12 to $15 a dozen. So far as I could tell, the unrealistic legal restrictions with respect to sizes and to holding in confinement during the breeding season (April 15 to August 15) were not observed.

In the conditions under which terrapin were generally kept, feeding was hardly practicable. Since terrapin can live without food for long periods of time, the lack of food probably caused little if any harm other than to prevent the slight increase in size and value which the very slow-growing animals might have gained if kept under proper conditions. It would have been better, however, if the law had sanctioned and the dealers been inclined, to keep, feed, and water the terrapin in open ranges, used in other states and known as pens, pounds or, more commonly, "crawls." There were then extensive "crawls" at Crisfield, Md., and at Savannah, Ga. Subsequently, in 1913, State authorization was received for the establishment of the Beaufort Terrapin Farm at Beaufort, N. C., under the leadership of Dr. Charles Duncan. This company, to quote Dr. Hildebrand (1929, pp. 26, 27):

"...built concrete pounds and a terrapin nursery house and provided itself with all the facilities necessary for raising terrapins. A large brood stock was obtained, and within a few years from 15,000 to 20,000 terrapins per annum were being hatched. This farm progressed nicely until the beginning of the World War and the adoption of the eighteenth amendment to the Constitution. The cost of labor was more than tripled locally, the market value of terrapins dropped, owing to the general curtailment of the use of luxuries during the war, and it seems to have been believed by the manager that under prohibition terrapins never again would be in demand or command the fancy prices paid for them prior to prohibition and the war.
In view of these seemingly adverse circumstances, the breeding terrapins as well as some of the young that had attained a marketable size were sold, and in 1918 the plant virtually was abandoned. The Beaufort Terrapin Farm was patterned after the experimental plant of the Bureau of Fisheries, and the success attained in raising terrapins compared very favorably with that of the Bureau of Fisheries.

A contributing cause for discouragement to the company was the fact that the heating system for the nursery house was designed for use of anthracite coal, which was unobtainable in Beaufort during the war.

As regards the deprivation of food for terrapin during long periods of confinement, it may be remarked that it is a condition of the preparation of terrapin for the table that they should have been starved for a considerable period, in order that the digestive tract may be entirely empty. Before cooking or serving, terrapin are cleaned only on the outside by scalding for removal of the outer skin and the horny covering of the shell and jaws; after further cooking, bottom and top shells and the head are removed to be used for the soup; only the gall bladder is then discarded; all the remainder goes into the stew.

**KINDS OF TERRAPIN**

Diamond-back terrapin occur along the Atlantic and Gulf coasts from Buzzard's Bay to Texas, but systematists have recognized distinct species on the Atlantic coast and the Gulf coast and several subspecies. The species *Malaclemmys pileata* (knobbed terrapin) occurs along the Gulf coast with fairly distinct subspecies for, respectively, the region of the west coast of Florida, an intermediate zone westward to the mouth of the Mississippi and the westernmost territory from the Mississippi to and including the coast of Texas. All the Gulf coast terrapin can be distinguished from terrapin of the Atlantic coast south to Florida by the prominent knobs or tubercles on the plates of the middle part of the upper shell.

On the Atlantic side the species *Malaclemmys centrata* (Latreille) occurs from Buzzard’s Bay, Massachusetts, to Florida; but two subspecies are recognized in this area. The species *centrata* proper is found from the region of Cape Hatteras to Florida. The range of the subspecies *M. centrata concentrica* (Shaw) is from the Hatteras region northward to Massachusetts. The estuaries of North Carolina are therefore within the ranges of both the southern species proper and the northern subspecies: both “Chesapeake” and “Carolina” terrapin are native to the State. The species *centrata* is believed to have been described from terrapin from Charleston, S. C., *concentrica* from examples from Delaware Bay.

It must be understood that there is no sharp line of division between the
described subspecies. Apparently the diamond-backs have to a considerable extent developed characteristic ecological forms or varieties in response to environmental difference or to geographic isolation. Dealers have always recognized geographic varieties: "Connecticuts," "Long Island terrapin," "Delaware Bays," "Chesapeakes," and "Carolinas" (Hay, 1905). South Carolina terrapin are considered inferior to North Carolina terrapin, and Florida terrapin are still less prized. The term "Florida terrapin" in the market has, however, generally been applied to the Gulf species found on the west coast of Florida. I have been told by a well-informed dealer that historically the Long Island terrapin were the premium terrapin of the market. As the limited supply was depleted, Delaware Bay terrapin assumed first rank. Somewhat later, but perhaps a century ago, the less exhaustible supplies of the Chesapeake areas of Maryland and Virginia came to the front and have held top rank ever since.

How extensive was the practice, it cannot be said, but it was certainly not uncommon in the past for terrapin to be sold from Georgetown, S. C., to a dealer in Wilmington, then passed from Wilmington to a dealer in the Beaufort, N. C., region and thence to Crisfield, Md. Thus, terrapin from South Carolina might finally reach the city market as "Chesapeakes." Doubtless the more expert fanciers, being able to recognize the varietal distinction, were not always misled. In later years the "Carolina" terrapin gained in market favor, particularly those not markedly different from terrapin of the Chesapeake area, and shipments were generally made direct from North Carolina dealers to the largest city markets (Coker, 1906, and Hildebrand, 1929, p. 28).

The distinctions between "Chesapeake" and "Carolina" diamond-backs have been given on page 220. In regard to their respective distributions, several qualifications must be made. In the first place, the terrapin of any region are so variable in form that strictly dependable classification of individual terrapin is often impossible: both "Chesapeakes" and "Carolinas" occur outside of their respective "book" ranges. Second, since the supposed limits of the subspecies are within the State of North Carolina, terrapin of either type would be expected to be native to the State. Thirdly, through long periods of years southern terrapin have been shipped in quantities from southern to northern coastal points to be held for months in captivity, and many escapes must have occurred to give opportunity for the mixing of types beyond that provided by nature. Finally, in the culture of terrapin at the U. S. Fisheries Laboratory at Beaufort, large numbers of Chesapeake terrapin have been imported and bred and have been allowed to hybridize with native North Carolina terrapin (Hildebrand, 1929 and 1933). The young reared from both stocks and their hybridization have been widely distributed to all coastal states from Delaware to Alabama, and
to Louisiana, New Mexico (!) and California. 4 The immediate geographic source of a terrapin brought to market is now, therefore, even more than in the past, no reliable indication of its type.

EXPERIMENTAL PROPAGATION

The question of exhaustion of a self-reproducing actual resource is not always one that is easily answered with assurance. It would, however, seem unnatural if an animal as highly valued and as eagerly sought as the diamond-back terrapin, as limited in distribution (to estuarial areas), as weak in reproduction, as slow in growth and as helpless against man, had not suffered serious depletion in two centuries of search, capture and destruction. While exact quantitative data were not available, it was not doubted at the turn of the century that the more northern areas of fishery had been depleted of terrapin for many decades, that even the extensive Chesapeake area had long had greatly reduced population, and that the North Carolina terrapin were reduced almost to the vanishing point. At any rate, at the beginning of the present century, two definite moves were undertaken to replenish the supply by propagating terrapin under artificial conditions.

In 1902, studies and experiments were begun at two places—in the Chesapeake Bay area at Lloyd's, Md., in charge of Dr. W. P. Hay, and at Beaufort, N. C., under the direction of the present writer assisted by Mr. Charles Hatsel. These were prompted by the late Dr. Hugh M. Smith, in charge of Scientific Inquiry in the United States Fish Commission 5 and the late Professor Joseph A. Holmes, State Geologist and Director of the North Carolina Geological Survey. 6 The experiments and studies at Beaufort were at first supported cooperatively by the Federal Government and the State. The early studies at Beaufort resulted in part in the publication of Bulletin No. 14 of the Geological Survey (Coker, 1906). In 1904 the support of scientific work at the fisheries station by the State was discontinued. Although the small terrapin stock at Beaufort was kept and maintained by the custodian of the laboratory, Mr. H. D. Aller, and Mr. Hatsel, the Government's emphasis was shifted temporarily to the Chesapeake. In 1909 the activities and breeding stock were transferred to Beaufort, Dr. Hay continuing to give general direction until 1915. During this period Mr. Aller planned and carried out the significant new undertaking of winter-feeding of yearling terrapin in warmed nursery houses. Guidance of the work was later in the hands of the successive Directors, Lewis Radcliffe, S. F. Hildebrand, R. L. Barney, and

5. Part predecessor of the present U. S. Fish & Wildlife Service.
H. F. Prytherch. All concerned with the undertaking would subscribe fully to Dr. Barney's statement (Barney, 1922):

"The large share of credit for the continuity and the accuracy of the observations of the entire experimental terrapin propagation project is due to Mr. Hatsel for his exceptionally careful, energetic, and faithful work."

In all, the Fisheries Station at Beaufort, up to August, 1949, had hatched and distributed 249,373 young diamond-back terrapins. Distribution was very wide, as previously mentioned. At the recent close of the experiments older terrapin including brood stock were distributed.

Although many questions in regard to the terrapin remain to be answered, a vast amount of information has been gained in the long-continued experimental and propagational work at Beaufort. The results are embodied in the papers cited in the bibliography by Hay (1904 and 1917), Coker (1906), Hay and Aller (1913), Barney (1922), Hildebrand and Hatsel (1926), and Hildebrand (1929 and 1933). Only a brief summary of results need be included in the following paragraphs.

NATURAL HISTORY AND PROPAGATION

The diamond-back terrapin lives in the zone between pure fresh water and pure salt water. It can pass into and out of the water, but seems habitually to live in the water, coming on the beaches principally in the season of laying to form nests for its eggs on the sand. Without such strong jaws as have the freshwater snapping turtles or the loggerhead sea turtle, it must feed upon such small mollusks, crustacea and other small animals as it can find (Coker, 1906; Hildebrand, 1929). A readily available food in the marshes and along shore in brackish waters is the periwinkle, a small snail, and this was the chief item of food found in the stomachs of wild terrapin that I have examined. Hay, 1904, says that shoots and rootlets of marsh plants are eaten to some extent, as well as insects when available in time of high tides. There are needed more extensive studies of the food of terrapin, as this may well have much to do with the peculiar and esteemed flavor of the meat.

In the breeding pens at Beaufort practicable feed has been found to be chopped fresh fish, including menhaden and low-priced or unsalable foodfish of various kinds, crabs, shucked reef oysters and clams. The cost was found to be about 6 cents per head for a year. Small mollusks and fiddler-crabs were also eaten. Salted mullet was not taken unless the terrapin had been starved. Vegetables of various kinds were tried but they were not eaten by the terrapin. It was thought advantageous to supplement the usual fresh-fish diet from time to time with oysters, clams, and crabs. A supply of fresh water for drinking seemed desirable.
Egg laying is accomplished on sandy beaches—which generally are not too abundant in areas of salt marshes. In late spring or early summer (May, June, and July at Beaufort in the artificial pens) the female using her hind legs excavates a jug-shaped cavity about 3 inches in diameter and 6 to 8 inches or more in depth. In this she deposits a number of eggs. Five to about 15 eggs have been found in a nest, but a female may lay 4 or 5 times. The cavity is then filled, the eggs being covered to a depth of several inches, and the sand tamped down. After the female makes the nest inconspicuous by crawling back and forth over it, the eggs are left to their fate. Hildebrand concluded that, under good conditions of terrapin culture, about 12 eggs per female per year may be expected.

In the experimental pounds terrapin may begin laying at about 6 years of age and continue to do so for at least 10 years. Annual mating is not required, since female terrapin have facilities for retaining sperm in good condition for several years. Females isolated from males after mating produced fertile eggs for four years, although the proportion of fertile eggs diminished rather rapidly after the second year. Since a male may fertilize several females, it is not necessary to keep for breeding purposes an equal number of males and females: one male to 5 females seems to be adequate. As a matter of fact, in the breeding pens at Beaufort the sexes, without selection, developed in about this proportion.

The period of incubation of the eggs is about 90 days, varying with temperature and other conditions. The exact duration is difficult to determine, since the young do not usually emerge from the nest until several days after hatching. The newly-hatched young, about 1½ inches (27 mm.) on the bottom shell are relatively helpless, and may fall easy prey to crabs, fish, birds, and rats. What the survival rate during the first year may be in nature is quite unknown. In respect to survival in the experimental pens, under conditions of substantial protection from most enemies, Hildebrand (1926) reported that about 60 per cent of the terrapin hatched came to maturity, a reasonable proportion in comparison with the survival rate in poultry production. The mortality rate in nature may be presumed to be much higher.

The chief causes of mortality in pens were disease and unpreventable depredations of enemies, chiefly rats; some possibly escape. The common diseases were described as “sores,” referred to by Hildebrand as cancerous, “soft-shell,” associated with failure to eat and subject to rapid recovery, and “limber-neck,” a form of paralysis from which recovery is rare.

Young terrapin in nature or in confinement, unless kept warm, were not observed to eat; there is, then, no growth in size until the spring of the following year. It was found at the Beaufort Laboratory, however, that if the baby terrapin are kept in warmed nursing houses during the first
winter, they would mostly remain active, feed and grow during the winter. By the following spring they were about the size of year-old terrapin and had thus been put forward about one year toward maturity. They could be kept from hibernating in following winters and fed as during the first winter, but the gain after the first winter was not considered sufficient to justify the expense.

In rearing terrapin in open pens, space requirements will depend in part upon the nature of the area, and especially upon the clearness of the water and the regularity of its change by tidal action or other cause. "The main consideration," says Hildebrand (1929, p. 66), "is the provision of sufficient room to furnish the necessary sanitation." He thought that under the conditions existing at Beaufort 100 animals could safely be grown to maturity in a pen 5 x 22 feet. This would allow about 1.6 square feet per terrapin.

The sexes are externally indistinguishable in the first few years of life, although adult males and females are markedly different in size and form. While females may attain a length on the lower shell of 7 or 8 or even nearly 9 inches, males rarely exceed 4½ inches in such measurement. They are thus quite diminutive in comparison with the larger females with which they may mate. Males are also flatter, and the top shell is rather more wedge-shaped behind. The heads are smaller and more pointed, and the tails are very much larger and heavier because of the included penis. It is only when males are about four years old, with an undershell more than three inches long, that they are readily distinguishable.

Males grow more slowly, but females are too variable in growth for size at a given early age to be a criterion of sex. In a particular brood, that of 1912, about one-eighth of the females had attained the "legal" length of 5 inches (125 mm.) in the sixth year, when the largest male was 4 inches. A little over 50 per cent of females had a 5-inch undershell in the eighth year and 82 per cent in the thirteenth year. The smallest female of the lot in that year was about 4½ inches (115 mm.). A length of 6 inches was first attained by a female in the thirteenth year. The gain in undershell length per year after the eighth year is measured in millimeters, one or two. Unless the rate of growth in nature is much more rapid than it is in confinement with regular feeding, it may be assumed that a 7-or 8-inch female, rare in nature, but of highest value in the market, is from 20 to 30 years old at least. It would seem to require 10 to 20 or more years to add an inch in length after about the tenth year (data gathered from tables in Hildebrand, 1929).

The results obtained with different yearly broods were variable, but generally not markedly different. In the case of the brood of 1910, however, a female (or, perhaps, more than one) was over 6 inches in the sixth year. Nine years later (1925) the largest female was 6¾ inches (165 mm.),
indicating a gain of 11 mm in 9 years. Probably North Carolina terrapin do not often attain an undershell length much exceeding 5\(\frac{1}{2}\) inches. It is a well known fact that for many animals there is an inverse relation between size and temperature during development. Animals of the same species may attain larger sizes in more northern and colder waters.

On the other hand, among individuals of any given brood, the variability in growth is extreme. Coker (1906), Hildebrand and Hatsel (1926), Hildebrand (1929), and others, have remarked on the extraordinary variability of turtles in respect to rate of growth.

**SUMMARY**

1. The diamond-back terrapin, once the most valuable (per unit) food product of the coastal region, has depreciated greatly in value since the time of World War I but there are indications of continued esteem and perhaps of substantial recovery in market value.

2. Presumably in consequence of exhaustive fishery the populations have been seriously depleted in northern waters and in North Carolina. Production in the State is now negligible.

3. The waters of North Carolina in northern and southern parts are within the respective ranges of terrapin of the "Chesapeake" and "Carolina" types.

4. Cultural experiments have been conducted at the U. S. Fisheries Biological Station, Beaufort, N. C., since 1902, but chiefly from 1909 to 1948. Although over-all direction of the experiments has undergone many changes, and several scientists have contributed substantially to this development, great credit for continuity and success must be attributed to the late Captain Charles Hatsel of Beaufort for most efficient care from the beginning in 1902 until his retirement in 1947.

5. Terrapin are readily kept in confinement for breeding and rearing at relatively small expense for food. Data are available in various publications regarding space requirements, sex ratios, diseases and mortality, and rate of growth. Keeping newly hatched terrapin in warmed nursery houses and feeding them during the first winter, not only reduces mortality during the period of greatest helplessness, but also enables the terrapin to make two years growth in one year.

6. If a high market price can be depended upon, there is promise in the breeding and rearing of diamond-back terrapin in privately managed terrapin farms.

7. In spite of much scientific study, particularly under conditions of propagational experiments, there is still a paucity of information regarding the natural history of terrapin in the wild. There is particular need of fuller
quantitative studies of the natural food in different geographic areas and the relation of food to flavor.

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