

GROWTH OF DIAMOND-BACK TERRAPINS SIZE ATTAINED, SEX RATIO AND LONGEVITY

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(Figs. 383-384)

INTRODUCTION

The studies and experiments upon which this paper is based were carried on at the U. S. Fisheries Biological Station, Beaufort, N. C., and some of them were undertaken as early as 1909. Although the present writer did not participate in the work prior to 1914,² the data from the beginning of the experiments are at his disposal and are drawn upon freely. This report, therefore, is based on experiments conducted from 1909 to 1931 when the writer's connection with the work terminated.

The animals used as a broodstock in the experiments mostly were caught locally and may be referred to as Carolina terrapins for convenience. Two subspecies, namely, *Malaclemmys centrata centrata* and *M. centrata concentrata*, however, are involved, as explained by the present author (1929, p. 27).

GROWTH

Various experiments pertaining to the care and winter feeding in a nursery house were conducted and are reported upon by the writer at some length in another paper (1929, pp. 44 to 54).

It is sufficient to say here that in general a year's growth is gained by feeding the young during their first winter. Incidentally, mortality too apparently was greatly reduced. Older terrapins, that is, animals in their second and third years, did not respond to winter feeding as favorably as the recently hatched ones. While no harmful effects from the prevention of hibernation were noticed, the increase in size was so small that winter feeding of the older

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² The terrapin cultural experiments at Beaufort were under the general supervision of W. P. Hay, of the Washington, D. C., Public Schools from 1909 to 1915.

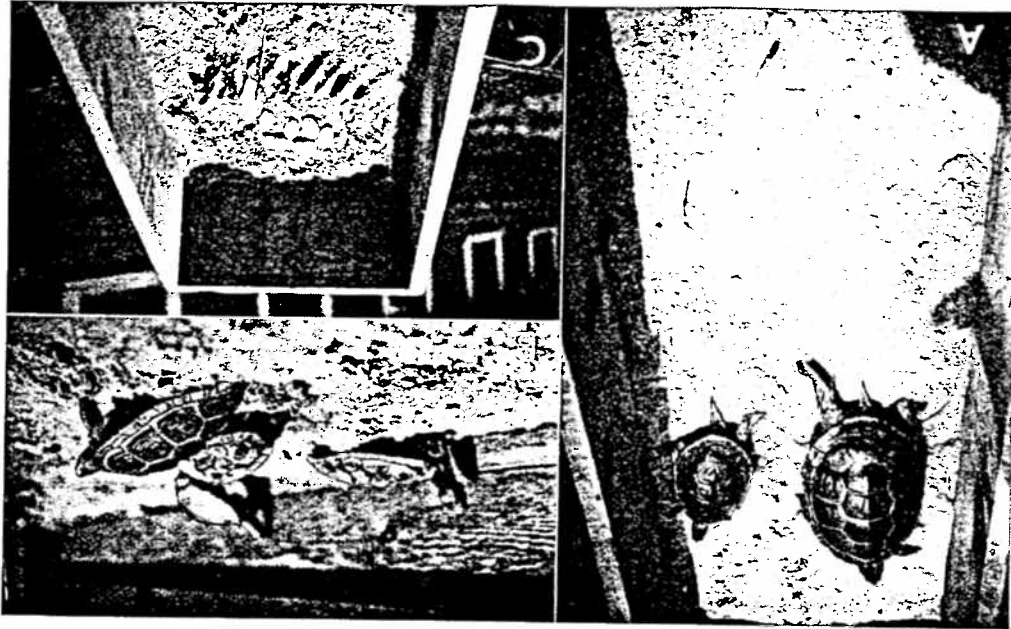
animals obviously is not feasible from an economic viewpoint. Nearly all the terrapins grown to maturity in captivity, therefore, either were allowed to hibernate each winter or were fed only during their first winter. It is principally with the growth and development of the animals after an age of about one year is attained that this report concerns itself. The general treatment and conditions provided were about the same for all lots considered and the feed consisted of chopped fish, occasionally mixed with blue crabs.

The active annual feeding and growing period of terrapins is comparatively short. At Beaufort the animals sometimes become active in March, if the season happens to bring warm days. However, they seldom are continuously active and feed regularly before about the first of May. Egg laying commences very soon after the terrapins become active in the spring, and it continues for several weeks. The earliest date on which laying has been observed is May 6, and the latest one is July 31. Some females lay only once during the season, others lay two and three times, a few lay four times and rarely five times. The usual number of eggs laid at one time is eight, and the average incubation period is close to 90 days. By the first to about the middle of October the terrapins again become inactive and cease feeding. The animals are so sensitive to temperature that even during cool days in mid-summer their capacity for food consumption is markedly reduced. It perhaps is superfluous to say that growth stops as soon as feeding ceases.

While the annual growing period lasts only about five or six months (at Beaufort), the life growing period is a long one, and it varies greatly among individuals as well as among different lots and broods. A few animals have attained a length of five and one-half to six inches (on the median line of the plastron) in six years. Other individuals have required more than twice that length of time to attain such a size.

The older broods, that is, the lots hatched in 1910, 1911 and 1912, grew comparatively fast until the age of eight or nine years was reached. Thereafter, the rate of growth was so slow that the present writer (1929, p. 57) was led to make the statement that it probably would not be profitable in commercial terrapin culture to retain the animals after an age of eight to ten years was attained. However, some of the younger broods have grown more slowly during the first eight or nine years of life and accordingly needed a

Fig. 383 A. Diamond-back terrapin (*Malaclemys centralis*): left, adult female; right, adult male. The males are much smaller than the females and are correspondingly less valuable. Fortunately, from a commercial standpoint, the males have been greatly in the minority among terrapins grown in captivity. B. Female in foreground on nest. To make the nest, a jug-shaped hole five or six inches deep is dug with the hind feet in the moist sand in which the eggs are deposited and then covered with the sand previously removed. C. Diamond-back terrapin eggs. The eggs are elongate and have a very tough, leathery case.



greater length of time to reach a marketable size.³ Two lots of the 1916 brood, the slowest growing of any terrapins raised in captivity, apparently were gaining growth more rapidly during their twelfth year than during their eighth and ninth years. It is to be noted, also, that even at the age of twelve years only thirty-nine of the seventy-four females (52.7 per cent.) in one lot and forty of seventy-four (54.0 per cent.) in the other one were 125 millimeters (5 inches) or more in length. Therefore, many of the animals were still definitely below a marketable size at the age of twelve years.

The other younger broods on hand grew somewhat more rapidly than the 1916 brood. Yet it is evident from the accompanying tables that it would have been decidedly advantageous from a commercial standpoint to retain most, if not all, of the animals until an age of ten or even twelve years was attained.

The tables offered herewith are based upon lots of the broods of 1916, 1919, 1920, and 1922. For the rate of growth of the older broods, that is, those of 1910 to 1915 inclusive, the reader is referred to an earlier paper by the writer (1929, pp. 59 to 61, tables 22 to 27, figs. 1 to 6). One series of measurements made in the fall of 1928, in addition to the ones in the earlier paper, is available. The average size of the three oldest broods, namely the broods of 1910 (last previous measurements made in 1925), 1911 and 1912 (last previous measurements of each made in 1927), consisting of six lots had increased at most only two to three mm. in average length. The animals of the 1913 and 1914 broods (those of the 1915 brood having been discarded), being younger, had gained considerable growth, the sixty-eight females of the 1913 brood having increased in average length from 128.5 mm., when measured previously in 1925, to 135.2 mm., but the five males in this lot had not grown. The brood of 1914, consisting of seventy-eight females and three males, had increased in average length (sexes combined) from 121.3 mm. in 1925 to 131.0 mm. in 1928. When the last measurements were made (in 1928), and the animals of the 1913 brood were fifteen years old, six of the females were still under 125 mm. (5 inches) in length, and fourteen of the seventy-eight females in the 1914 brood, fourteen years old, were under that length.

³ Terrapins less than six inches long on the median line of the plastron do not command a fancy price and those less than five inches in length have little value on the market. Accordingly the males, which seldom exceed a length of four and one-half inches, are almost worthless.

With the view of determining whether the stock was improving or deteriorating under domestication as early as the second generation, equal lots of the broods of 1916, 1919, 1920, and 1922 of the offspring of wild animals confined for breeding purposes and of the offspring of terrapins grown in captivity were retained for comparison. These lots of each brood either were placed in separate pens and treated identically or placed in the same pen, each lot bearing a distinctive mark. In the tables which accompany this paper

TABLE 1
RATE OF GROWTH OF THE WILD AND DOMESTIC STOCK OF THE 1916 BROOD

WHEN MEASURED.	WILD STOCK.					DOMESTIC STOCK.				
	Number.	Smallest mm.	Largest mm.	Females 125 mm. length, and over in.	Average mm.	Number.	Smallest mm.	Largest mm.	Females 125 mm. length, and over in.	Average mm.
Oct. 4, 1918.....	120	47	104	..	70.6	81	47	83	..	63.2
Oct. 9, 1919.....	99	45	116	..	74.4	96	45	85	..	65.3
Oct. 8, 1920.....	99	42	123	..	75.5	95	47	92	..	66.8
Sept. 24, 1921.....	99	56	133	1	82.6	88	53	103	..	73.7
Sept. 13, 1922.....	103	69	136	1	91.4	192	69	120	..	85.2
Oct. 5, 1923.....	100	74	138	4	97.2	91	71	135	2	93.0
Sept. 12, 1924.....	100	77	139	6	101.9	195	73	130	2	95.5
Oct. 20, 1925.....	93	78	140	7	103.3	95	74	132	5	98.0
Oct. 1, 1927:										
Males.....	18	81	102 ¹	33	89.3	22	78	101	33	90.7
Females.....	82	92	111 ¹	..	119.4	76	83	141	..	116.4
Nov. 6, 1928:										
Males.....	18	78	99	39	96.5	23	83	104	40	96.3
Females.....	74	97	142 ¹	..	123.9	71	107	142	..	124.8

* The apparent decrease in size no doubt is due to the failure to find all the animals when the previous measurements were made.

¹ An increase in the number of terrapins shows that all the animals were not found when the previous census was taken.

the offspring of the wild breeders is designated "wild stock" and the offspring of the animals grown in captivity as "domestic stock."

A study of the data given in the various tables shows that comparatively great fluctuations in the rate of growth, as already stated, may be expected. The two lots of animals of the brood of 1916 (Table 1), for example, grew more slowly than any others

grown in captivity. A comparison of Tables 1 and 2 shows that the average length of these animals (both wild and domestic stock) was less at twelve years of age than that of the animals composing the two lots of the 1919 brood at nine years of age. This difference in rate of growth occurred, notwithstanding that virtually identical food and treatment was supplied.

The data set forth (Tables 1 to 4) show, furthermore, that sometimes the domestic stock grew slightly faster than the wild

TABLE 2
RATE OF GROWTH OF THE OFFSPRING OF THE WILD AND DOMESTIC STOCK OF THE 1919 BROOD

WHEN MEASURED.	OFFSPRING OF WILD STOCK.					OFFSPRING OF DOMESTIC STOCK.				
	Number.	Smallest mm.	Largest mm.	Females 125 mm. and over in length.	Average mm.	Number.	Smallest mm.	Largest mm.	Females 125 mm. and over in length.	Average mm.
May 13, 1920	100	37	55	..	38.4	100	33	48	..	40.2
Sept. 20, 1921	44	36	71	..	51.8	90	41	82	..	62.0
Sept. 19, 1922	47	49	96	..	70.7	87	46	110	..	77.4
Oct. 10, 1923	..	..	..	..	..	81	53	117	..	87.6
Oct. 8, 1924	46	75	114	..	91.3	78	69	123	..	90.2
Oct. 27, 1925	44	78	123	..	96.0	78	75	132	4	95.2
Oct. 8, 1926	41	83	135	..	101.0	78	75	139	14	104.7
Sept. 28, 1927:										
Males.....	..	..	..	..	..	22	74	98	..	90.4
Females.....	..	..	..	..	..	52	87	144	26	119.3
Nov. 2, 1928:										
Males.....	8	89	101	..	..	26	86	101	..	92.0
Females.....	38	102	142	18	{ 92.2 127.1	45	109	147	37	131.5
Oct. 23, 1929:										
Males.....	..	..	..	..	..	24	86	103	..	93.5
Females.....	..	..	..	..	..	46	115	149	43	135.5

* Many terrapins in this lot were destroyed by rats. This accounts in a large measure for the decrease in number over the preceding year.

stock. Again the reverse was true. The conclusion apparently may be drawn that domestication had not influenced the rate of growth. It is evident, also, that many of the terrapins in the oldest brood (Table 1) both of the wild and domestic stock at the age of twelve years, were still under 125 mm. (5 inches) in length and below a marketable size. These animals had gained a comparatively

TABLE 3
RATE OF GROWTH OF CAROLINA TERRAPINS OF THE 1920 BROOD

WHEN MEASURED.	OFFSPRING OF WILD STOCK.					OFFSPRING OF DOMESTIC STOCK.				
	Number.	Smallest mm.	Largest mm.	Females 125 mm. and over in length.	Average mm.	Number.	Smallest mm.	Largest mm.	Females 125 mm. and over in length.	Average mm.
June 1, 1921	50	33	45	..	37.5	200	32	47	..	38.5
Sept. 24, 1921	50	46	83	..	59.6	165	35	57	..	43.8
Sept. 14, 1922	..	..	..	..	..	163	35	73	..	50.3
Oct. 10, 1923	39	68	105	..	83.2	144	40	87	..	61.3
Oct. 11, 1924	*31	76	108	..	91.1	145	45	110	..	63.0
Oct. 22, 1925	..	..	..	..	..	122	52	111	..	75.7
Oct. 1, 1926	26	76	130	4	108.0	121	56	126	1	81.7
Sept. 28, 1927:										
Males.....	..	..	..	..	..	23	72	97	2	84.0
Females.....	25	98	138	6	116.9	89	161	132	..	98.1
Nov. 16, 1928:										
Males.....	..	..	..	..	..	30	68	96	..	86.4
Females.....	24	99	144	11	122.2	83	82	136	11	103.5
Oct. 23, 1929:										
Males.....	..	..	..	..	..	20	81	98	..	88.3
Females.....	26	110	149	22	134.3	86	75	141	39	119.3

* The males were removed from this lot as soon as recognized. Thereafter no measurements are available of them.

† It is quite certain that some of the animals listed as females, later proved to be males, as the sexes generally are not distinguishable until a length of about 80 millimeters is attained.

TABLE 4

RATE OF GROWTH OF THE BROOD OF 1922

WHEN MEASURED.	OFFSPRING OF WILD STOCK.					OFFSPRING OF DOMESTIC STOCK.				
	Number.	Smallest mm.	Largest mm.	Average mm.	Number.	Smallest mm.	Largest mm.	Average mm.		
June 3, 1923	200	36	51	37.2	200	36	47	37.0		
Oct. 24, 1924	*142	36	72	47.5	*130	36	70	43.1		
Oct. 27, 1925	99	41	92	58.0	105	41	84	53.4		
Oct. 7, 1926	93	44	95	65.2	91	42	91	62.3		
Sept. 27, 1927	93	51	130	80.6	93	46	106	78.7		
Nov. 2, 1928	85	56	141	92.7	83	57	117	80.2		

* This lot was selected from the one listed under the preceding date.

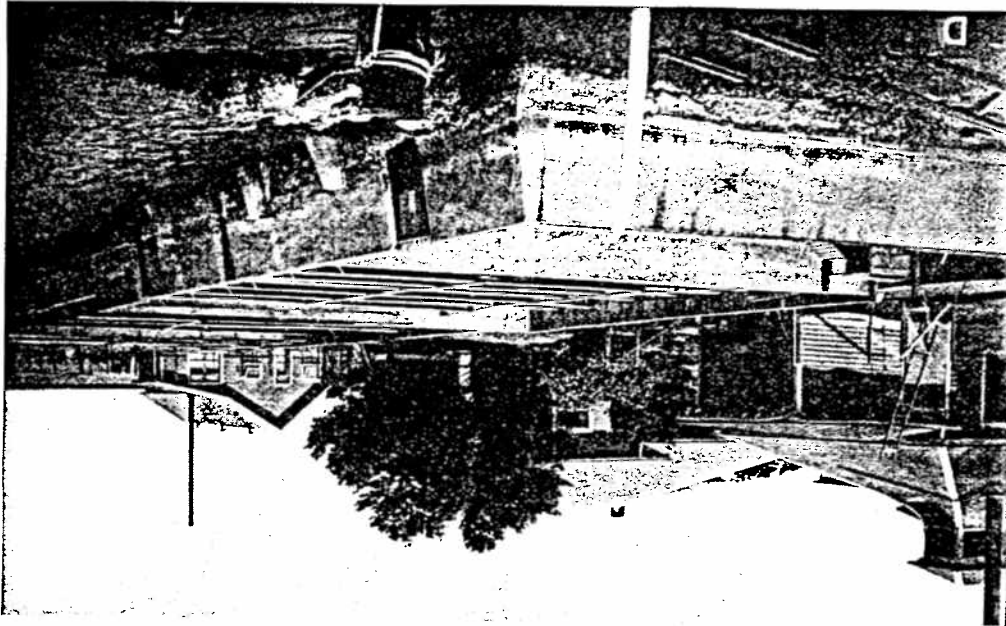


Fig. 384 D. Terrapin pounds at the U. S. Fisheries Biological Station, Beaufort, N. C., at near low tide. Interior of pounds are provided with beds of sand for laying eggs. An average change of about three feet in the water level takes place twice a day, due to tides, which bring a fresh supply of sea water and aid in washing away

large amount of growth during their twelfth year. It is obvious, therefore, that although a few terrapins grown in captivity attained a marketable size in five or six years and were nearly or quite full grown in eight or nine years, the majority required a much longer period of time to attain the same size. Some animals very evidently (Table 1) require twelve to fifteen years or possibly longer to reach full growth. The number of measurements of recaptured terrapins that had been liberated when less than a year old is quite limited. The indications are, however, that the rate of growth in nature may be about equal over a period of years to that of animals in confinement.

SIZE ATTAINED

Carolina female terrapins in nature occasionally reach a length as great as seven inches and rarely slightly more than seven inches. One female occurred among the original wild brood stock which had a length of nearly seven and one-half inches (185 millimeters). This animal probably approached the maximum size attained by the species. Texas terrapins, of course, grow larger and the females of that species may attain a length of eight inches or slightly more.

Male terrapins do not attain a large size and are of little commercial importance. The largest male included in the wild brood stock was about four and four-fifths inches (120 millimeters) long. This probably is near the maximum size attained by the male Carolina terrapin. Although the male of the Texas terrapin no doubt grows larger occasionally, no record of one exceeding the length of the largest Carolina male is at hand.

While terrapins occasionally reach the large size indicated in the foregoing paragraphs, the average size is very much smaller. A six-inch female and a four-inch male may be regarded as large Carolina terrapins. Although a terrapin must be six inches or more in length to be a "count" and to bring a fancy price on the market, it is quite certain that many females never reach that large a size. Among the original wild brood stock, confined in part in 1909 and in part in 1912, in which all animals were considered adult at that time, seventeen of the seventy-three females (23.3 per cent.) remaining in this lot in 1925 were still less than six inches (150 millimeters) in length. The age of these animals, of course, is not

known. Judging by the information gained during more than a score of years relative to the rate of growth of terrapins in nature and more particularly in confinement, it seems certain that few, if any, of the terrapins of the original brood stock were less than eight years old when procured. If that were true, then the youngest females in this lot would not have been much less than twenty-one years old in 1925. It is highly probable that animals of such an age had attained full growth.

Many of the females of the older broods grown in captivity are still less than six inches in length. In one of the lots of the 1910 brood containing ninety females in 1928, at the age of eighteen years, just seventeen (18.9 per cent.) were six inches (150 millimeters) and more in length. In another lot of the same brood containing eighty-seven females eighteen (20.7 per cent.) were six inches and more in length at the same time. A lot of the 1911 brood consisting of seventy-six females, contained thirty individuals (39.5 per cent.) six inches and more in length in 1928, or at the age of seventeen years. Another lot of the same brood consisting of seventy-five females contained twenty-six individuals (34.6 per cent.) which were six inches and more in length at the same time. Similarly, a lot of the 1912 brood, containing sixty-eight females, included just one individual (1.4 per cent.) over six inches in length in 1928 at the age of sixteen years. Another lot of the same brood, containing fifty-four females, included eleven individuals (20.3 per cent.) six inches and more in length at the same time.

The average size of the several lots mentioned in the preceding paragraph has increased little since an age of eight to ten years was attained, and it is evident that the animals, although some of them are still growing slightly, have just about attained full growth. Therefore, it is rather certain that the majority of the females in the older broods grown in captivity will never reach as great a length as six inches.

SEXUAL MATURITY

During the course of the experiments no eggs have been produced by any lot grown in captivity until at least some of the females were five and one-half inches (137 millimeters) in length. However, smaller females among the older broods have been observed making nests and laying eggs. The smallest one seen, which was caught

after laying eggs, was only four and three-fourths inches in length. Presumably, the male is sexually mature as soon as the external sex characters are fully developed. These characters, consisting of a longer and heavier tail, narrower head and somewhat narrower and proportionately longer carapace, may be quite evident at a length of three and one-fifth inches (80 millimeters) in some individuals, but considerably later (90 millimeters) in others. Males, no doubt, reach sexual maturity equally as early as the females, for at least some of the first eggs produced by every lot of terrapins grown in captivity (exclusive of two of the 1911 brood which contained no males) were fertile and hatched.

It is quite evident from the data that the size of a terrapin is a better criterion relative to sexual maturity than age. The youngest terrapins that have produced eggs were four years old (a lot of the 1911 brood, fed three winters) and the highest age at which eggs were produced for the first time was eight years (brood of 1919, fed one winter). Therefore, a variation in the attainment of sexual maturity of four years in age has taken place. It is true that the lot of the 1911 brood, having been fed three winters, was "forced" somewhat. However, the lot of the 1919 brood, too, was fed one winter. On the other hand, a lot of the 1910 brood that had hibernated each winter laid eggs at the age of six years. Therefore, winter feeding, although it no doubt hastens maturity in some lots, is not wholly responsible for the variation indicated. The most usual age at which eggs were produced for the first time was seven years. Of fifteen different lots, from ten broods, nine lots began laying at seven years of age, three at the age of six years, one at the age of five years, and the other two respectively at four and nine years, as already stated.

It may be concluded from the evidence presented that when Carolina female terrapins reach a length of five and one-half inches (137 millimeters) they are sexually mature, regardless of age. It was shown that one brood when it began to produce eggs was four years younger than another. It has been shown, also, under the section of this paper entitled, "Growth" (p. 551) that great variations in the rate of growth of animals within a single lot and brood has occurred. Therefore, some females, as well as males, no doubt reach sexual maturity four or more years earlier than others, even when identical treatment is provided.

SEX RATIO

The latest full census of all terrapins grown in captivity was taken in 1928. At that time 1,442 Carolina terrapins were large enough to show plainly the external sex characters. This number of animals consisted of 209 males and 1,233 females. The ratio, therefore, was one male to 5.9 females. The extremes of the sex ratio in the Carolina terrapins was met, on the one hand, in the 1911 brood, which consisted of 148 females and no males, and on the other in the brood of 1919, which consisted of fifty-four males and ninety-three females, that is, one male to 1.7 females.

In view of the scarcity of males among the straight Carolina stock it is very interesting to find eighty-six males and fifty-three females, a ratio of 1.66 males to one female, among three lots of hybrid terrapins resulting from cross breeding Carolina and Texas terrapins.

Most of the lots of Carolina terrapins were selected for large size and vigor at eight to ten months of age. However, a few lots were unselected, and the animals of one lot of the brood of 1912 (consisting of ten males and fifty-four females) were selected as runts when about a year old. It is not evident that the selections affected the sex ratio.

No information is available relative to the sex ratio of terrapins caught in nature. In any event, such data would not show the natural ratio for the Carolina terrapins, because of the extensive fishing operations carried on for many years throughout its range. During all this time it has been the practice to return to the water most of the males caught, because they were almost worthless, whereas the females were valuable and were marketed. Such a practice, in a group of such long-lived animals, having a small population, no doubt would affect the sex ratio profoundly.

The sex ratio of young immature terrapins has not been studied. Since the external sex characters are not evident until the animals reach a length of at least three inches, the sex of the young could be determined only through dissections. While such a study would be very interesting, time and proper material have not been available.

It appears to be of interest to note in connection with the discussion of sex ratio that experience proves it unnecessary to main-

tain an even sex ratio for breeding purposes. Comparatively large fluctuations in the rate of fertility of the eggs have prevailed, sometimes within a single lot, without change in the sex ratio and again among various lots containing a variation in sex ratio of one male to 1.7 females to one male to twenty-six females. It may be stated, however, with some degree of certainty that a ratio of one male to five females is ample for a high degree (80 to 90 per cent.) of fertility.

LONGEVITY

It was pointed out in an earlier paper (1929, p. 42) that in age the wild brood stock probably ranged from twenty-five to possibly more than forty years. It cannot be stated yet what the span of life of diamond-back terrapins is. However, the lot of wild breeders have not yet shown any signs of weakening, for in 1930 this lot produced 22.2 eggs per female, a much higher rate of production than any of the several lots grown in captivity. It was higher, also, than the average of 14.5 eggs per female for this lot from 1915 to 1927 inclusive.

The oldest lots grown in captivity (brood of 1910) now on hand are twenty-one years old. These animals all have the appearance of being young, as the growth rings on the carapace are all quite prominent, whereas in several of the wild breeders the carapace is smooth with scarcely an indication of growth rings. The smoothness of the shells is believed to be due to long wearing. Furthermore, to the writer's personal knowledge, some of these animals had smooth shells as much as seventeen years ago. Judging from this and other meager information at hand, the writer now regards the estimate of the highest age of forty years, made in the earlier paper referred to, for the animals which have been in captivity nineteen and twenty-two years as much too low. However, he is not prepared to state how old they are, nor to predict how much longer they will live. The evidence certainly is that these slow-growing and late-maturing animals reach a high age.

BIBLIOGRAPHY

- HILDEBRAND, SAMUEL F.
1929. Review of Experiments on Artificial Culture of Diamond-back Terrapin. Bull. U. S. Bureau of Fisheries, Vol. XLV, 1929, pp. 25 to 70, 36 tables, 14 figs.