REVIEW OF EXPERIMENTS ON ARTIFICIAL CULTURE OF DIAMOND-BACK TERRAPIN[1]

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INTRODUCTION

It is a well-known fact that the diamond-back terrapin (Malaclemmys) once was plentiful. When this animal first came into demand only the terrapins taken in Chesapeake Bay and northward brought a good price, and the more southern terrapins frequently were shipped to dealers at certain points on Chesapeake Bay, to be reshipped from thence to the larger cities as "Chesapeakes." Gradually the Carolina terrapins gained in favor, and more often they were shipped directly to the larger markets. The practice of sending southern terrapins to dealers on Chesapeake Bay, however, appears not to have been discontinued entirely, as the writer has been informed authoritatively that some southern animals are still sent there to be reshipped. It is not known to the writer whether the more northern terrapins actually excel in flavor. It seems probable, though, that the difference is not great or Chesapeake dealers would not, for many years, have been able to sell animals from the South as "Chesapeakes."

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The catch of terrapins, soon after the flesh came into demand, exceeded production, for the animals could not stand a heavy drain, as they do not reproduce rapidly and growth is gained slowly. The natural supply, therefore, was quickly diminished. It was quite evident by the beginning of the present century that these valuable creatures were being reduced so rapidly that very soon they would be so scarce as to make fishing for them unremunerative, if, indeed, the animals were not doomed to extinction. In view of the rapid depletion the Bureau of Fisheries (then the Fish Commission) instituted an investigation in 1902 on Chesapeake Bay, which had for its principal object the determination of the adaptability of the diamondback terrapin to artificial propagation (Hay, 1905). About the same time the State of North Carolina, in cooperation with the United States Fish Commission at the United States Fisheries Biological Station at Beaufort, N. C., undertook another investigation, which consisted principally of an inquiry into the habits and life history of the terrapin and the condition of the terrapin industry in North Carolina (Coker, 1906). The investigation at Beaufort was discontinued in 1903, but the investigations on the Chesapeake Bay were made more comprehensive. In 1904 a comparatively large wooden pound was built at Lloyds, Md., which provided facilities for holding both young and adult terrapins, and suitable sand beds, in which the terrapins might lay their eggs, were furnished. The experimental work at Lloyds was continued until 1909, when activities were transferred to Beaufort. The series of experiments upon which the present report is based dates from that year.[2]

It was learned from the early experiments conducted at Beaufort, N. C., and at Lloyds, Md., that adult terrapins would produce eggs when confined in pens; also, that the eggs could be transferred from where they were laid to "suitable hatching boxes," where most of them would hatch. Raising the young, however, appears not to have been successful prior to the transfer of the work to Beaufort and the beginning of the present series of experiments in 1909.

A number of attempts to raise terrapins in captivity have been made by private individuals. Most of the private terrapin "farms," however, consist of pens, often called "crawls," in which the animals are placed and fed in order to gain growth or merely to be held for a better market. However, in 1913 a company was organized in Beaufort, which 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 trippled 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

[2] Because of the rather frequent changes in the scientific personnel, the experiments were planned by various individuals. The care of the terrapins and the actual work of carrying on the experiments, however, have always been in the hands of Charles Hatsel, the station's able terrapin culturist and foreman. Mr. Hatsel also kept nearly all of the original records, and the success of the undertaking is due, in a very large measure, to his interest and painstaking work.

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.

EXPLANATIONS

Wherever the size of terrapins is mentioned in this paper it refers to the length along the median line of the plastron or lower shell, as this measurement has long been in use in classifying terrapins for the market.

"Carolina terrapins," when used in this paper to designate animals grown in captivity, refer to terrapins that actually are not of "pure blood," because, as shown below, they are the result of a cross between the two closely related subspecies, *Malaclemmys centrata centrata* and *M. centrata concentrata*. This term is used for convenience in distinguishing the Atlantic-coast animals from the Texas-coast species, *M. pileata littoralis*, as well as from certain hybrid lots also used in the experiments.

DISTRIBUTION OF TERRAPINS

Diamond-back terrapins occur on the coasts of the United States from Buzzards Bay, Mass., to Texas. Two species, divided into five subspecies, are recognized by Stejneger and Barbour (1923, pp. 131–132), as follows: The Carolina terrapin (*Malaclemmys centrata centrata*), ranging from central North Carolina to Florida; the Chesapeake terrapin (*M. centrata concentrata*), ranging from Buzzards Bay to North Carolina; the Florida terrapin (*M. pileata macrospilota*), on the Gulf coast of Florida; the Louisiana terrapin (*M. pileata pileata*), ranging from the mouth of the Mississippi River eastward on the Gulf coast to Florida; and the Texas terrapin (*M. pileata littoralis*), which inhabits the coast of Texas and the shores of the outlying islands. The differences between the Chesapeake terrapin and those from the Gulf coast are quite pronounced; that is, the Gulf-coast terrapins have evident tubercles (humps) on the median line of the back, which are obsolete or wanting in the Atlantic species, and generally there are also differences in color that aid in separating the species. The differences between the Atlantic (Chesapeake and Carolina) terrapins, however, are slight. In general, the Carolina terrapin has a larger head, a blunter snout, and the sides (lateral outlines) of the carapace are more nearly parallel and less flaring posteriorly than in the Chesapeake terrapin. These differences usually are evident and are recognized by dealers. However, North Carolina is the geographical meeting place of the Chesapeake and Carolina terrapins. Therefore, it is not surprising that some animals are seen from time to time that are difficult to place in either variety.

The Atlantic varieties (Chesapeake and Carolina) of terrapins have both been used from the very beginning of the experimental work at Beaufort, for the original brood stock (still on hand) was obtained in part from Chesapeake Bay and in part from the general vicinity of Beaufort, where both varieties occur. These terrapins have been confined together in a small pen for almost a score of years, and there is not the slightest doubt that interbreeding is occurring freely. It may be stated here that apparently no inferior stock has resulted from this "crossbreeding," as the offspring raised to maturity in captivity are a fine race of animals and superior in appearance to their parents.

The Chesapeake terrapin is generally preferred on the market, but the difference between it and the Carolina terrapin is so slight that large, fat animals of the last-mentioned variety are accepted readily as "Chesapeakes."

EXPERIMENTS CONDUCTED AND SOURCES OF INFORMATION

At the present time (January 14, 1928) 33 lots of terrapins are on hand at the station. The animals composing the various lots, exclusive of those that comprise the original brood stock, were hatched and grown in captivity and therefore are of known age. Every lot itself forms the basis for a separate experiment or is a part of an experiment. The following are some of the experiments for which the various lots of terrapins are being used: (a) Space requirements for young and adults; (b) size of egg beds required; (c) natural sex ratio; (d) sex ratio required for breeding purposes; (e) practicability for increasing growth, hastening maturity, and reducing the death rate by feeding young terrapins during the winter; (f) the control of disease among recently hatched animals (young terrapins only are mentioned in this connection, as no disease has occurred during the course of the experiments among animals a year or more of age); (g) several experiments in selective breeding; (h) two experiments in crossbreeding the Carolina with the Texas terrapin. Some of the experiments have not been carried on long enough or far enough to yield results, and these will not be reported upon at this time. Others have yielded noteworthy results, however, and the information derived forms the basis for the present report.

The latest previous report [3] made upon this investigation is entitled "Further Notes on the Natural History and Artificial Propagation of the Diamond-Back Terrapin," by R. L. Barney (Bulletin, U. S. Bureau of Fisheries, Vol. XXXVIII, 1921–22 [1922], pp. 91 to 111). Although the present paper essentially is a progress report, nevertheless it is based upon the original data, all of which have been studied carefully. The data presented cover the entire period during which each experiment reported upon has been under way. In the interpretation of the data due consideration, however, was given to the published accounts. A different conclusion occasionally was arrived at, mainly on account of the much more extensive data now at hand and partly because of errors that were corrected and, no doubt, also in part because of a different personal viewpoint.

PRODUCTION OF EGGS

The production of eggs has varied from year to year within broods and even within lots of the same brood, as shown by tables presented herewith. Similar variations have taken place among wild terrapins of unknown age confined for breeding purposes. For example, among a certain lot of wild breeders production has varied from about 7.6 to about 23.9 eggs [4] per female during the period 1915 to 1926, inclusive. It appears to be of interest to mention in this connection that wild terrapins have produced few eggs during the first two and three years of confinement. The

[3] U. S. Bureau of Fisheries Economic Circular No. 60, entitled "Diamond-Back Terrapin Culture at Beaufort, N. C.," by Samuel F. Hildebrand and Charles Hatsel, was issued in October, 1926. This short paper gives only the economic phases of the work and gives no specific account of the many experiments performed nor of the more scientific aspects of the work.

[4] A slightly larger number of eggs per female was produced than shown, as the terrapins themselves accidentally destroyed a few eggs from time to time and rats often destroyed an unknown number. Eggs thus destroyed are not taken into consideration in these data.

records for the original brood stock are rather obscure, but sufficient data are available to show that only a small number of young was produced during the first years of confinement. Similar results (no definite figures are available) were obtained at a local terrapin farm and also for some wild terrapins purchased by the State of North Carolina and confined in 1925 for breeding purposes at the United States fisheries biological (Beaufort) station. The last-mentioned lot, consisting of 478 females and 108 males, laid only 0.8 egg per female in 1925, 1.2 eggs in 1926, and 4.2 in 1927. Another large increase was expected in 1928 but this, for reasons unknown, did not materialize, as the production of eggs remained the same as in 1927.

The largest number of eggs laid per female by any group of terrapins that has been held in confinement during the course of the present experiments was produced by the first brood (1909) hatched and grown in captivity. In the first year few animals were hatched and only four females were grown to maturity. These four animals grew at a fairly uniform rate, and apparently all reached maturity at the same time. The rate of egg production was high and fairly constant, varying during the years 1915 to 1925, inclusive, from 22 to 34.3 eggs per female, with an average for the entire period of 29.4 eggs. The four females in this lot (used in certain dye feeding experiments in 1926, which proved fatal to two of them and sickened the others) appear to have been extremely fertile, and the rate of egg production far surpassed that of the later and larger broods. The broods of 1910 and 1911 probably show to a far greater extent the rate of egg production that may be expected from terrapins grown in captivity. An increase in the average number of eggs laid per female for the lots is expected, as some of them have only recently reached sexual maturity. The tables show that a downward trend in egg production took place from 1919 to 1925 in the two lots of the 1910 brood and also for the winter-fed lot of the 1911 brood. A recovery is indicated for 1926 and a further one apparently will result for 1927, when all the young have been collected and counted. The general downward trend for these broods that took place, therefore, appears to have been only a "fluctuation," which is shown also for the original wild brood stock.

The data appear to indicate that certain years are not as productive of eggs as others. The tables show that egg production in 1921 and again in 1925 was lower than usual for nearly all the lots on hand. The causes for the "lean" years are not obvious. The care and the food received have not varied from year to year. In fact, the animals have remained in the immediate care of the same terrapin culturist throughout the course of the experiments. A study of the weather records kept at the station reveals nothing unusual during the lean years. On the other hand, the winters of 1917–18 and 1918–19 were both unusual, the first one having been extraordinarily cold and the second exceptionally mild, yet each of these winters was followed by a good laying season. The cause or causes of poor laying seasons remains for future investigation.

The great variation in the number of eggs produced by individuals is referred to under the section of this report dealing with fertility, the range given for a single season being from 5 to 29 eggs. Experiments are under way whereby it is hoped to determine whether certain females more or less constantly lay a small number of eggs while others produce a much larger number. These experiments have not been running long enough to yield definite results. The indications are, however,

that among terrapins, as among chickens, certain females are "boarders." If further observations confirm the results already obtained, it should be possible to eliminate the boarders and to select animals of high fertility for breeding purposes.

It appears to be of interest to call attention to the long period of time during which the original brood stock has produced eggs. Some of these animals were confined in 1909 and others in 1912. The early records of egg production by the old breeders are rather obscure, but there is on hand a fairly definite record dating from 1915 to 1926. Table 1 is based upon this record. It is evident from the table that the general trend in egg production over this period of years has been downward. Yet it has fluctuated from year to year, and the rather sharp recovery in 1926 is noteworthy. The age of these animals, as stated elsewhere, is not known, and the length of life of diamond-back terrapins, too, in unknown. Therefore, it is entirely impossible to state that the general decline in egg production is due to old age. Furthermore, the table shows an upward trend since 1921. An upward trend during recent years would scarcely be expected if the general decline were due to old age. For the same reason it does not seem logical to assume that the long confinement affected egg production. Neither can the decline readily be ascribed to food and care, for these have been uniform throughout the period. It seems very difficult, therefore, to find the cause or causes for the decline in egg production from 1915 to 1921, the partial recovery during recent years, and the annual fluctuations that have taken place. The number of eggs destroyed by rats has varied from time to time, but it is not believed that the loss was great enough to affect the results greatly.

TABLE 1.—*Average number of eggs produced by the wild brood stock, based on a lot confined in a single pen from 1915 to 1927*

Year	Eggs	Year	Eggs	Year	Eggs
1915	23.9	1920	13.4	1925	9.8
1916	21.6	1921	7.6	1926	14.8
1917	20.8	1922	8.2	1927	10.1
1918	18.6	1923	9.2		
1919	19.6	1924	11.6	Average	14.5

The yearly egg production by the wild brood stock from 1915 to 1927, inclusive, has averaged 14.4 eggs per female. The average per year for all females 5½ inches [5] and over in length, exclusive of two lots of wild animals recently confined, is 13 eggs per female. This, then, appears to be about the number of eggs per female that may be expected of acclimated animals. It is shown in another section of this report that a rate of fertility of the eggs of about 90 per cent usually prevails when sufficient males are present. These data, then, indicate that in general terrapin-cultural work about 12 young per female per annum may be expected.

[5] The records show that no lot of terrapins grown in captivity has ever produced eggs until at least some of the females had reached a length (on the median line of the plastron) of 5½ inches or more. Therefore, animals less than 5½ inches long are considered immature and are not considered in computing this average.

TABLE 2.—*Average number of eggs produced per female of the brood of 1909* [1]

Year	Eggs [2]	Year	Eggs [2]	Year	Eggs [2]
1915	24.0	1920	35.0	1924	22.0
1916	29.5	1921	32.3	1925 [3]	29.8
1917	24.5	1922	29.4		
1918	29.2	1923	33.0	Average	29.4
1919	34.3				

[1] These animals hibernated each winter.
[2] All of the females in this lot were 5½ inches in length or longer during the entire period.
[3] Discontinued after 1925.

TABLE 3.—*Average number of eggs produced per female of the brood of 1910*

Year	Fed first winter		Hibernated each winter		Year	Fed first winter		Hibernated each winter	
	Entire lot	All 5½ inches and over in length [1]	Entire lot	All 5½ inches and over in length [1]		Entire lot	All 5½ inches and over in length [1]	Entire lot	All 5½ inches and over in length [1]
1915	0.3	1.4			1923	6.1		4.0	
1916	5.7	13.4	0.4	4.2	1924	6.0		3.5	
1917	8.1		2.9	11.3	1925	5.1	5.9	3.2	4.4
1918	7.6	12.3	4.2		1926	6.5		3.2	
1919	11.1	16.2	7.1	13.2	1927	9.2		3.6	
1920	9.5		5.1						
1921	6.6		2.1		Average	[2] 6.9	9.8	[2] 3.8	8.3
1922	8.1		5.2						

[1] Female terrapins less than 5½ inches long apparently do not lay eggs. Therefore, the rate of production shown in this column is the actual rate per sexually mature female. Measurements of the size of the terrapins are not available for every year and, therefore, the rate of egg production per mature female can not always be given.
[2] The first year of egg production is not considered in determining this average, as only a few eggs were produced and nearly all of the females were still immature.

TABLE 4.—*Average number of eggs produced per female of the brood of 1911*

Year	Fed first 3 winters		Hibernated each winter		Year	Fed first 3 winters		Hibernated each winter	
	Entire lot	All 5½ inches and over in length [1]	Entire lot	All 5½ inches and over in length [1]		Entire lot	All 5½ inches and over in length [1]	Entire lot	All 5½ inches and over in length [1]
1915	0.1	0.8			1923	7.1		8.7	11.2
1916	0.1	0.3			1924	6.8		8.0	
1917	5.3				1925	4.3	5.5	7.5	9.3
1918	7.6		0.7	1.5	1926	8.6		8.6	
1919	11.9	18.0	2.3	4.8	1927	7.8		11.6	
1920	8.1		5.6						
1921	4.2		6.9		Average	[2] 6.0	6.1	6.7	6.7
1922	6.5		7.1						

[1] Female terrapins less than 5½ inches long apparently do not lay eggs. Therefore, the rate of production shown in this column is the actual rate per sexually mature female. Measurements of the size of the terrapins are not available for every year and, therefore, the rate of egg production per mature female can not always be given.
[2] The first 2 years of egg production are not considered in determining this average, as only a few eggs were produced and nearly all the females were still immature.

TABLE 5.—*Average number of eggs produced per female of the brood of 1912*

Year	Runts		Selects		Year	Runts		Selects	
	Entire lot	All 5½ inches and over in length [1]	Entire lot	All 5½ inches and over in length [1]		Entire lot	All 5½ inches and over in length [1]	Entire lot	All 5½ inches and over in length [1]
1919	2.4	5.0	1.6	2.5	1925	5.1	9.0	1.7	8.9
1920	4.5	21.1	2.5	31.5	1926	8.1	----------	3.7	----------
1921	4.1	----------	1.9	----------	1927	8.5	----------	6.9	----------
1922	6.4	19.5	3.2	41.0					
1923	7.6	18.1	2.1	14.2	Average	5.8	14.6	3.0	19.6
1924	6.1	----------	3.6	----------					

[1] Female terrapins less than 5½ inches long apparently do not lay eggs. Therefore the rate of production shown in this column is the actual rate per sexually mature female. Measurements of the size of the terrapins are not available for every year and, therefore, the rate of egg production per mature female can not always be given.

TABLE 6.—*Average number of eggs produced per female of the brood of 1913* [1]

Year	Entire lot	All 5½ inches and over in length [2]	Year	Entire lot	All 5½ inches and over in length [2]
1920	0.4	----------	1925	0.8	4.1
1921	.4	----------	1926	1.5	----------
1922	1.8	18.2	1927	3.1	----------
1923	1.2	8.9			
1924	1.4	----------	Average	1.3	10.4

[1] These animals were fed the first winter.
[2] Female terrapins less than 5½ inches long apparently do not lay eggs. Therefore, the rate of production shown in this column is the actual rate per sexually mature female. Measurements of the size of the terrapins are not available for every year and, therefore, the rate of egg production per mature female can not always be given.

TABLE 7.—*Average number of eggs produced per female of the brood of 1914* [1]

Year	Entire lot	All 5½ inches and over in length	Year	Entire lot	All 5½ inches and over in length
1920	0.4	17.5	1925	0.7	6.8
1921	.3	----------	1926	1.7	----------
1922	.8	6.8	1927	4.5	----------
1923	1.4	12.1			
1924	1.6	----------	Average	1.4	10.8

[1] These animals were fed the first winter.

FERTILITY OF EGGS

The percentage of fertility of the eggs has fluctuated greatly from year to year and often within a single small lot. For example, in a lot of terrapins hatched in 1910 (fed the first winter), which consists of 13 males and 116 females, the percentage of fertile eggs has varied from 79.2 to 92.8 the average for the period 1915 (when the terrapins laid for the first time) to 1926, inclusive, being 85.2 per cent. In another lot hatched in the same year (1910), but which was allowed to hibernate each winter, now (1928) consisting of 5 males and 87 females, fertility has ranged from 57 to 91.9 per cent, with an average for the period 1917 [6] to 1926, inclusive, of 71.8 per cent.

[6] This lot laid for the first time in 1916, but the number of eggs produced was so small that the results for that year do not appear to be worthy of consideration.

Tables 8 to 15 show in detail the approximate number of eggs produced each year, the number of young hatched, and the percentage of fertility. It is difficult to account for the wide yearly fluctuations in the fertility of the eggs that have occurred in nearly all lots on hand. In general, the highest percentage of fertile eggs has been produced by those lots having the largest proportionate number of males. Examples of a high degree of fertility, as already shown, occurred in the wild brood stock (Table 8), in which the ratio of males to females has usually been about 1 to 2. A very high percentage of fertile eggs was laid from 1918 to 1925 by a small brood hatched in 1909, in which there also was one male to two females. During the first three years in which eggs were laid by this brood the percentage of fertile ones ran very low, and then, as shown by the table, fertility suddenly increased and thereafter remained fair to very high.

The lowest percentage of fertility among the older broods, for which considerable data are at hand, occurred in a lot belonging to the brood of 1911 (Table 11), which was allowed to hibernate each winter. This lot now (1928) consists of 3 males and 35 females. Egg laying began in 1918. Since no males were penned with the females until the fall of 1919, the eggs for the first two summers were not fertile and have not been considered in these data. Fertility has varied from 23.6 to 89.7 per cent during the period 1920 to 1926, inclusive, with an average fertility for the whole period of 64.8 per cent. Another lot of the same brood (1911), consisting of 38 females (originally penned with the lot just discussed) and 3 old males taken from the original brood stock, has produced consistently a higher percentage of fertile eggs over the same period of years. Fertility in this lot was the lowest in 1921, when only 71.4 per cent of the eggs hatched, and it was highest in 1925, when 93.4 per cent of the eggs were fertile, the average fertility for the entire period being 81.5 per cent. It seems probable, although by no means certain, that the higher fertility in the last-mentioned lot may have been due to the old and fully matured males that were introduced, whereas it is not known that the young males of the other lot were all mature when eggs first were produced.

It is a well-known fact that all females of one age do not become mature at the same time. Some females, in fact, require several years longer to reach sexual maturity than others. The same very probably is true of the males. This subject is discussed more fully in another section of this paper (see p. 56). The fact that the percentage of fertility in the lot penned with young males increased each year (Table 11) until 1925 lends support to the belief that the number of mature males present may have been insufficient. It will be seen, also, from Table 11 that the lot penned with young males each year produced a larger number of eggs than the other one, notwithstanding that there were three more females in the pen with the old males. This suggests earlier maturity for a larger proportion of the females penned with young males than for those penned with old males, and this, too, may have had a bearing upon fertility in relation to the number of males present.

Owing to such great fluctuations in egg production, it can not be stated definitely that one of the two lots of the brood of 1911, compared in the preceding paragraphs, produced a greater number of eggs than the other because it contained a larger number of mature females, for the difference in egg production, as just shown, may have

been due to a difference in fecundity rather than to the number of mature females present.

The highest degree of fertility for all broods on hand or used at one time or another in the many experiments conducted has almost consistently occurred among wild terrapins (Table 8) that have been confined for breeding purposes. The product of all wild animals is considered together here for convenience, although these terrapins have been separated into smaller lots at various times. To give a record of each lot separately would require much space. When last enumerated (1926) there were on hand 39 males and 72 females belonging to this "wild stock," and this ratio has not varied greatly for several years. Fertility among the wild terrapins, or the "orignal brood stock," during the period 1912 to 1926 was lowest in 1912, which was the first year of confinement for the majority of these animals, when 83.9 per cent of the eggs hatched. Two years later (1914) it was the highest that it has ever been, namely, 97.9 per cent. The average fertility for the entire period was 94.4 per cent.

In the case of a few groups of animals the results with respect to fertility, as related to sex ratio, are contrary to the more general rule stated in a preceding paragraph, namely, that a large proportionate number of males tends to bring about a high percentage of fertile eggs. The 1910 brood (Table 10), for example, was divided into two lots. One lot was fed the first winter, the other being allowed to hibernate. The first-mentioned lot has one male to nine females and an average percentage of fertility for the entire period during which eggs have been produced (1915 to 1926) of 85.2 per cent; whereas in the hibernating lot, in which there is a ratio of one male to 7.8 females, the percentage of fertility during the period (1916 to 1926) in which eggs have been produced is only 71.8 per cent.

It is evident from the foregoing discussion that the reason or reasons for the great fluctuations in fertility among the various lots and broods and even within a single lot and brood are not understood, and that sufficient data are not yet at hand from which specific recommendations relative to the proper sex ratio that should be maintained for breeding purposes may be made. This question is further complicated by the fact that females appear to produce a high percentage of fertile eggs for at least two years without recopulation. Thereafter, fertility apparently drops rapidly. This conclusion is based upon the results obtained from penning 10 old females without males. During the first season following separation from males these 10 females laid 124 eggs, and only 1 failed to hatch; during the second summer 116 eggs were produced and 14 failed to hatch; during the third summer 130 eggs were laid and 91 failed to hatch; and during the fourth summer 108 eggs were produced and only 4 hatched. Thereupon, seven old males were introduced, and in the next season 145 eggs were laid, of which only 4 failed to hatch. The results of this experiment would indicate that annual copulations are not necessary, and that very few males would suffice for breeding purposes. The combined records for all adult terrapins on hand appear to show, however, that the highest rate of fertility is obtained when the males are fairly numerous. The indications are that for breeding purposes a ratio of about 1 male to 5 females should be maintained.

TABLE 8.—*Production and fertility of eggs of the original wild brood stock, most of which were confined between 1909 and 1912. Males, 39; females, 72* [1]

Year	Eggs laid	Young hatched	Per cent fertile	Year	Eggs laid	Young hatched	Per cent fertile	Year	Eggs laid	Young hatched	Per cent fertile
1912	1,337	1,121	83.9	1918	1,157	1,113	96.2	1924	870	829	95.3
1913	1,374	1,289	93.9	1919	1,451	1,398	96.4	1925	719	680	94.6
1914	1,411	1,381	97.9	1920	939	915	97.5	1926	1,065	985	92.5
1915	1,480	1,415	95.7	1921	531	512	96.5	1927	733	626	92.2
1916	1,415	1,335	94.4	1922	615	566	92.1				
1917	1,275	1,215	95.3	1923	686	654	95.4	Total	17,058	16,084	94.2

[1] The number of females in this brood stock was reduced from 123 in 1912 to 72 in 1927, which accounts in part for the smaller number of eggs produced during recent years.

TABLE 9.—*Production and fertility of eggs of the 1909 brood, which hibernated. Males, 2; females, 4*

Year	Eggs laid	Young hatched	Per cent fertile	Year	Eggs laid	Young hatched	Per cent fertile	Year	Eggs laid	Young hatched	Per cent fertile
1915	96	17	17.5	1920	140	126	90.0	1925 [1]	119	116	97.5
1916	118	75	63.5	1921	129	120	93.1				
1917	98	72	73.5	1922	118	114	96.6	Total	1,293	1,098	85.0
1918	117	112	95.8	1923	132	129	97.7				
1919	137	129	94.2	1924	89	88	98.9				

[1] Discontinued after 1925.

TABLE 10.—*Production and fertility of eggs of the 1910 brood*

Year	Fed first and in part in the second winter. Males, 13; females, 116			Hibernating each winter. Males, 5; females, 87			Year	Fed first and in part in the second winter. Males, 13; females, 116			Hibernating each winter. Males, 5; females, 87		
	Eggs laid	Young hatched	Per cent fertile	Eggs laid	Young hatched	Per cent fertile		Eggs laid	Young hatched	Per cent fertile	Eggs laid	Young hatched	Per cent fertile
1915	39	34	87.2				1923	710	648	91.3	360	233	64.7
1916	754	587	77.9	38	37	97.3	1924	697	606	87.0	304	218	71.8
1917	1,071	902	84.3	260	214	82.3	1925	592	549	92.8	283	223	78.8
1918	1,015	934	92.2	379	348	91.9	1926	757	652	86.2	281	203	72.3
1919	1,428	1,136	79.5	633	475	75.1	1927	1,071	768	71.7	318	221	69.5
1920	1,111	932	83.9	456	263	57.7							
1921	768	687	89.5	187	128	68.5	Total	10,950	9,228	84.2	3,961	2,836	71.6
1922	937	793	84.7	462	273	59.1							

TABLE 11.—*Production and fertility of eggs of the 1911 brood*

Year	Fed first 3 winters. Males, 10 "old"; females, 78 [1]			Hibernated each winter (2 lots)					
				Males, 3; females, 35			Males, 3 "old"; females, 38 [1]		
	Eggs laid	Young hatched	Per cent fertile	Eggs laid	Young hatched	Per cent fertile	Eggs laid	Young hatched	Per cent fertile
1917 [2]	445	417	93.3						
1918	628	582	92.7						
1919	973	821	84.4						
1920	641	572	89.3	[4] 250	59	23.6	187	152	89.1
1921	336	302	89.9	394	182	46.2	160	114	71.4
1922	515	461	89.6	387	228	59.0	170	127	74.2
1923	561	529	94.3	452	305	67.5	224	174	77.7
1924	529	471	89.1	353	252	71.4	253	215	85.2
1925	335	311	92.9	367	329	89.7	181	169	93.4
1926	673	532	79.1	336	290	86.3	294	245	89.4
1927	613	463	75.5	454	288	61.2	393	320	81.4
Total	6,249	5,461	87.3	2,993	1,933	64.5	1,862	1,516	81.4

[1] This lot of terrapins upon maturity proved to be all females. 10 old males taken from the original brood stock of wild terrapins of unknown age were then added.

[2] Three old males taken from the original brood stock were added in 1919.

[3] In 1915 and 1916 a few eggs were produced but they are not considered in calculating fertility, as the number is too small to be of significance.

[4] Eggs were produced for 2 years prior to this date but are not considered in calculating fertility as the females were penned without males.

TABLE 12.—*Production and fertility of eggs of the 1912 brood*

Year	Smallest (runts) of the entire brood selected at 1 year of age, in part fed the first winter and all the second winter. Males, 10; females, 54			Largest selected from entire brood at 1 year of age, all fed first 2 winters. Males, 17; females, 67			Year	Smallest (runts) of the entire brood selected at 1 year of age, in part fed the first winter and all the second winter. Males, 10; females, 54			Largest selected from entire brood at 1 year of age, all fed first two winters. Males, 17; females, 67		
	Eggs laid	Young hatched	Per cent fertile	Eggs laid	Young hatched	Per cent fertile		Eggs laid	Young hatched	Per cent fertile	Eggs laid	Young hatched	Per cent fertile
1919	135	102	75.5	124	113	91.2	1925	279	247	88.5	116	116	100.0
1920	255	226	88.7	189	161	85.2	1926	447	395	88.4	255	209	82.0
1921	228	182	79.9	142	130	91.6	1927	461	396	85.9	459	392	85.3
1922	350	288	82.5	246	227	92.3							
1923	416	356	85.6	171	167	97.7	Total	2,907	2,480	85.3	1,953	1,750	89.6
1924	336	288	85.8	251	235	93.7							

TABLE 13.—*Production and fertility of eggs of the 1913 brood, which were fed first winter. Males, 4; females, 75*

Year	Eggs laid	Young hatched	Per cent fertile	Year	Eggs laid	Young hatched	Per cent fertile
1920	31	29	93.1	1925	61	41	67.0
1921	42	35	83.3	1926	115	60	49.0
1922	146	73	50.4	1927	234	157	67.0
1923	101	88	87.1				
1924	118	101	83.2	Total	848	584	69.1

TABLE 14.—*Production and fertility of eggs of the 1914 brood, which were fed first winter. Males, 2; females, 83*

Year	Eggs laid	Young hatched	Per cent fertile	Year	Eggs laid	Young hatched	Per cent fertile
1920	35	35	100.0	1925	61	61	100.0
1921	26	12	46.2	1926	140	99	71.0
1922	75	34	46.4	1927	371	241	64.9
1923	121	121	100.0				
1924	147	147	100.0	Total	976	750	76.8

TABLE 15.—*Production and fertility of eggs of the 1916 brood, which were fed first winter. Males, 40; females, 158*

Year	Eggs laid	Young hatched	Per cent fertile	Year	Eggs laid	Young hatched	Per cent fertile
1922	2	2	100.0	1926	133	122	91.8
1923	34	34	100.0	1927	219	183	83.6
1924	63	61	96.9				
1925	52	44	84.6	Total	503	446	88.6

RECORDS OF SURVIVAL

During the entire course of the experiments no evident diseases have occurred among the terrapins after they had attained an age of about 1 or 2 years, and thereafter the loss from this source has been negligible. A very considerable death rate, apparently due to disease, has occurred among the young. Further remarks con-

cerning diseases are to be found in subsequent paragraphs. A definite record of the deaths that have occurred can not be given because several animals in nearly every lot are *missing*. Some of these animals may have died unnoticed (especially when they were small), others undoubtedly were carried away by rats, birds, or other enemies, or, again, they may have found an avenue for escape. It is definitely known that in a few instances a number of animals got away during storms, when the water nearly reached the top of the walls of the pens. On the other hand, not infrequently the missing animals simply were overlooked when a census was taken. It is very difficult, because of their very proficient hiding propensities, to find all the terrapins in an inclosure even though the pen be small. Therefore, the "missing" animals of one census sometimes reappeared in the next one. On account of the impracticability of getting and keeping definite records of deaths and escapes only the animals found when a census was taken were considered in many of the tables appearing in this report. From a practical standpoint, the animals that are missing, of course, are of no more significance (unless they can be found) than the dead ones, and the proportionate number of those hatched that may be grown to maturity is of chief importance.

Many of the terrapins grown in captivity, as stated elsewhere, were selected, and the entire brood was kept only in 1910,[7] when only a small number was hatched. This brood originally consisted of 293 animals. It was divided into two lots. One lot, consisting of 120 individuals, was allowed to hibernate, and the other one, consisting of 173 animals, was kept warm and fed the first winter and part of the second winter. At the age of 1 year 93 per cent of the winter-fed terrapins and 85.8 per cent of the hibernating ones were alive. At 6 years of age, when at least some of the animals had become sexually mature and reproduction had begun, 83.2 per cent of the winter-fed lot and 78.3 per cent of the hibernating one still survived, and at 15 years of age 74 per cent of the former and 76.6 per cent of the latter lot were found.

In two unselected lots of the brood of 1911, each originally consisting of 100 terrapins, the percentage of survival at 1 year of age was 95 for the winter-fed lot and 89 for the hibernating one. At 6 years of age 82 per cent of the winter-fed animals were found and 78 per cent of the hibernating ones, and at 15 years 77 per cent of the former and 76 per cent of the latter were on hand.

The four lots discussed in the preceding paragraphs are the only ones of those at hand that have reached maturity that were carried through as separate lots and without selection from the time of hatching to maturity. All the other lots of mature terrapins were selected at about 1 or 2 years of age from lots that had been fed the first winter, and therefore the records are not continuous and not directly comparable with those of the 1910 and 1911 broods.

Winter feeding in an especially constructed brooder house[8] was begun with the 1913 brood. The object of winter feeding, of course, was mainly to increase the growth of the young animals. The results of this project, with respect to the rate of growth, are discussed in another section of this paper. Its results with respect to mortality or survival, however, appear to belong to the present section of this report.

[7] In 1909 only a few terrapins were hatched, of which only 12 grew to maturity. This number is regarded as too small to be of much significance and is omitted in this discussion.

[8] A description and photograph of the terrapin brooder house used in these experiments may be found in Bureau of Fisheries Economic Circular No. 60, 1920, pp. 17 and 18, fig. 8.

Winter feeding, from the standpoint of survival, has resulted in varying degrees of success. The highest percentage of survival during the course of the experiments was obtained in the 1915 brood when 97.6 per cent of 1,306 animals placed in the brooder house in October, 1915, lived until May 15, 1916, at which time the surviving ones were removed from the house and placed in outdoor pens (Table 17). The results for the preceding brood (1914), however, were the most unsatisfactory, from the standpoint of survival, obtained to the present time (1928). Of 1,349 animals placed in the brooder house only 53.9 per cent lived until May 24, 1915, when the surviving ones were removed from the house.

The best results under more crowded conditions, such as have prevailed during recent years in the nursery house, were obtained with the brood of 1921, of which 2,395 young were placed in the house in October, 1921. Of this number 87.7 per cent lived until May, 1922, when the surviving ones were removed from the house (Table 17), and this rate, under similar conditions, has not fallen below 68.6 per cent to the present time (July, 1928).

Various methods of sanitation, several different kinds of food, fresh and salt water, and wooden and metal (galvanized-iron) tanks have been employed, but generally with indifferent success with respect to mortality. After an epidemic of a disease (elsewhere described and designated as "sores") in the brood of 1914, the tanks were disinfected weekly with a solution containing potassium permangenate and sodium bicarbonate. In 1922 this method of disinfecting the tanks was abandoned largely because it did not prevent the growth of algæ. Food and excreta readily became lodged in the algæ, fouling the tanks, and it was necessary to scrape the tanks to keep them clean. Thereafter an extra tank was provided, making it possible always to have an empty one, and the animals were shifted at about weekly intervals. Each trough was allowed to dry, and before replacing the animals it was scalded with hot water. This treatment prevented the growth of algæ, and a considerable amount of work previously necessary to keep the tanks clean was saved. The results with respect to mortality, however, were quite indifferent (Table 16).

It would appear from the rather unsatisfactory records that the death rate during the first winter among young terrapins subsisting on foods producing the greatest gain in growth (oysters and fresh fish) increased, whereas it decreased when food (salted fish) producing little growth was supplied. It does not necessarily follow, however, that a larger percentage of the slow-growing animals would reach maturity, for the larger and more robust ones appear to stand a much better chance of survival when liberated or placed in outside pens. Unfortunately, the data bearing upon this phase of the work are very meager. Animals kept in salt water had the appearance of being healthier, and generally the death rate appears to have been a little lower. It has been thought necessary, however, to supply such animals with fresh water once a day, which increases the amount of labor, and the slight advantage gained may not be sufficient, in practical terrapin culture, to offset the extra amount of work involved. A few galvanized-iron tanks have been in use for several years. Such tanks are kept clean somewhat more easily than wooden ones, but no advantage from the stand point of mortality is apparent.

Different degrees of crowding of the animals have been tried in the brooder house with the view of determining the space requirements of the young animals. In this

series of experiments tanks 8 feet long and 20 inches wide, divided into four equal compartments, have been used. Each compartment, therefore, had a floor space of about 20 by 24 inches. In some of the compartments 25 to 50 animals were held, 100 in others, and in still others 125 to 150 were placed. The experiment was carried through three seasons (October to May, 1923 to 1926) using each year an equal number of compartments for the different degrees of crowding. The rate of survival is very slightly in favor of the least crowding, for of 325 animals used, 80 per cent survived. Of 1,100 terrapins held 100 to a compartment, 79.5 per cent survived, whereas under the crowded condition of 125 to 150 animals to a compartment only 70.7 per cent of a total of 1,530 terrapins survived. The results with respect to the rate of growth for the different degrees of crowding are discussed elsewhere. It is sufficient to state here that they bear a relationship to each other somewhat similar to the rate of survival. It may be concluded, therefore, that it is practicable to confine as many as 100 young terrapins in a space having an area of 20 by 24 inches.

The death rate among the young animals that are allowed to hibernate frequently is almost negligible during their first winter, as in the brood of 1926, of which 99.9 per cent of 1,627 animals survived (Table 17). However, in a few instances the death rate has run very high, as, for example, in the brood of 1922, in which only 44.7 per cent of 789 animals survived the winter.

Records of survival of the hibernating animals, as well as the winter-fed ones, as far as data are available, are given in Table 17. The percentage of survival of the winter-fed and hibernating terrapins, given in the table are not directly comparable, as the hibernating ones usually emerged from hibernation and were counted during the latter part of March or early in April, whereas the winter-fed animals each year were counted from four to six weeks later; that is, at the time they were removed from the nursery house. During the first four to six weeks after emerging from hibernation the death rate usually is quite heavy and generally much greater than in non-hibernating animals. Therefore, Table 17 does not contain directly comparable data, with respect to survival, of the advantages of one method over another. It does show, however, the yearly fluctuations in the rate of survival during the early months of life that has taken place during the course of the experiments, both for hibernating and winter-fed animals.

The fluctuations in the death rate in the winter-fed animals can be accounted for, in part, by the prevalence of a cancerous disease (elsewhere referred to as "sores") that as yet (1928) is of unknown origin and for which no preventive or cure has been found. This disease, which outwardly makes its appearance as sores chiefly on the tail or as discolored areas on the plastron, has always existed among winter-fed animals throughout the course of the experiments. However, it reached serious epidemic proportions only in the 1914 and 1927 broods, when the rate of survival, as shown in Table 17, was greatly reduced. Deaths have occurred from other causes, of course; principally of "soft shell" and a few of "limber neck" and miscellaneous causes. The deaths from these sources, too, have varied and are the cause of a part of the great fluctuations.

The disease designated as "soft shell" is associated with a failure to eat, resulting, of course, in a failure to grow and in general emaciation. The majority of cases of soft shell occur among young that never have been induced to take food, although rather

rarely it occurs in animals that have fed and have gained some growth. Animals that fail to take food are inactive, and they seldom enter the water but seek the sun and heat. Many of these animals die, but others often suddenly begin to feed, and a rather rapid recovery (for a terrapin) takes place. For example, 200 soft-shell terrapins (the very poorest) were selected late in May, 1927, from 2,180 winter-fed terrapins of the 1926 brood. Of the 200 animals selected, 74 were living on August 15, 1927, when they were liberated. All had gained some growth, the shells had become hard, and, with the exception of 1 animal that had a tail lesion, all gave the appearance of being healthy and sound.

Soft shell, except possibly during 1914, when a severe epidemic of sores existed, has caused the greatest loss among winter-fed terrapins. The loss from this source, combined with minor losses from limber neck, etc., for the several broods (1920 to 1927) for which fairly accurate data are available has ranged from 10.3 per cent (1921 brood) to 23 per cent (1924 brood). Table 16 shows in detail the percentage of deaths among winter-fed animals ascribed principally to soft shell and those due to sores. Soft shell, too, appears to be the chief cause, during their first summer, of the heavy mortality among terrapins that hibernated.

Limber neck apparently is a form of paralysis, which most frequently causes the animal to lose the use of the muscles in the neck and fore limbs, but occasionally it affects only the hind limbs or the control of all muscles may be lost. Few recoveries have been noticed. No definite records of the death rate caused by this disease are available, but it quite certainly has never exceeded one-half of 1 per cent and, therefore, is quite negligible.

The cause or causes of the great fluctuations in the death rate of hibernating terrapins is much more difficult to find. Since the animals do not feed during the hibernation period, nor have fed previously, and since they do not expose themselves to light but lie buried underneath sand, sod, or débris, food and light appear to be eliminated as factors influencing survival. Weather conditions—that is, temperature and precipitation—appear to be the most plausible influences to consider. Precipitation is of little importance, however, as the hibernating animals are provided with covered quarters,[9] into which little rain can enter, and moisture is provided artificially. Therefore, rainfall appears to be of little importance. A careful study of temperature records has revealed nothing. The greatest mortality that has occurred during the course of the experiments, as shown by Table 17, took place in the brood of 1922. In the 1926 brood it was negligible.

In view of the contrast in the death rate of young hibernating terrapins, temperature records (kept at this station in cooperation with the United States Weather Bureau) were carefully compared for the months during which the 1922 and the 1926 broods were in hibernation. Comparing temperatures, month by month, for the two seasons, the greatest difference occurs in February, for the average maximum and minimum temperatures each were 9.5° F. higher in 1927 than in 1923. The highest temperature on any one day during February, 1927, was 74° and the lowest

[9] A description of the winter quarters provided for hibernating terrapins is given in Bureau of Fisheries Economic Circular No. 60, 1926, p. 16.

was 28°. The highest temperature reached in 1923 was 66° and the lowest was 23°. None of these temperatures is regarded as unusual. The differences in the averages for the other months do not exceed 4°; nor are any of the daily temperatures regarded as excessively high or low. Certainly, if low temperatures were a detriment, the brood of 1917 would have perished, as the winter of 1917–18 was by far the coldest that has occurred during the course of the experiments (definite temperature records for this winter, unfortunately, are not at hand). The mortality records show, however, that only 1 of 735 animals placed in hibernating boxes died that winter. The highest percentage of survival throughout the course of the experiments, then, appears to have occurred during an excessively cold winter and again (1926) during a moderate winter. Therefore, it is not evident that the fluctuations in winter temperatures as they have occurred at Beaufort in the years during which the present experiments have been under way have affected the death rate of young hibernating terrapins.

The hibernating terrapins have been kept in winter quarters that have varied little, and the care has been about the same and in the hands of the same terrapin culturist from the beginning. It is evident, therefore, that the cause or causes for the pronounced differences in the death rate of various broods of young hibernating terrapins has not been found, and this subject remains for future investigation.

Table 17 shows that in 9 of a total of 14 broods the percentage of terrapins that lived until they were removed from their winter quarters was greater among the hibernating terrapins than among winter-fed ones. However, the hibernating ones, as already stated, each year were taken from their winter quarters and counted four to six weeks earlier than the winter-fed lots. It has been pointed out elsewhere that the death rate usually has been quite heavy during the first several weeks after the terrapins emerge from hibernation and certainly much heaveir than in the winter-fed animals for the same period of time. Definite statistics are not available for comparison, but our terrapin culturist and the writer have not the slightest doubt, from their observations extending over several years, that by the middle of May, when the winter-fed terrapins usually were counted, the percentage of survival among them at that time, for all years combined, exceeded that of the hibernating animals. Furthermore, the winter-fed animals nearly all had gained some growth and thereafter had a much better chance to survive. A few comparatively large lots of terrapins have been retained at the laboratory during recent years, and although the records are marred by depredations wrought by rats, a far larger percentage of the winter-fed lots than of the hibernating ones survived to reach an age of 1 and 2 years, and the deaths from natural causes certainly were much greater among the hibernating animals than among the winter-fed ones.

The early broods (1910 and 1911) carried to maturity in captivity, as indicated in a preceding paragraph, appear to show that winter feeding, from the standpoint of survival, has a slight advantage. Later records (if they were not clouded with missing animals killed and frequently carried away by rats), it is confidently believed, would show a much greater advantage in winter feeding than the early ones. Our terrapin culturist and the writer are both firmly convinced (although they are unable to supply

definite statistics) that a much larger percentage of winter-fed than of the hibernating terrapins (if both were retained in equal numbers) would survive to reach an age of 2 or 3 years. Thereafter, as shown elsewhere (Table 19), the death rate is small. Winter feeding, even though considered only from the standpoint of survival and entirely aside from the faster growth and earlier maturity, undoubtedly is advantageous.

The percentages of survival of most of the lots of terrapins that were hatched and raised, or partly raised, in captivity are shown in Table 18. In this table "missing" terrapins are counted as dead, and the percentages are based upon the surviving ones only. In next to the last column is given (except in those lots in which the terrapin were carried through from hatching to maturity without selection and without removing any of the original number) the percentage of the whole lot that probably would have survived had they been retained. In making the calculations it is assumed that equally as large a percentage of the entire broods or lots from which selections were made would have survived, had they been kept in captivity, as of the smaller lots selected. This appears to place the probable averages of survival a little too high, because in most instances the largest and finest animals were retained. The probable percentage of survival at 6 years of age (when at least some of the animals had reached sexual maturity) for all lots combined is 60.7. If depredations by rats could have been avoided, the average percentage of survival undoubtedly would have been considerably greater. It is quite certain, also, that in a plant built in the light of the knowledge gained from the experiments conducted and constructed especially for terrapin growing a somewhat better average could be attained. On the other hand, the average of 60.7 per cent of survival apparently compares favorably with results obtained in chicken farming. (See Hildebrand and Hatsel, 1926, p. 15, footnote.)

It was stated in the first paragraph of this section that accurate records of deaths are not available. However, after a terrapin has reached an age of 3 years or more it is of a sufficiently large size that a dead one in a pen scarcely would be unnoticed. Table 19, giving the number of terrapins at 3 years of age in various lots held in confinement, together with the deaths that were noticed during their third year and thereafter until disposed of or last counted, nevertheless appears to be of interest. It is evident at once that the death rate has been consistently low. Generally it was impossible to determine the cause or causes of the deaths that have occurred among the larger terrapins.

The low death rate (see Table 19) that has occurred among the wild brood stock is noteworthy. Some of these animals were confined in 1909, others in 1911, and a few appear to have been held over from certain experiments conducted in 1902. Most of these animals were mature when confined, but not all of them, as stated by Barney (1922, p. 94) and Hildebrand and Hatsel (1926, p. 13). Measurements of the first lot of breeders, taken when purchased in Beaufort in 1909, have been found recently among the early records, and these show that 10 of 45 females obtained in this lot were less than 5½ inches long and therefore almost certainly sexually immature. The second lot of breeders, bought in 1910 and 1911, also appears to have contained at least 6 of a total of 43 females that were less than 5½ inches long. It seems to be incorrect, therefore, to say that all the wild terrapins were mature when

confined. On the other hand, some of them probably already were very old. The shells of some of these old animals have been worn smooth, leaving no trace of growth rings, which are prominent in younger terrapins. The writer does not care to venture to make an analysis of the age [10] of these terrapins. A conservative estimate, in the opinion of our terrapin culturist and the writer, is that the ages range from 25 to possibly 40 years or more. It is pointed out in the section of this report dealing with egg production that there is as yet no conclusive evidence indicating that these animals are declining in egg production because of old age; nor is the death rate such (only two deaths having occurred during the past four years) as to suggest old age. The span of life of a diamond-back terrapin, therefore, remains undetermined.

TABLE 16.—*Percentage of deaths caused by sores and other causes among winter-fed terrapins*

Brood	Animals fed	Per cent of deaths due to sores	Per cent of deaths due to other causes, principally soft shell	Brood	Animals fed	Per cent of deaths due to sores	Per cent of deaths due to other causes, principally soft shell
1920	2,502	[1] 4.9	14.7	1924	2,407	6.3	23.0
1921	2,395	3.7	10.3	1925	2,391	2.0	13.2
1922	2,787	3.7	21.4	1926	2,936	2.4	20.8
1923	2,427	2.3	12.7	1927	3,720	13.4	15.0

[1] The combined percentages of deaths due to sores and all other causes do not quite equal the percentages of loss shown in Table 17, because each year a small number of animals is missing and in the table showing survival such animals are counted as dead.

TABLE 17.—*Survival of young terrapin during their first winter* [a]

Year	Terrapins fed in nursery house	Per cent survived	Animals hibernated	Per cent survived	Year	Terrapins fed in nursery house	Per cent survived	Animals hibernated	Per cent survived	Year	Terrapins fed in nursery house	Per cent survived	Animals hibernated	Per cent survived
1912 [b]	500	92.6	480	95.0	1917	1,481	82.5	735	99.9	1923	2,427	85.0	993	93.8
1913	525	96.0	716	99.7	1919	2,937	82.0	1,590	70.6	1924	2,407	68.6	1,163	99.0
1914	1,349	53.9	254	82.2	1920	2,502	79.6	1,404	99.5	1925	2,391	85.0	1,066	81.3
1915	1,306	97.6	736	87.2	1921	2,395	87.7	231	82.2	1926	2,936	74.2	1,627	99.9
1916	1,906	89.7	636	90.2	1922	2,820	75.6	789	44.7	1927	3,720	69.4	3,192	89.2

[a] The percentages of survival of the winter-fed and hibernating terrapins are not directly comparable because the hibernating terrapins were taken from the hibernating boxes and counted late in March or early in April, whereas the winter-fed terrapins were counted when removed from the nursery house at least 1 month later. The death rate among hibernating animals during the first month after emerging from hibernation usually is large and generally much greater than among winter-fed animals.

[b] It must not be assumed that the sum of the winter-fed and the hibernating lots of each year equals the total hatch. All the young animals rarely are found in the autumn, and frequently there is a considerable addition in the spring. Such animals, of course, are not included in this table.

[10] Barney (1922, pp. 93 and 94) has attempted to analyze the age of the wild brood stock on hand at this station. He estimated that their average age in 1921 was 28 years. If that be true, they would now (1928) be about 35 years old.

TABLE 18.—*Actual and probable percentage of survival of terrapins at 6 years of age*

Brood	Terrapins originally in brood or lot	Number surviving when selections were made (usually at 8 or 9 months of age)	Number selected and retained	Per cent of lots retained surviving at 6 years of age	Probable per cent of whole brood or lot surviving at 6 years of age	Remarks
1910	173	(1)		83.2		All fed first winter and in part the second. Entire lot retained.
1910	120	(1)		78.3		Hibernating lot, all retained.
1911	100	(1)		82.0		Fed three winters.
1911	100	(1)		78.0		Hibernating each winter.
1912	500	463	100	93.0	86.1	Largest (best) selected from entire lot.
1912	500	463	100	69.0	63.9	Smallest (runts) selected from entire lot.
1913	525	504	100	92.0	88.3	Largest selected.
1914	1,349	661	100	91.0	49.0	Do.
1915	703	(1)		51.1		Missing, 84; probably escaped or carried away by rats or other enemies. This lot was liberated when 5 years of age.
1916	2,006	1,710	200	97.5	83.1	Largest selected.
1917	1,481	910	200	50.5	34.4	Largest selected; many missing.
1918						All liberated soon after hatching.
1919	2,433	1,938	100	78.0	63.9	Largest selected.
1919	214	(1)		61.2		Hybrids; Texas male, North Carolina female.
1919	300	(1)		31.0		Hybrids; North Carolina male, Texas female. Rats destroyed many during first year.
1920	2,503	1,995	337	62.0	52.7	Largest selected, three lots combined.
Average					[2] 60.7	

[1] No selection.
[2] In computing this average, the actual number of terrapins that survived in the unselected lots, as well as the number estimated that would have survived of the lots and broods from which selections were made, were taken into consideration.

TABLE 19.—*Deaths among adult and growing terrapins after an age of 3 years was attained*

Lot	On hand 3 years old	Last counted	Deaths during intervening period	Missing at end of period	Lot	On hand 3 years old	Last counted	Deaths during intervening period	Missing at end of period
1910—Fed	157	1925	13	14	1917—Wide range	63	1927	3	21
1910—Hibernated	96	1925	5	0	1919—Hybrids; Texas male, Carolina female	54	1927	1	1
1911—Fed	84	1926	6	0	1919—Hybrids; Texas females, Carolina male	31	1927	0	0
1911—Hibernated	81	1927	2	3	1919—Domestic stock	87	1927	1	12
1912—Selects	96	1927	6	6	1920—Hybrids; Carolina males, Texas females	64	1927	1	6
1912—Runts	79	1927	3	12	1920—Domestic stock	144	1927	6	24
1913—Selected	94	1927	9	6	Adults—Wild stock, age unknown	[1] 154	1927	9	[2] 29
1914—Selected	96	1926	7	4					
1915—Selected	440	1920	20	82					
1916—Selected	195	1927	6	0					
1917—Close range	52	1927	1	0					

[1] On hand in 1911.
[2] Mostly sold.

RATE OF GROWTH

The average length of diamond-back terrapins at hatching is about 27 millimeters (1½ inches), the usual range in size being from 25 to 30 millimeters. Occasionally individuals are hatched that are only 22 to 24 millimeters long, and there is a record of one abnormally small one with a length of only 19 millimeters. The largest one of which we have a record was 31.5 millimeters long.

Newly hatched terrapins do not feed immediately. Those that are left outdoors to hibernate, as in nature, do not take food until they are from 7 to 8 months old; that is, they do not feed in the autumn during which they are hatched. In fact,

some of them do not even leave the "nests." They hibernate during cool and cold weather and generally do not emerge from the shelter in which they have spent the winter until the first warm days of the following spring. Even then they do not feed until the weather gets fairly warm. At Beaufort some of the terrapins generally emerge from hibernation during the latter part of March and others in

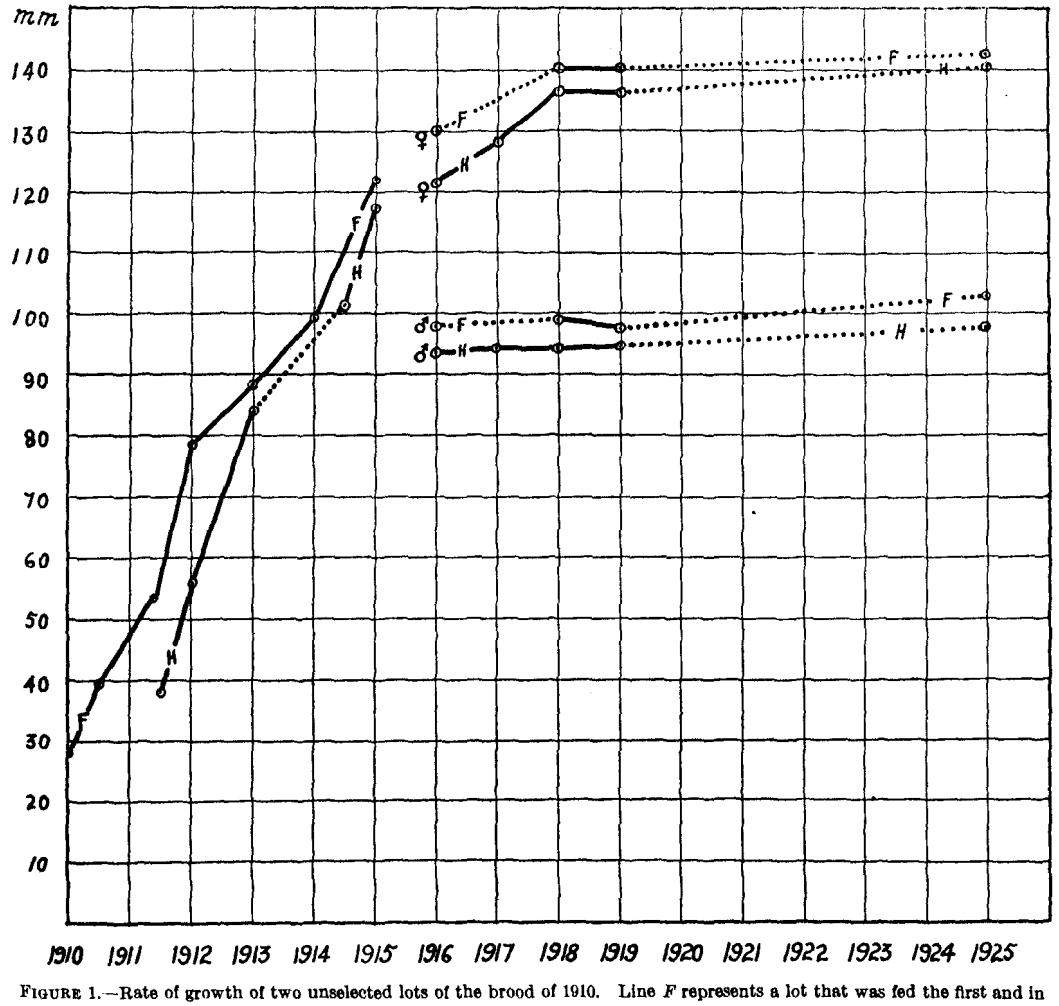

FIGURE 1.—Rate of growth of two unselected lots of the brood of 1910. Line *F* represents a lot that was fed the first and in part the second winter, and line *H* represents a lot that hibernated each winter

April. They do not feed regularly until about the latter part of May and do not make perceptible growth for a month or more after regular feeding takes place.

GROWTH OF YOUNG TERRAPINS KEPT WARM AND FED DURING THE WINTER

Winter feeding experiments were carried on at Beaufort almost from the beginning of the present investigation, and since 1912 a small house especially constructed for this purpose has been in use. This house, a frame structure with a natural sand floor, was provided with a long, gently sloping glass roof on the south side, which

admitted direct sunshine to most of the floor space during the greater part of the day. The animals were held in water-tight wooden boxes or tanks (a few metal tanks also were used) from 8 to 10 feet long and 20 to 24 inches broad. These tanks were divided into four or five compartments. Each tank was tilted to one side, and enough water was supplied to cover about half of the bottom of each compartment. This arrangement made it possible for the animals to enter the water or to stay out, according to choice. The house was heated by a stove.

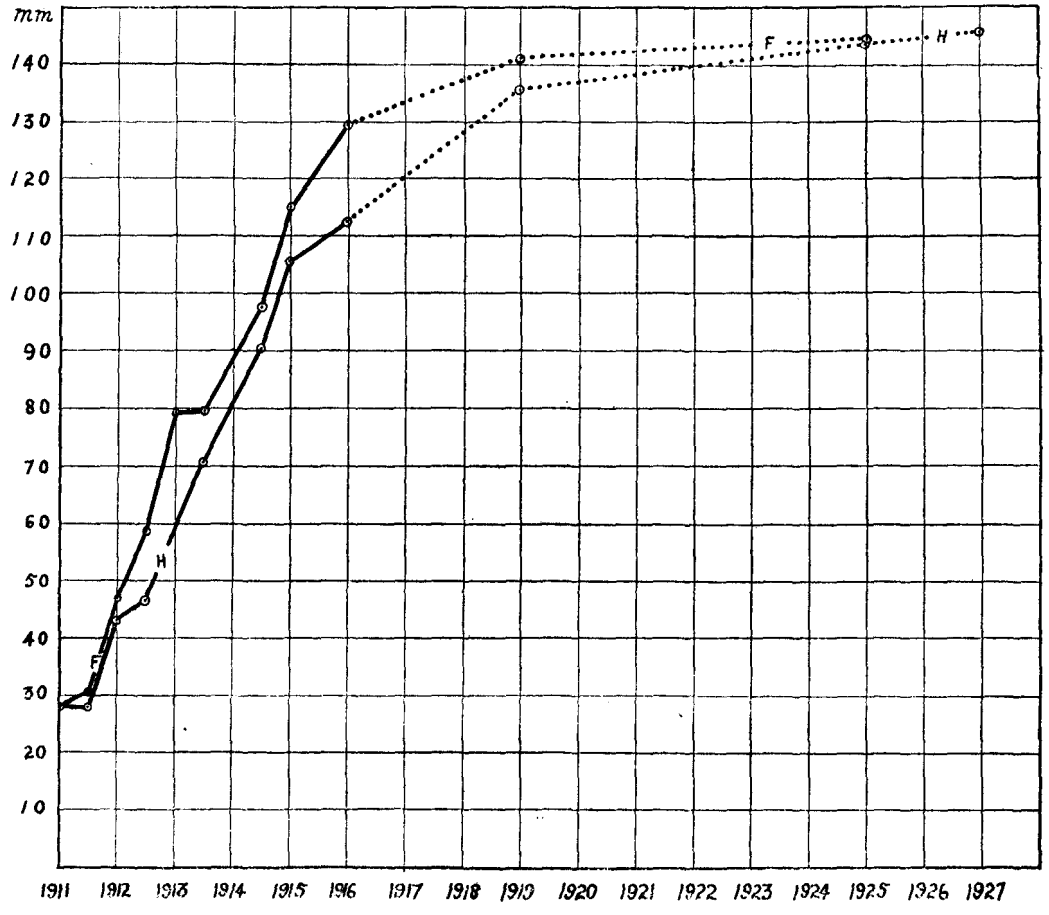

FIGURE 2.—Rate of growth of two unselected lots of the brood of 1911. Line *F* represents a lot that was fed the first three winters, and line *H* represents a lot that hibernated each winter. No males were present in either lot

Generally, young animals were placed in the brooder house in October, and an effort was made to keep the temperature at or above 80° F. in so far as possible with such an inefficient heating plant as a stove. Under these conditions terrapins remain active all winter.

Recently hatched young, only, were winter fed, except a lot of the 1910 and another of the 1911 brood, which were fed, respectively, two and three winters. The gain in growth during the winter of terrapins that were over a year old was so small that winter feeding of all except the recently hatched young was abandoned because it appeared to be impracticable.

A small percentage of the terrapins placed in the brooder house begin to take food almost immediately, others will not eat for several weeks, and still others apparently never eat. Those that start to feed first also begin to grow earlier than the others. In general, very little growth is made, however, prior to the month of December. The animals that do not appear to feed at all for a long period of time become more and more sluggish, they become emaciated, and the shells gradually soften, causing what is described as "soft shell" under another section of this report. The death rate from this source, as shown elsewhere, has been heavy. It is remark-

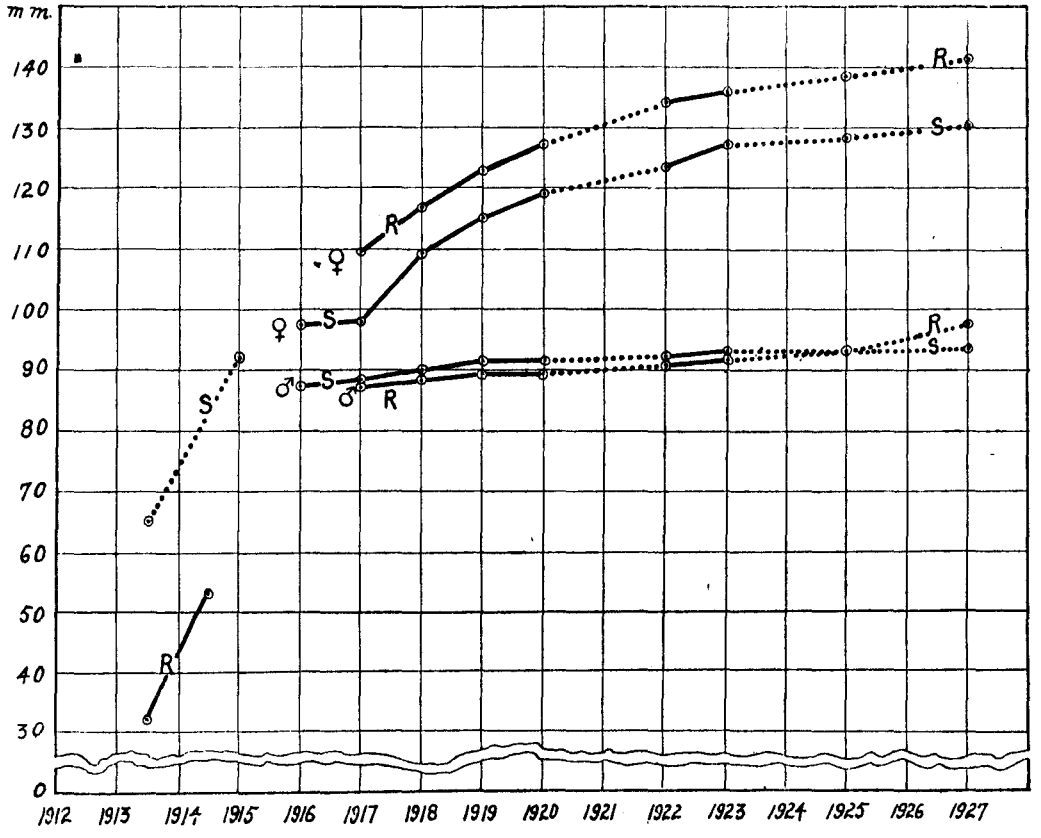

FIGURE 3.—Rate of growth of two lots of terrapins of the brood of 1912. Line *S* represents a lot that was selected at about 1 year of age as the largest, and line *R* represents a lot selected at the same time as the smallest (runtiest) in the whole brood

able, however, that some of these animals that appear to have subsisted for months upon food stored within their bodies or, as it were, upon their own substance, until they are pitiful objects, may suddenly take food and thereafter make rapid growth and become strong and healthy animals. Elsewhere in this report (p. 40) it is shown that of 200 such animals selected during the latter part of May, 1927, which had never gained growth and which, so far as known, had never taken food although it had been supplied almost daily, 74 recovered without providing a change in food or in the environment in which they were living. Animals that have once fed occasionally

cease feeding and in that event also become emaciated and gradually acquire a soft shell. The sudden change in the rate of growth of animals that have made little or no growth is further discussed in connection with the brood of 1912.

Animals in hibernation, of course, make no growth, but subsist upon foods stored within the body. Such animals are poor when they emerge and generally have to feed for a month or more, as already stated, before perceptible growth is made. This is especially true of terrapins in their first year, and that is one of the reasons why winter feeding of recently hatched young appears to be profitable.

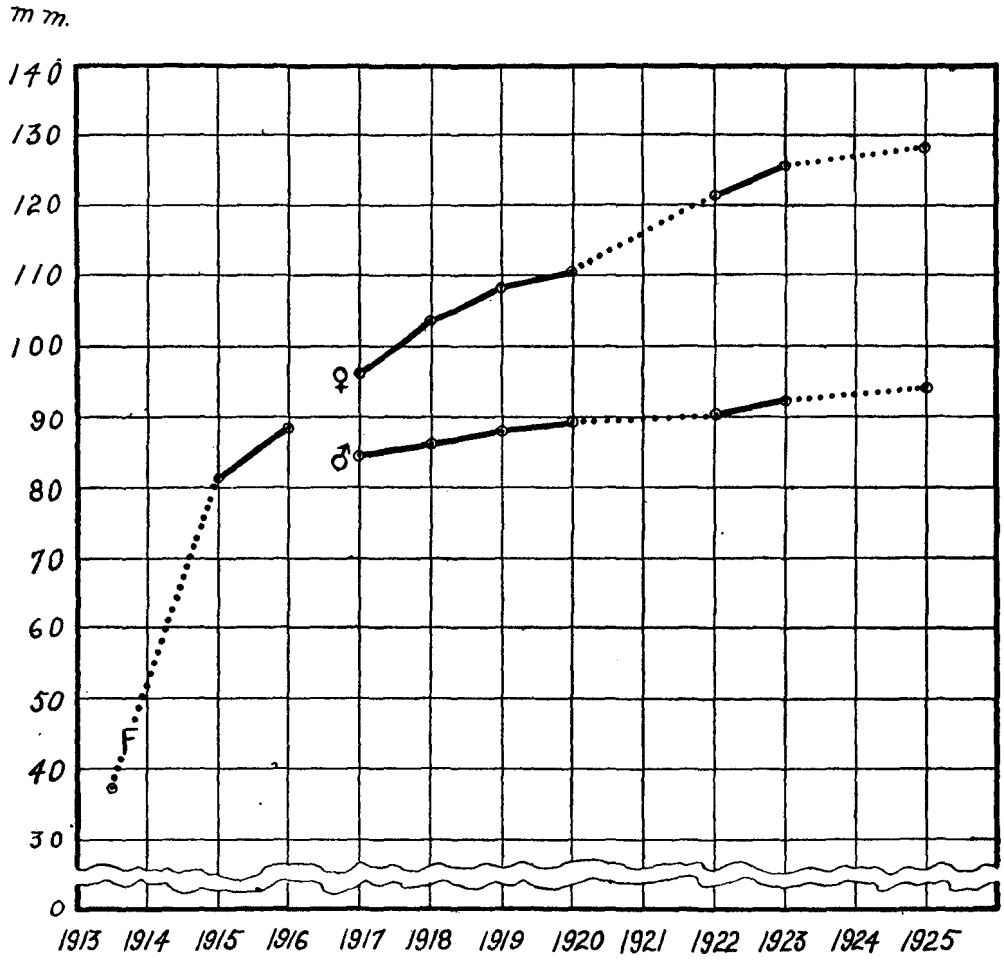

FIGURE 4.—Rate of growth of a selected lot of the brood of 1913

The rate of growth of the winter-fed lots while in the nursery house—that is, until they are about 8 months old—has varied greatly, as shown by Table 20. The small lot of the brood of 1910, consisting of only 173 animals, the first one fed during the winter, was among the best produced to date (1928); for the average length of the terrapins was 39.7 millimeters (representing a gain of 11.6 millimeters) when they were removed from winter quarters on May 10, 1911 (Table 22). Small lots of 100 or so, held in separate compartments in the terrapin house, have done equally

as well or slightly better, but the greatest gain made by a large lot occurred in the 1916 brood, when 1,040 animals reached an average length of 39.2 millimeters on

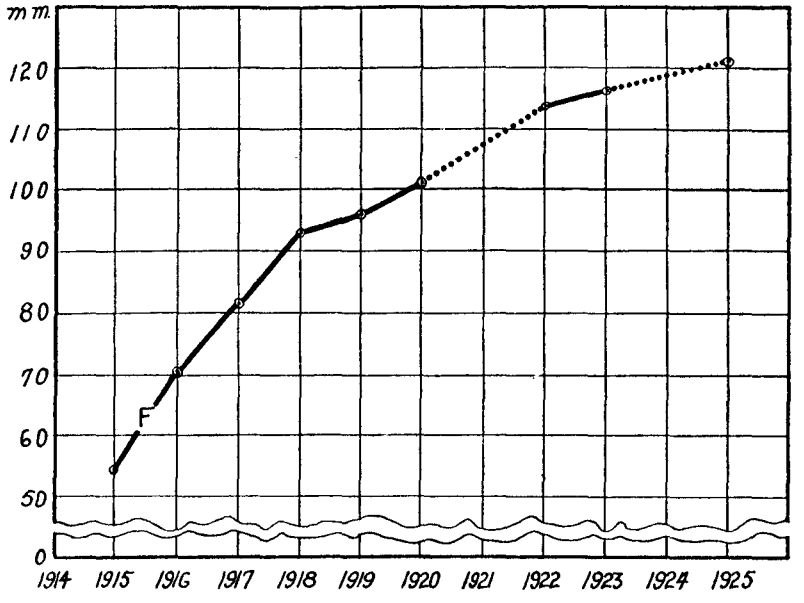

FIGURE 5.—Rate of growth of a selected lot of the brood of 1914

May 25, 1917, when they were removed from winter quarters. The least growth attained to date occurred in the broods of 1911 and 1923, the animals in each brood, upon removal from winter quarters, being found to have reached a length of only 30.9 millimeters.

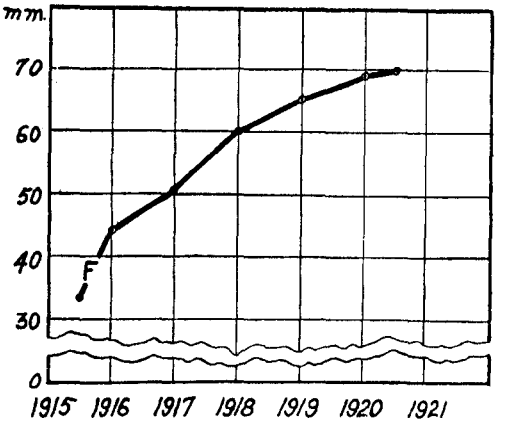

FIGURE 6.—Rate of growth of a large lot of the brood of 1915. This lot was discarded in the spring of 1921

The average rate of growth of the 1923 brood, as in several other broods, quite probably was considerably reduced because of experimentation with different kinds of foods and various kinds of treatment. For example, some of the animals of the brood of 1923 were fed salted fish, which proved to be less acceptable to the terrapins than fresh fish or oysters and produced slower growth. Then, too, some of the animals, for the purpose of experimentation, were greatly crowded in the tanks in which they were held, and that appears to have retarded growth. The different kinds of foods used and their relative value, as well as the different conditions with respect to crowding, heat, water supplied, etc., are discussed elsewhere in this section. It appears to be sufficient to state at this point that a considerable number of experiments were run and that several of them actually retarded growth, which, however, was not unexpected.

If the sole aim had been to produce the greatest gain possible, a much better average rate of growth undoubtedly could have been produced.

The excellent growth made by the winter-fed lot of the 1910 brood is noteworthy, especially because of the seemingly unfavorable conditions under which it was held. A special house, as already indicated, was not yet available. Therefore, the animals were placed in the pump house at the station. The tanks were so arranged with respect to the windows that they received the rays of the sun through the window glass during a part of the day. No special heating plant was provided. Some heat, however, was obtained from the steam boiler used for pumping water, but the boiler was used only intermittently and not every day. On especially cold days some

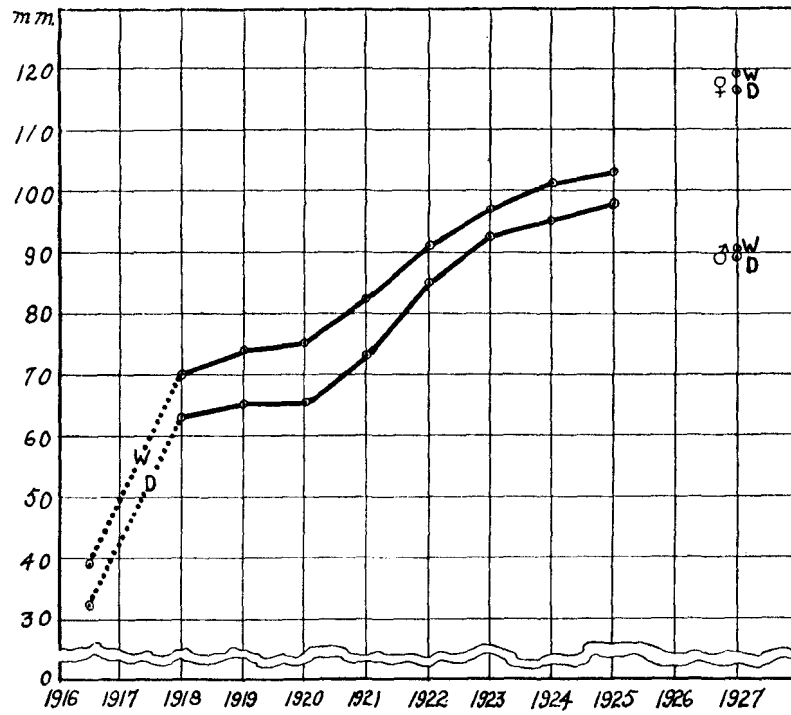

FIGURE 7.—Rate of growth of two lots of selected terrapins of the brood of 1916. Line *D* represents offspring of domestic stock and line *W* that of wild stock

extra heat was supplied from oil stoves that were run only on such occasions. It is quite remarkable, in the light of present knowledge, that such excellent results were obtained under these circumstances, and furthermore, as shown elsewhere, the death rate was extremely low. A part of the next brood (that of 1911) was kept under identical conditions, and although the death rate remained remarkably low, the rate of growth, as already indicated, was as low as it has been to date (1928) for any winter-fed lot. Somewhat similar fluctuations with respect to growth, as shown by Table 20, have taken place from year to year. They have occurred, also, within a brood among animals of the same parents and not infrequently among the small lots held in adjoining compartments of the same tank, receiving identical treatment. It is impossible, as yet, to explain the reason or reasons for all fluctuations.

In general, those animals that were nearest the stove where the temperature was the highest and probably somewhat more uniform than elsewhere made the greatest growth. On the other hand, those held in certain tanks rather far removed from the stove and placed in such a position that the animals received no direct sunshine invariably made the least growth.

Various methods of sanitation (some of which are described in the section of this report dealing with the records of survival) have been employed, but apparently without appreciable effects upon the rate of growth.

One metal (galvanized iron) tank has been used for several years. The animals in this tank, which was always placed near the stove, gained a fair to a good rate

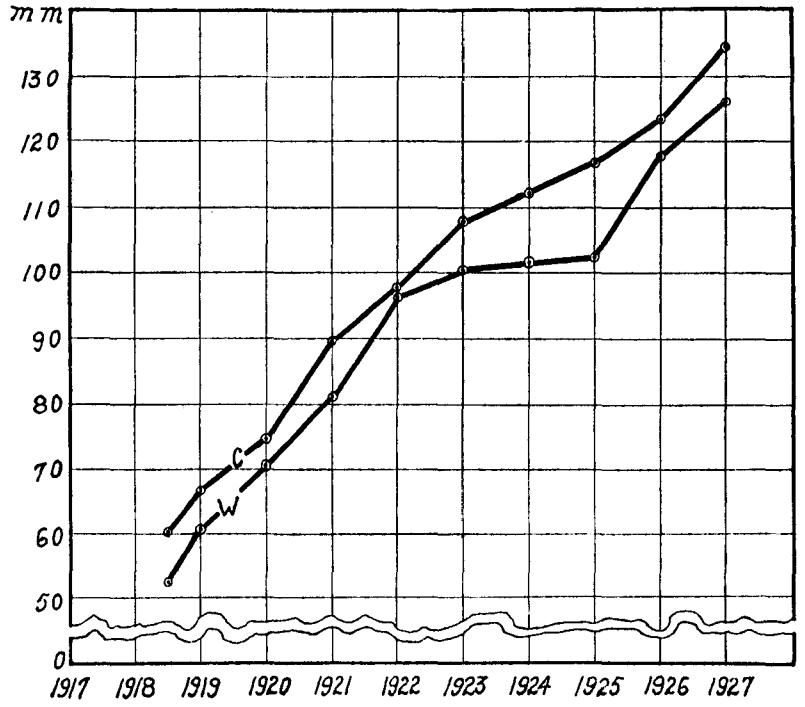

FIGURE 8.—Rate of growth of two lots of terrapins of the brood of 1917. Line *C* represents the lot under close "range" and line *W* the lot under a wild "range"

of growth during certain years, and again the gain was quite small. The average rate of growth of the animals held in this tank during the period 1920 to 1926, compared with that of animals held in adjoining tanks during the same period of time, is just about equal; that is, the average size of 1,018 animals held in the metal tank during the period indicated was 32.5 millimeters, whereas it was 32.3 millimeters for 1,195 animals held in a wooden tank placed at one side of it, and 32.9 millimeters for 973 animals in another wooden tank on the opposite side. The metal tank, as indicated elsewhere, did not bring a lower death rate, for in this respect the results also are intermediate of those for the adjoining tanks. A metal tank is kept clean somewhat more easily, and this apparently is the only advantage it has over a wooden one. On the other hand, galvanized iron corrodes in a comparatively brief

period of time in this climate and does not last so long as wood. Other metals and enamel are regarded as rather too expensive for economical use.

TABLE 20.—*Average size of terrapin fed during their first winter*

Brood	When measured	Number measured	Average length in millimeters	Remarks
1910	May 10, 1911	173	39.7	
1911	Apr. 23, 1912	216	30.9	
1912	May 5, 1913	463	31.8	
1913	Apr. 29, 1914	504	31.0	
1914	May 24, 1915	351	32.9	Fed fresh fish and oysters.
1914	do	376	31.5	Fed salted fish.
1915	Mar. 15, 1916	662	33.8	Fed fresh fish and oysters.
1915	do	613	29.9	Fed salted fish.
1916	May 17-25, 1917	1,040	39.2	
1917	May 15, 1918	1,045	31.1	
1919	May 11, 1920	290	33.7	Hybrids, Texas and Carolina terrapins.
1919	do	169	34.9	Offspring domestic stock.
1919	do	158	36.0	Offspring wild stock.
1920	May 13, 1921	1,994	31.8	
1921	May 16, 1922	2,101	31.7	
1922	May 23, 1923	2,132	32.2	
1923	May 16, 1924	2,054	30.9	
1924	May 11, 1925	1,651	32.3	
1925	May 13, 1926	2,019	32.4	
1926	May 12, 1927	2,180	31.7	
1927	May 7, 1928	2,583	30.8	
Average			32.4	

FOOD

The following foods have been supplied: Fresh and salted fish, oysters, clams, and crabs. Vegetables have been offered at different times but were not eaten. A comparison of the utility of the various foods can not yet be given because of the unequal distribution of heat in the terrapin house. It is pointed out elsewhere that the greatest amount of growth almost invariably was made by the terrapins nearest the stove. This is true, in a measure, regardless of the food supplied or other treatment given. This factor, therefore, evidently is an important one, and a comparison of the rate of growth with respect to the foods supplied is not a fair one unless the animals were similarly situated with respect to the source of heat. As far as possible such comparisons have been made but are considered of only limited value, and only general discussions are given. It remains for future investigation to determine the actual value of the various foods that are available and that seem suitable, and that can be done only when a house becomes available in which uniform temperatures can be provided.

Fresh fish was used much more extensively than the other foods that have been mentioned, because (next to salted fish) it was the most convenient and economical to use and the growth attained apparently was exceeded slightly only when oysters were fed. Salted fish (mullet) was not taken readily. In fact, terrapins that had been feeding on fresh food had to be starved for a week or two before they would take salted fish. It is not surprising that animals fed with this apparently distasteful food grew slowly. Crabs appear to be a good food and are taken readily, but they are so difficult to get during at least a part of the winter that it was found impracticable to feed them continuously. Clams are taken readily but have not been supplied over long periods of

time and are regarded as too expensive to use in practical terrapin culture. Oysters, also, are regarded as too expensive to use extensively, even though they produce rapid growth in the young animals. Although definite data are not available, it would appear advantageous to supplement fresh fish from time to time with oysters, clams, and crabs.

CROWDING

Various degrees of crowding have been tried in the tanks in the brooder house with the view of determining the space requirements of the young animals. In this series of experiments, which extended over three seasons (October to May, 1923 to 1926), tanks 8 feet long and 20 inches broad, divided into four compartments, were used. Each compartment, therefore, had a floor space of about 20 by 24 inches.

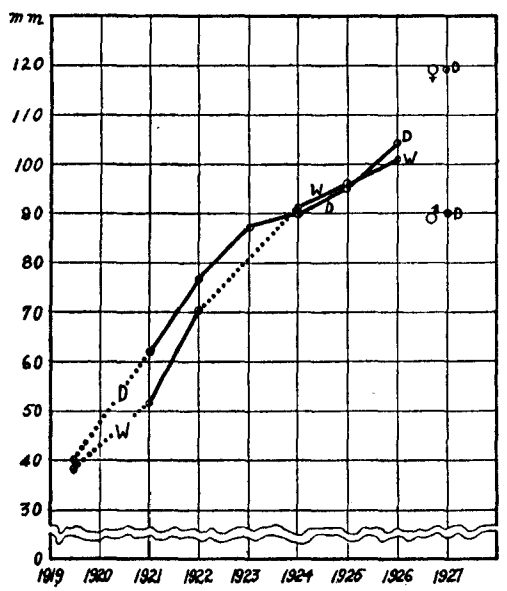

FIGURE 9.—Rate of growth of two lots of terrapins of the brood of 1919. Line *D* represents offspring of domestic stock and line *W* offspring of wild stock

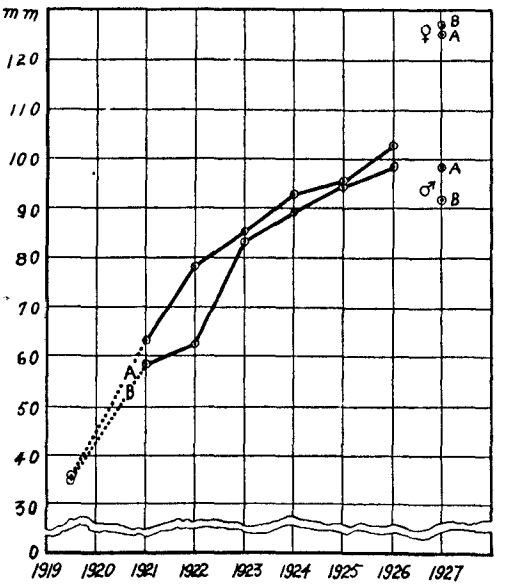

FIGURE 10.—Rate of growth of two lots of hybrid terrapins of the brood of 1919. Line *A* represents a cross between Texas males and North Carolina females, and line *B* represents a cross between Carolina males and Texas females

In some of the compartments 25 to 50 animals were confined, in others 100 were held, and in still others from 125 to 150 were placed. The rate of growth appears to be slightly in favor of the least crowding, for the average length of the 260 animals that survived was 34.8 millimeters. For the next degree of crowding, namely 100 animals to a compartment, the average size of 877 surviving animals was 33 millimeters, and for 1,082 surviving animals crowded to the extent of 125 to 150 to a compartment the average length attained was 31.1 millimeters. It is shown elsewhere that a somewhat similar relationship with respect to the rate of survival existed for the different groups of crowding. It appears reasonable to conclude, therefore, that it is feasible and economically advantageous to hold as many as 100 young animals in a tank having a floor space of about 20 by 24 inches, but greater crowding appears to result in higher mortaility and slower growth.

COMPARISON OF THE SIZE OF WINTER-FED AND HIBERNATING TERRAPINS AT ABOUT 1 YEAR OF AGE

It has been shown that young terrapins were kept active and were induced to feed during the winter when they were placed in a warm house. Under such conditions the average gain in length per year over a period of 17 years ranged from about 4 to slightly over 11 millimeters, the average gain for all winter-fed terrapins (20,034) being 5.7 millimeters. During this time the hibernating terrapins, of course, are making no growth. Table 21 shows the difference in size of winter-fed and hibernating animals at about 1 year of age for six pairs of lots of six different broods. The winter-fed animals of all lots combined (1,069 animals) had an average length of 44.1 millimeters, whereas the hibernating animals (780) had an average length of 37.5 millimeters. This advantage in growth appears to have been maintained fairly well in those lots that were grown to maturity in confinement.

The gain in growth during their first winter of the animals that were fed represents about a year's growth. This lead in size over hibernating terrapins is important in terrapin farming, as it would hasten the turnover by just that length of time. Furthermore, sexual maturity was reached a year earlier and, as stated elsewhere, the death rate apparently was considerably lower. Winter feeding, when terrapin culture is engaged in for the purpose of reestablishing or augmenting the supply in nature, offers the advantage that most of the young will have gained considerable growth and will have passed through the most critical stages of life at about 8 months of age, when they may be liberated with the assurance that they stand a fair chance of survival. On the other hand, it has been considered advisable at Beaufort to retain the hibernating terrapins a year longer, involving extra care and work and a greater mortality.

TABLE 21.—*Comparison of size of winter-fed and hibernating terrapins at about 1 year of age*

Brood	When measured	Winter-fed			Hibernating		
		Number measured	Total length	Average length	Number measured	Total length	Average length
1910	Apr. 15, 1912	[1] 105	5,614	53.4	[1] 104	3,954	38.0
1911	Sept. 9, 1912	95	4,464	47.0	89	3,833	43.0
1923	Oct. 9, 1924	241	9,424	39.1	163	5,350	32.8
1924	Oct. 27, 1925	262	11,074	42.2	122	3,977	32.5
1925	Oct. 5, 1926	228	9,097	39.4	206	7,469	36.2
1926	Sept. 27, 1927	138	7,531	54.4	96	4,686	48.7
Total		1,069	47,204	44.1	780	29,269	37.5

[1] These animals were not measured at 1 year of age. However, the measurements were taken the following spring before the terrapins had started to make new growth, and the sizes here given of course, are the same as they would have been the preceding autumn, or at the age of 1 year.

GROWTH OF TERRAPINS PAST 1 YEAR OF AGE

It has been pointed out already that the rate of growth of terrapins during their first year is very irregular both among broods and within single broods. This irregularity in size and rate of growth is equally pronounced in the older terrapins that are being grown in captivity. It does not follow, however, that those animals that grow slowly at first will continue their slow growth and always be "runts." If that were the case, the runts would not constitute the serious problem they are to the terra-

pin culturist, for then they could be eliminated at an early age and before they had become much of a liability. It is not practicable to do this, however, for frequently the slow-growing animals suddenly begin to grow fast and in a comparatively brief time overtake those that grew fast earlier in life but discontinued their rapid growth.

An excellent example of the changes in the rate of growth of terrapins is found in the brood of 1912 (Table 24). In this instance, from a total of about 800 yearling animals 100 of the largest were selected and placed in a separate pen; also 100 of the smallest and runtiest were selected and placed in an adjacent pen. Food and treatment and the general environment were made as nearly identical as possible. Measurements of the two lots at the time of selection (September 13, 1913) are not available. The animals were measured in the following spring (April 29, 1914), however,

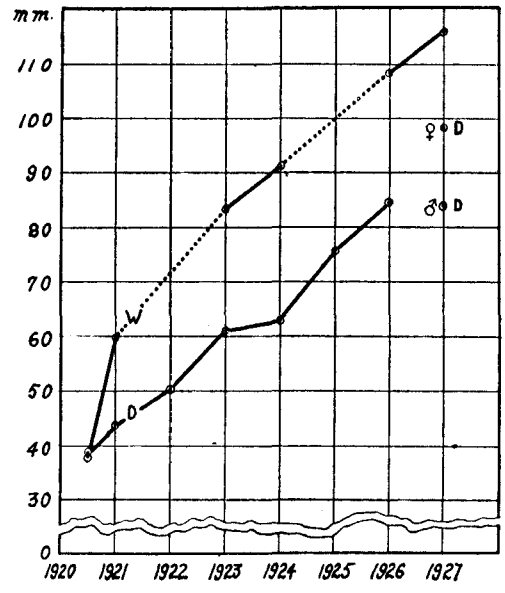

FIGURE 11.—Rate of growth of two selected lots of the brood of 1920. Line *D* represents offspring of domestic stock and line *W* that of wild stock

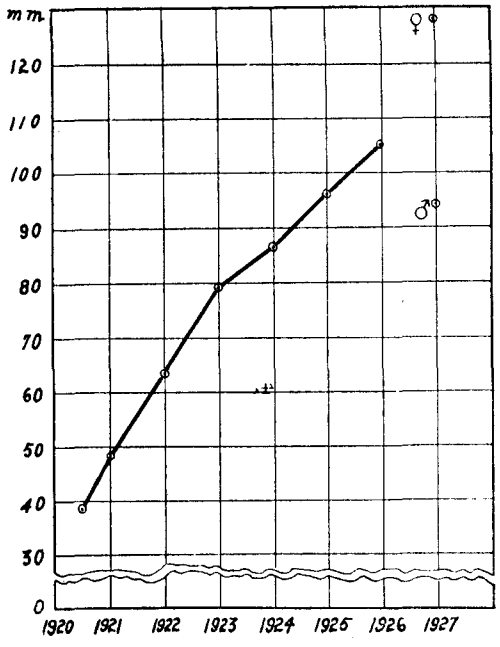

FIGURE 12.—Rate of growth of an unselected lot of hybrid terrapins (Carolina males and Texas females) of the brood of 1920

and of course not much growth had taken place during the interval. The 100 "selects" all survived until spring and had an average length of 65 millimeters. The 100 "runts" had diminished to 89, and these animals had an average length of 32.3 millimeters. On October 6, 1917, the selects, which then numbered 89, consisted of 18 males and 72 females. The males had an average length of 88.7 millimeters and the average length of the females was 98 millimeters. On the same date the runts numbered 69 and were composed of 13 males and 56 females. The males averaged 87.2 millimeters in length and the females 109.5. The combined average length of male and female "runts," therefore, was greater than that of the "selects." The lead then secured by the "runts" has been maintained to the present time (1928).

It is not known that identical results would be obtained if a similar experiment were to be undertaken. The selection experiment with the brood of 1912, together

with others of much shorter duration, offer sufficient evidence, however, to show that it is not practicable to make selections of fast growing terrapins at 1 year or less of age. Furthermore, it seems very probable that such selections can not be made even at 2 or possibly at 3 years of age. The data on this last point still are quite meager. The fact that some animals (as is plainly shown by the accompanying tables) grow very slowly and require a much longer time than others to reach maturity and a size sufficiently large to make them valuable on the market, however, is well established, and these extremely slow growing individuals appear to furnish the chief obstacle to terrapin farming as an enterprise.

Comparatively few females [11] (as shown by the tables presented herewith) reached sexual maturity and a length of 5½ inches at the age of 5 years. A somewhat larger percentage reached it at 6 years of age. However, 9.8 per cent of the females of the winter-fed lot of the 1910 brood were still under that size at the age of 15 years. Among the hibernating lot of the same brood, 19.5 per cent were under 5½ inches in length at the same age. Although marketable at a smaller size, a terrapin is not considered a "count" and does not bring a fancy price until it has reached a length of 6 inches or more. According to this classification only 28.5 per cent of the winter-fed lot of the 1910 brood and 25.2 per cent of the hibernating lot of the same brood would have passed as counts at the age of 15 years.

In the 1911 brood 12.9 per cent of the animals (no males included) of the winter-fed lot were less than 5½ inches in length at 14 years of age, and in the hibernating lot of the same brood 15.2 per cent were under this size at 14 years of age. The percentage of counts was somewhat greater than in the 1910 brood, for 41 per cent of the fed lot and 45.8 per cent of the hibernating lot could have been classed as counts at 14 years of age. Younger broods have made even slower growth.

The growth curves presented herewith show that, in general, the average rate of growth is fairly rapid until the terrapins reach an age of 5 or 6 years. Thereafter it becomes much slower, and after the eighth to the tenth year it is extremely slow. The almost negligible growth of the older animals, as, for example, those of the 1910 brood, after attaining an age of about 8 years suggests that some of the animals will never reach a length of 6 inches. It seems improbable, even, that all of them will reach 5½ inches. In the winter-fed lot of the 1910 brood, for example, 11 of the 102 females included were less than 5½ inches long, the smallest one having a length of only 4 4/5 inches when last measured at the age of 15 years. In the hibernating lot of the same brood, at the same age, 17 of the 87 females included were less than 5½ inches long, and the 2 smallest ones were only 5 inches in length. The first-mentioned lot, according to our records, appears to have made an average gain in growth of only 2.5 millimeters, and the other lot only 4 millimeters during the six years prior to the last measurements, or between the ages of 9 and 15 years.

In the winter-fed lot of the 1911 brood, 10 of the 78 females included were under 5½ inches long, the smallest one having a length of 4 4/5 inches when last measured at the age of 14 years. Among the hibernating lot of the same brood at the same age 11 of the 72 females were less than 5½ inches long, and the smallest one was 5⅛ inches in length. The winter-fed lot had made an average gain of 3.4 millimeters

[11] The males are not considered in this connection as none of them appear ever to reach as great a length as 5½ inches, and they reach sexual maturity at a much smaller size.

and the hibernating lot a gain of 8.9 millimeters during the 6 years prior to the last measurements, that is, between the ages of 8 and 14 years.

The data presented in the foregoing paragraphs are illustrative of the extremely slow growth that is made by terrapins that are 8 to 10 years or more of age, and they suggest, as already indicated, that some females will never reach a length of 6 inches and that a small percentage may not even reach 5½ inches. It appears to be of interest to note that among the original wild brood stock confined, part since 1909 and part since 1911, and with few exceptions "adult" terrapins when secured, 17 females were under 6 inches in length when last measured (1925). It would seem almost certain that such animals will never reach a length of 6 inches. It is not surprising, therefore, that all females grown in captivity apparently do not reach a length as great as 6 inches. In commercial terrapin growing it probably would not be profitable to retain the animals after comparatively rapid growth ceases; that is, after an age of 8 to 10

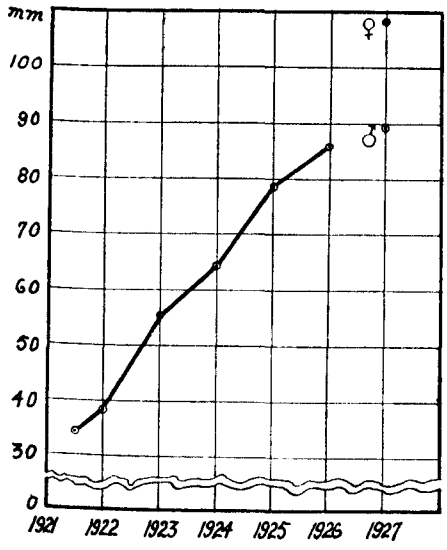

FIGURE 13.—Rate of growth of a selected lot of the brood of 1921

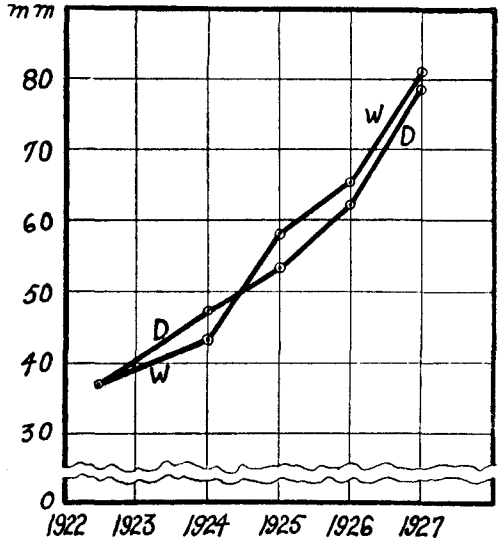

FIGURE 14.—Rate of growth of the brood of 1922. Line *D* represents offspring of domestic and line *W* of wild stock

years is reached. A considerable percentage of the terrapins at these ages, as shown by the accompanying tables, are 5 inches and over in length and would bring a fair price on the market, and it seems doubtful if the increment in size thereafter would justify the expense of food and labor involved to produce it.

The largest size attained to date by any terrapin grown in captivity is 6⅝ inches. It is well known, of course, that in nature individuals measuring 7 inches and over in length occasionally are taken. A single female occurs among the wild brood stock confined at this station having a length of slightly less than 7½ inches (185 millimeters). This animal probably approaches the maximum size attained by Carolina terrapins. The Texas terrapins, of course, grow somewhat larger and occasionally slightly exceed a length of 8 inches.

Information relative to the rate of growth of terrapins in nature virtually is wanting. A few animals hatched at this station and liberated at about 1 year

of age have been retaken. The recaptured animals had gained growth at about the same rate as the fastest growing ones of the same age that were raised in captivity. In the almost total absence of data on the rate of growth in nature, a comparison of the rate of growth of domestic and wild animals can not be given. Neither will it be known, until much more information is obtained, whether an equally large percentage of wild animals are slow growers or runts as among domestic ones. Therefore, it is not yet known what influence, if any, domestication has on the rate of growth.

Male terrapins have been omitted in the discussions on growth because they do not reach a large size and are of comparatively little value on the market. The sexes can not be distinguished in young terrapins until a length of about 3 inches or more is attained. For this reason the sexes are not listed separately in the accompanying tables until they have attained a considerable size. It is not evident that there is a difference in the rate of growth with respect to the sexes until they become distinguishable. Thereafter the males appear to grow less rapidly, and consequently they are soon much smaller than the females. It is fortunate, from an economic point of view, as pointed out eleswhere, that the males appear to be greatly in the minority, for the largest one of which a record is on hand was 4⅝ inches long and the largest one among the domestic animals has a length of only 4½ inches. The average size of adult males appears to be around 4 inches, and a considerable percentage apparently never exceeds a length of 3¾ inches.

CONCLUSIONS

It is evident from the foregoing discussion and the data presented that the chief problem of the terrapin culturist is the elimination of the runty and slow-growing animals. It has been shown that this can not be done through selection at an early age. Therefore, the problem apparently must be solved, if in fact it can be solved, through selective breeding. Experiments along that line are under way, but owing to the slow growth and the long time it takes terrapins to mature no definite results have been obtained to the present time (1928). Slow growth, late maturity, and animals of comparatively small size may not be of importance in the case of terrapins that are liberated and attain their growth in nature, but they are of extremely great importance to the terrapin farmer, who would of necessity be interested in as quick a turnover as possible and in the production of large animals that would bring a fancy price on the market. It has been shown that little growth is gained after the animals reach an age of 8 to 10 years, and the writer believes that it would not be profitable in terrapin farming to retain the animals longer, but that they should be disposed of at about that age regardless of size.

TABLE 22.—*Rate of growth of the brood of 1910*

When measured	Winter fed					Hibernating				
	Number	Smallest	Largest	Females 125 mm. or more in length	Average length	Number	Smallest	Largest	Females 125 mm. or more in length	Average length
		Mm.	*Mm.*		*Mm.*		*Mm.*	*Mm.*		*Mm.*
October, 1910	171	25	31		[1] 28.1					
May 10, 1911	173	28	61		39.7					
Feb. 9 to Apr. 22, 1912	105	35	78		53.4	104	29	49		38.0
Sept. 9, 1912	161	41	98		78.7	98				56.5
July 2, 1913						94	38	90		68.5
Sept. 10, 1913	157	52	122		88.4	97	62	105		84.4
Apr. 30, 1914	153	52	124		99.4	97	62	105		84.4
Apr. 12, 1915						94	83	118		101.8
Oct. 5, 1915	143	83	154	71	122.1	95	89	137	19	117.6
Aug. 29, 1916: [2]										
Male	16	84	107	95	98.0	5	90	96	41	93.4
Female	127	100	154		130.1	89	99	147		121.4
Oct. 3, 1917:										
Male						5	91	97	55	94.2
Female						78	101	152		128.2
Sept. 13, 1918:										
Male	17	85	108	111	98.8	5	91	97	83	94.2
Female	129	117	165		140.3	89	112	156		136.7
Sept. 20, 1919:										
Male	18	85	[3] 109	123	[3] 97.7	5	92	97	86	[3] 94.8
Female	129	120	164		140.1	89	114	158		136.4
Oct. 21, 1925:										
Male	11	88	112	101	102.7	5	96	100	87	97.8
Female	102	123	165		142.6	87	127	163		140.4

[1] The average size of newly hatched terrapins, according to more recent measurements, is about 27 millimeters. This difference between the early and more recent measurements very probably is the result of the methods used. The recent measurements were made with calipers, whereas the early ones were made with an ordinary rule and are therefore less accurate.

[2] Some of the males, but not all, were distinguishable prior to this date.

[3] The apparent slight decrease in size may be due in part to a closer measurement, but it is more probable that the terrapins measured in 1918 and 1919, in part, were not the same ones, as all the terrapins in any one pen seldom are found at one time.

TABLE 23.—*Rate of growth of brood of 1911* [1]

When measured	Winter fed					Hibernating				
	Number	Smallest	Largest	Females 125 mm. or more in length	Average length	Number	Smallest	Largest	Females 125 mm. or more in length	Average length
		Mm.	*Mm.*		*Mm.*		*Mm.*	*Mm.*		*Mm.*
Sept. 10, 1911	100	25	30		[2] 28.1	100	25	30		[2] 28.1
Apr. 23, 1912	98	25	38		30.9	98	24	31		27.9
Sept. 9, 1912	95	29	68		47.0	89	30	59		43.1
May 21, 1913	86	41	79		58.8	86	31	63		46.8
Sept. 12, 1913	83	47	102		79.1	84	42	88		64.6
Apr. 29, 1914	82	49	105		79.5	81	51	89		71.8
Mar. 23, 1915	78	65	120		97.7	77	64	110		90.5
Oct. 5, 1915	81	96	145	33	115.0	78	83	131	5	105.8
Sept. —, 1916	82	94	155	49	129.8	78	85	141	19	112.4
Sept. 26, 1919	82	110	162	82	141.2	78	107	159	70	135.7
Oct. 16, 1923						74	116	162	38	140.7
Oct. 29, 1925	78	120	165	107	144.6	72	110	164	35	143.6
Oct. 21, 1927						72	129	164	35	145.6

[1] The two lots of the 1911 brood contain no males.

[2] The average size of newly hatched terrapins, as shown, is about 28.1 millimeters (1⅛ inches).

TABLE 24.—*Rate of growth of the brood of 1912*

When measured	Selects [1]					Runts [2]				
	Number	Smallest	Largest	Females 125 mm. or more in length	Average length	Number	Smallest	Largest	Females 125 mm. or more in length	Average length
		Mm.	*Mm.*		*Mm.*		*Mm.*	*Mm.*		*Mm.*
Apr. 29, 1914	100	51	83	----------	65.0	89	27	42	----------	32.3
Nov. 5, 1915	94	76	110	----------	92.0	82	30	82	----------	53.2
Sept. 7, 1916: [3]										
Male	19	81	98	----------	87.2	----------	----------	----------	----------	----------
Female	77	77	119	----------	97.6	----------	----------	----------	----------	----------
Oct. 11, 1917:										
Male	18	82	98	----------	88.7	13	80	95	9	87.2
Female	72	82	130	----------	98.0	56	77	136		109.5
Sept. 30, 1918:										
Male	18	85	100	6	90.0	13	83	94	17	88.3
Female	73	88	131		109.7	56	100	145		117.0
Oct. 1, 1919:										
Male	18	[4] 83	[4] 99	19	91.8	12	83	95	34	89.7
Female	75	[4] 87	139		115.1	56	[4] 95	149		123.0
Oct. 5, 1920:										
Male	17	83	100	27	[4] 91.6	13	83	95	39	[4] 89.6
Female	75	89	143		119.0	55	108	151		127.1
Dec. 12, 1922:										
Male	18	83	100	32	92.3	12	84	97	48	91.0
Female	[4] 73	97	145		123.7	55	118	153		134.0
Oct. 10, 1923:										
Male	18	85	101	38	93.4	12	85	98	50	91.7
Female	70	111	146		127.1	55	122	155		135.9
Oct. 21, 1925:										
Male	17	85	[4] 100	48	93.8	12	87	102	55	93.9
Female	69	[4] 106	148		128.6	55	125	155		138.2
Oct. 15, 1927:										
Male	17	86	102	63	94.0	11	90	[4] 101	55	97.7
Female	67	115	151		130.7	54	126	158		141.1

[1] "Selects"; 100 best selected from entire brood, Sept. 13, 1913.
[2] "Runts"; 100 poorest selected from entire brood, Sept. 13, 1913.
[3] The sexes could not be distinguished definitely prior to this date.
[4] The apparent decrease in size may be due to a somewhat closer measurement, or it may be that the same terrapins were not measured, for all the terrapins in 1 pen often are not found.

TABLE 25.—*Rate of growth of the brood of 1913*

When measured	Number	Smallest	Largest	Females 125 mm. or more in length	Average length	Remarks
		Mm.	*Mm.*		*Mm.*	
Apr. 29, 1914	686	22	32	----------	27.6	Hibernated.
Do	504	23	48	----------	31.1	Fed first winter.
Do	100	34	48	----------	37.5	Selected best from preceding lot; measurements based on 100 largest.
Nov. 5, 1915	96	69	104	----------	81.1	
Sept. 20, 1916	94	73	112	----------	88.6	
Oct. 11, 1917:						
Male	4	77	95	1	84.5	Prior to this date the sexes could not be separated definitely.
Female	90	76	125		96.0	
Oct. 1, 1918:						
Male	4	80	[1] 89	3	86.0	
Female	90	83	134		103.7	
Oct. 1, 1919:						
Male	4	80	100	10	88.0	
Female	88	86	138		108.3	
Oct. 13, 1920:						
Male	4	81	101	11	89.2	
Female	86	88	140		110.7	
Dec. 12, 1922:						
Male	4	82	[1] 100	29	90.2	
Female	85	95	144		121.2	
Oct. 10, 1923:						
Male	4	85	101	59	92.2	
Female	79	102	148		125.5	
Oct. 21, 1925:						
Male	4	85	103	55	94.0	
Female	75	105	150		128.1	

[1] All the terrapins in a pen seldom are found at one time. The decrease in size probably is due to missing one of the smallest animals the preceding year.

TABLE 26.—*Rate of growth of the brood of 1914*

When measured	Number	Smallest	Largest	Females 125 mm. or more in length	Average length	Remarks
		Mm.	*Mm.*		*Mm.*	
May 24, 1915	351	25	48		32.9	Fed fresh fish.
Do	376	24	45		31.5	Fed salt fish first winter.
Aug. 25, 1915	284	27	67		42.2	Fed fresh fish.
Do	303	28	69		41.6	Fed salt fish first winter.
Do	100	49	69		54.2	Selected 100 best from preceding lots.
Sept. 20, 1916	97	58	93		70.3	
Oct. 11, 1917	88	63	115		81.6	
Oct. 3, 1918	91	75	126	1	93.2	Two males present in lot but they were not kept separate in measurements and therefore their size can not be shown.
Oct. 2, 1919	91	76	133	2	96.1	
Oct. 13, 1920	91	76	138	9	101.3	
Dec. 12, 1922	92	79	144	19	114.0	
Oct. 10, 1923	97	87	146	27	116.6	
Oct. 21, 1925	85	84	149	34	121.3	

TABLE 27.—*Rate of growth of the brood of 1915*

When measured	Number	Smallest	Largest	Females 125 mm. or more in length	Average length	When measured	Number	Smallest	Largest	Females 125 mm. or more in length	Average length
		Mm.	*Mm.*		*Mm.*			*Mm.*	*Mm.*		*Mm.*
Mar. 15, 1916	[1] 613	24	40		29.9	Oct. 15, 1918	435	35	112		60.3
Mar. 16, 1916	[2] 662	25	51		33.8	Oct. 8, 1919	395	38	122		65.6
Aug. 24, 1916	586	29	76		44.8	Oct. 8, 1920	338	41	134	2	69.4
Oct. 13, 1917	475	32	94		50.8	June 23, 1921	303	47	127	1	69.9

[1] This lot was fed on salted fish during the winter of 1915–16. After these measurements were taken it was discarded.
[2] This lot was fed on fresh fish during the winter of 1915–16. All subsequent measurements are based on this lot. It was discarded after the last measurements listed in the table were taken.

TABLE 28.—*Rate of growth of the brood of 1916*

When measured	Offspring of wild brood stock					Offspring of domestic stock				
	Number	Smallest	Largest	Females 125 mm. or more in length	Average length	Number	Smallest	Largest	Females 125 mm. or more in length	Average length
		Mm.	*Mm.*		*Mm.*		*Mm.*	*Mm.*		*Mm.*
May 25, 1917	1,040	23	80		39.2	670	24	62		32.5
Oct. 4, 1918	[1] 120	47	104		70.6	[1] 81	47	83		63.2
Oct. 9, 1919	99	[2] 45	116		74.4	96	[2] 45	85		65.3
Oct. 8, 1920	99	[2] 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	4	91.4	92	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	95	73	[2] 130	2	95.5
Oct. 20, 1925	93	78	140	7	103.3	95	74	132	5	98.0
Oct. 1, 1927: [3]										
Male	18	81	102	33	89.3	22	78	101	33	90.7
Female	82	92	141		119.4	76	83	141		116.4

[1] This lot was selected at 1 year of age from the lot listed above.
[2] The apparent decrease in size probably is due to closer measurements or to the probability that the same terrapins were not measured each year, for all the animals in a pen often are not found.
[3] The measurements of the sexes were not definitely kept separate prior to this date.

TABLE 29.—*Rate of growth of the brood of 1917*

When measured	Close confinement					Wide range				
	Number	Smallest	Largest	Females 125 mm. or more in length	Average length	Number	Smallest	Largest	Females 125 mm. or more in length	Average length
		Mm.	*Mm.*		*Mm.*		*Mm.*	*Mm.*		*Mm.*
May 19, 1919	100	50	84		60.1	100	46	72		52.5
Oct. 23, 1919	98	51	101		66.7	81	50	81		60.9
Oct. 5, 1920	[1] 50	58	109		74.8	[1] 63	57	96		70.6
Sept. 24, 1921	50	68	127	1	89.5	58	61	109		81.1
Sept. 13, 1922	55	77	135	3	97.8	51	81	121		96.3
Oct. 5, 1923	53	84	141	10	107.9	48	82	135	1	100.4
Sept. 11, 1924	50	86	141	15	112.1	44	83	139	1	101.7
Oct. 20, 1925	53	[2] 82	144	19	117.0	41	85	[2] 130	2	102.3
Sept. 30, 1926	50	91	152	32	123.8	39	85	147	13	118.0
Oct. 15, 1927	[3] 50	89	154	37	134.8	[4] 39	87	150	31	126.4

[1] Rats destroyed many of the animals in this lot. Others probably were not found when measurements were taken.
[2] The apparent decrease in size probably is brought about measuring different terrapins, as all the animals in any 1 pen seldom are found.
[3] This lot contained 10 males, but the measurements for them were not kept separate and can not be given.
[4] This lot contained 7 males, but the measurements for them were not kept separate and can not be given.

TABLE 30.—*Rate of growth of the offspring of the wild and domestic brood stock of the 1919 brood*

When measured	Offspring of wild brood stock					Offspring of domestic brood stock				
	Number	Smallest	Largest	Females 125 mm. or more in length	Average length	Number	Smallest	Largest	Females 125 mm. or more in length	Average length
		Mm.	*Mm.*		*Mm.*		*Mm.*	*Mm.*		*Mm.*
May 11, 1920	[1] 73	30	55		38.2	[1] 85	23	48		35.7
Do	[2] 85	26	46		34.1	[2] 84	26	54		34.2
May 13, 1920	[3] 100	37	55		38.4	[4] 100	33	48		40.2
Sept. 30, 1921	54	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	95.3
Oct. 8, 1926	41	83	135		101.0	78	75	139	14	104.7
Sept. 28, 1927:										
Males						22	74	98	26	90.4
Females						52	87	144		119.3

[1] This lot, which originally consisted of 100 terrapins, was fed on oysters during the winter of 1919–20.
[2] This lot, which originally consisted of 100 terrapins, was fed on fresh fish during the winter of 1919–20.
[3] This lot was selected on May 13, 1920, from the 2 lots listed above, and it originally consisted of 100 terrapins, some of which were destroyed by rats. All subsequent measurements were based upon the surviving ones of this lot.
[4] This lot was selected from the 2 lots listed under the preceding date. All subsequent measurements were based upon the surviving ones of this lot.

TABLE 31.—*Rate of growth of hybrid terrapins of the brood of 1919*

When measured	Texas males and Carolina females					Carolina males and Texas females				
	Number	Smallest	Largest	Females 125 mm. or more in length	Average length	Number	Smallest	Largest	Females 125 mm. or more in length	Average length
		Mm.	*Mm.*		*Mm.*		*Mm.*	*Mm.*		*Mm.*
May 11, 1920	[1] 48	25	52		35.6	[1] 96	26	47		33.4
Do	[2] 50	26	48		34.0	[2] 96	27	49		32.9
May 12, 1920	[3] 80	28	52		35.7	[3] 100	29	49		35.5
Sept. 24, 1921	[4] 54	33	90		63.0	[4] 30	43	93		58.3
Sept. 14, 1922	53	42	107		78.0	31	[5] 41	[5] 92		62.3
Oct. 10, 1923	54	55	120		86.1	31	65	119		83.1
Oct. 9, 1924	53	[5] 52	124		89.2	31	74	127	2	92.8
Oct. 22, 1925	49	61	135	3	95.5	30	[5] 72	130	1	94.2
Oct. 2, 1926	51	72	144	7	98.3	30	72	143	4	102.6
Sept. 28, 1927:										
Males	33	86	104	10	98.3	18	81	108	8	91.8
Females	19	81	148		125.3	13	92	150		127.0

[1] This lot was fed on oysters during the winter of 1919–20.
[2] This lot was fed on fish during the winter of 1919–20.
[3] This lot was selected on May 12, 1920, from the 2 lots listed under the preceding date. All subsequent measurements were based upon the surviving ones of this date.
[4] Many terrapins were destroyed by rats.
[5] The apparent decrease in size may be accounted for by closer measurements or by the fact that the same terrapins are not measured each year, as all the terrapins in a pen often are not found.

TABLE 32.—*Rate of growth of the Carolina terrapins of the brood of 1920*

When measured	Number	Smallest	Largest	Females 125 mm. or more in length	Average length	Number	Smallest	Largest	Females 125 mm. or more in length	Average length
		Mm.	*Mm.*		*Mm.*		*Mm.*	*Mm.*		*Mm.*
May 13, 1921	[1] 1,994	22	54		31.8					
June 1, 1921	[2] 200	32	47		38.5	[3] 50	33	45		37.5
Sept. 24, 1921	165	35	57		43.8	50	46	83		59.6
Sept. 14, 1922	163	35	73		50.3					
Oct. 10, 1923	144	40	87		61.3	39	68	105		83.2
Oct. 11, 1924	145	45	110		63.0	[4] 31	76	108		91.1
Oct. 22, 1925	122	52	111		75.7					
Oct. 1, 1926	121	56	126	1	84.7	26	76	130	4	108.0
Sept. 28, 1927:										
Males	23	72	97	2	84.0	25	98	138	6	116.9
Females	89	61	132		98.1					

[1] This lot contains all the winter-fed animals of the brood. The 2 lots listed under the next date were taken from this one.
[2] Offspring of domestic stock.
[3] Offspring of wild stock.
[4] 13 males, for which no measurements are available, were removed from this lot.

TABLE 33.—*Rate of growth of hybrids of the 1920 brood produced by crossing Carolina males with Texas females*

When measured	Number	Smallest	Largest	Females 125 mm. or more in length	Average length	When measured	Number	Smallest	Largest	Females 125 mm. or more in length	Average length
		Mm.	*Mm.*		*Mm.*			*Mm.*	*Mm.*		*Mm.*
June 13, 1921	87	28	50		38.5	Oct. 20, 1925	63	66	121		96.1
Oct. 3, 1921	65	31	68		48.4	Sept. 30, 1926	60	82	135	9	105.1
Sept. 14, 1922	67	41	86		63.6	Oct. 1, 1927:					
Oct. 5, 1923	64	51	115		79.1	Males	40	85	109	10	94.4
Sept. 12, 1924	64	55	115		86.6	Females	20	108	146		128.2

TABLE 34.—*Rate of growth of the brood of 1921*

When measured	Number	Smallest	Largest	Average length	When measured	Number	Smallest	Largest	Average length
		Mm.	*Mm.*	*Mm.*			*Mm.*	*Mm.*	*Mm.*
May 18, 1922	2,101	25	50	31.8	Oct. 27, 1925	45	51	106	78.8
June 5, 1922	[1] 100	29	42	34.4	Oct. 6, 1926	41	79	120	86.0
Sept. 19, 1922	72	29	48	38.5	Oct. 21, 1927:				
Oct. 5, 1923	56	40	69	55.3	Males	2	86	92	89.5
Oct. 7, 1924	50	46	94	64.4	Females	31	93	124	108.3

[1] This lot was selected from the one listed under the preceding date.

TABLE 35.—*Rate of growth of the brood of 1922*

When measured	Offspring of domestic stock				Offspring of wild stock			
	Number	Smallest	Largest	Average length	Number	Smallest	Largest	Average length
		Mm.	*Mm.*	*Mm.*		*Mm.*	*Mm.*	*Mm.*
May 23, 1923	2,051	23	47	31.9	454	25	51	33.3
June 3, 1923	200	36	47	37.0	200	36	51	37.2
Oct. 24, 1924	[1] 130	36	70	43.1	[1] 142	36	72	47.5
Oct. 27, 1925	105	41	84	53.4	99	41	92	58.0
Oct. 7, 1926	94	42	91	62.3	93	44	95	65.2
Sept. 27, 1927	93	46	106	78.7	93	51	130	80.6

[1] This lot was selected from the one listed under the preceding date.

PERIOD OF ACTIVITY

The length of the period of activity of diamond-back terrapins, of course, varies from year to year according to temperatures. At Beaufort some of the animals begin to move about on warm days in March, but generally they do not become active and take food until about the latter part of April or early in May, and the period of activity may be said to end again sometime during October or, rarely, as late as early in November. They feed regularly only from about the latter part of May until early in October. On cool days they cease to feed and even mild days in midsummer cut down their capacity for food.

FOOD, FEEDING, AND COST OF FOOD

The food of terrapins in nature is reported to consist of small mollusks and crustaceans. In captivity, as already indicated, they readily take fish cut in pieces of suitable size, crabs, shucked oysters, and clams. At Beaufort, however, fish and some blue crabs chiefly are fed. Fiddler crabs enter the pens, and some small mollusks, too, are available. The animals appear to thrive on these foods.

The fish used during the summer are purchased directly from commercial fishermen, and they generally consist of menhaden and other unsalable fish or of small food fishes that would bring little on the market. Frequently quite a few blue crabs are included with the "scrap" fish. During the winter months, when only about 1½ pounds of food a day is used, small and cheap grades of fish are purchased from local fish dealers; or when oysters were fed they either were collected by the terrapin culturist or purchased in the shell and opened at the laboratory.

During 1927 the fish and crabs delivered by the fishermen were purchased at 2 cents per pound. During the winter, when the fish were bought from dealers, the price ranged from 6 to 7¼ cents per pound. The total cost of food for the calendar year 1927 was $236.52. With this amount, about 2,936 recently hatched young terrapins were fed during the winter and 3,707 animals of various ages (mostly adults) were fed during the summer. The cost of food for the young winter-fed animals for a seven-months period was 7½ mills per head. The cost for all the animals held in outdoor pens for the year 1927 averaged nearly 6 cents per head. It is evident, therefore, that the cost of food at Beaufort is not great.

For the small terrapins, a year or less of age, the fish are scaled, the large bones are removed, and then they are put through a food chopper. For larger terrapins, the fish and crabs together, as received from the fishermen, are put through a feed cutter of the type used by farmers, which cuts the food into pieces small enough to be managed by the terrapins. The food is thrown on the ground in a clean, solid place near the edge of the water. The animals emerge, take a piece of food, and generally return to the water to eat it. Care is exercised to supply sufficient food and not too much. Food placed on the ground at the edge of the water can be removed readily if it is not all consumed, for it is highly essential to prevent putrefaction, and less is wasted by the animals than if it were thrown into the water.

COPULATION, LAYING SEASON, AND INCUBATION PERIOD

Copulation seldom has been observed. Males frequently persist in following certain females, however, and it is supposed that this indicates a desire to copulate and that copulation probably follows. If that be true, copulation may take place at any time during the period of activity. This sex activity is greatest in the spring, very soon after the animals emerge from hibernation, and it is probable that that is the chief "mating" season.

The laying season begins in May, generally about the middle of the month, and it ends about the first of August. A female may lay only once during a season, or she may lay as many as four and, rarely, five times.

The earliest date of hatching that has been noticed at Beaufort was July 28, but generally hatching does not occur before the middle of August, and the last eggs hatch during the first half of October. The length of the incubation period, of course, varies somewhat with the prevailing temperatures, being shortened by high temperatures and lengthened by low ones. Using the earliest dates (generally around May 15) when laying was observed and the first dates (generally around August 15) when young terrapins emerged from the nests as a basis, the incubation period would appear to extend over about 90 days. Since newly hatched terrapins generally do not emerge from the nests immediately upon hatching, it may be assumed that the incubation period is somewhat short of 90 days.

SPACE REQUIREMENTS

It has been shown elsewhere (p. 53) that it seems practicable to confine as many as 100 recently hatched terrapins for winter feeding in a brooder house in a tank having a floor space of about 20 by 24 inches. To this statement there is little to add, except the caution that a high degree of cleanliness must be maintained. The tanks in which the animals were held at Beaufort under such crowded conditions were washed twice a day and scrubbed whenever it appeared necessary, and after each washing and scrubbing new and clean water was supplied. Care must be taken particularly to prevent the decay in the tanks of uneaten foods.

The extent of crowding that terrapins can stand in outdoor pens is not well known. None of the experiments performed to date indicate that the different degrees of crowding that have been tried were deleterious. Certainly, much depends upon cleanliness and the free exchange of water; that is, much greater crowding will be possible when the pens are fairly free of decaying organic matter and when the tides and conditions are such that an almost complete exchange of water takes place twice daily and clean water is brought by each flood tide. The greatest crowding of growing and fairly large terrapins among the experiments under way at Beaufort is 198 in a pen 5 feet wide and 36 feet long. The length of the pen probably has little significance as the animals stay in the water, or at least very close to it nearly all of the time. Therefore, only about one to three fourths, depending upon the stage of the tide, of this particular pen generally is occupied by the animals. The rate of growth of the animals in this pen compares favorably with other less crowded lots, and from the standpoint of survival this lot is ahead of all others grown in captivity.

In 1919, 100 animals of the 1917 brood were placed in a small pen measuring about 5 feet wide by 36 feet deep and 100 in a much larger pen, similarly situated, having a width of about 24 feet and a depth of about 36 feet. Owing to depredations by rats the numbers were greatly reduced. In 1927 only 50 animals were left in the small pen, and these (including 10 males) had an average length of about 5⅜ inches (134.8 millimeters), whereas only 39 were found (more animals probably were present, but they were difficult to find due to the large size of the pen) in the larger pen, which (including 7 males) had an average length of slightly over 5 inches (126.4 millimeters). If this experiment could be used as a criterion, "close range" would seem to be better than a wider one. The animals are sluggish, and it is not believed that a large pen is necessary for the purpose of providing space for exercise. The main consideration is the provision of sufficient room to furnish the necessary sanitation.

It seems reasonable to conclude from the experiments described and from the results obtained with several other lots that under the conditions existing at Beaufort certainly as many as 100 animals may be held and grown to maturity in pens having an area of 5 by 32 feet. Space requirements, as already suggested, undoubtedly would vary in different localities according to the cleanness of the water brought by flood tides and other local conditions.

SEX RATIO

The sexes of terrapins can not be distinguished from external characters until a length of 3 to 4 inches is attained. When this size is reached the males may be recognized by the much larger and heavier tail. There are other differences, such as the smaller head and the more wedge-shaped posterior outline of the carapace in the male, but the most evident character is the tail. Because it is impossible to distinguish the sexes in young animals from external characters, and because dissections of such animals have not been attempted, information concerning sex ratio is still quite incomplete. It may be stated, however, that the males are greatly in the minority among the total number of terrapins grown to maturity in captivity. This becomes evident from the fact that in 1927 among a total of 1,300 such animals in which the sexes could be distinguished positively there were only 242 males, thus giving a ratio of 1 male to 4.4 females. Omitting certain hybrid lots, in which the males are numerous, and using only pure stock of Carolina terrapins, the ratio becomes 1 male to 6.4 females.

Most of the lots from which the foregoing data were derived consist of animals selected (usually at about 1 year of age) from a year's brood (which usually consisted of a few hundred to a thousand or more individuals) because of the rapid growth they had made, while the rest were liberated. One lot was selected for the opposite reason, however; that is, the "runts" were retained; and still other lots were unselected. It is not evident from the results that the selections affected the sex ratio constantly in any one direction. The large variation in sex ratio among the small lots on hand suggests, however, that the element of chance selection as well as chance survival may have been important.

The extremes in sex ratio are represented in two lots of the brood of 1911 of Carolina terrapins, and in a lot of hybrid terrapins (Carolina males crossed with

Texas females) hatched in 1920. The two lots of the 1911 brood originally consisted of two groups of 100 each of unselected animals. When last counted (1927), 163 of these terrapins were found, all of them being females; nor has a male ever been noticed among these animals.

The lot of hybrid terrapins to which reference was made in the preceding paragraph originally consisted of 100 animals selected at 8 months of age. This lot, when last counted (1927), consisted of 60 terrapins, of which 40 were males. It appears to be of interest to note further that a somewhat similar abundance of males prevails among the only other two lots of hybrid terrapins (both hatched in 1919) on hand. One of these is the product of Texas males crossed with Carolina females, and it originally consisted of 80 unselected animals. When last counted (1927), 52 of these terrapins were found, and 33 of them were males. The other lot at first contained 100 selected animals, the offspring of Carolina males crossed with Texas females. This lot, due largely to depredations by rats when the terrapins were small, has been reduced to 31, and of these 18 are males. The greatest abundance of males in pure stock occurs in a selected lot originally consisting of 100 young, now (1927) reduced to 74, of Carolina terrapins hatched in 1919, in which there are 22 males. In all other lots of pure stock the males are in an even smaller minority.

These data would appear to indicate that cross-breeding Carolina and Texas terrapins tended to increase the proportionate number of males. However, the lots are too small to justify that conclusion, and until more information is obtained it may be assumed that the present results are a mere coincidence.

Table No. 36 shows in detail the sex ratio existing among the several lots of terrapins grown in captivity. The lots appear to be sufficiently large and numerous to justify the conclusion that a considerably larger number of females than males may be expected to reach maturity in terrapin farming. This is important from a practical viewpoint, as the females reach a relatively much larger size than males and have a correspondingly greater value on the market. As stated elsewhere, no definite information relative to the natural sex ratio in terrapins has been gained. A few lots of young animals are on hand, however, which may help to cast some light on this problem when they reach a sufficiently large size to admit of the recognition of the sexes.

If it were assumed that the usual 1 to 1 ratio prevails among young terrapins, then it would follow that the males simply fail to reach maturity. The selection of the larger and stronger animals at about 1 year of age, as was often done, does not appear to have resulted in constantly choosing females in preference to males. If it had, then it might be reasonable to expect the males to be in the majority among those terrapins that were chosen because they were small and undersized. This does not appear to be the case, however, for a lot of 100 terrapins of the 1912 brood was selected at 1 year of age as the very poorest and smallest among several hundred animals. When last counted (1927), 64 animals were found and among them were only 10 males. In unselected groups of Carolina terrapins the males, too, are greatly in the minority.

The supposition that the males failed to mature is complicated by the fact that the number of males present at maturity in some of the unselected lots as well as selected ones, added to the total number of animals that died (assuming that the loss consisted wholly of males), still would not make a sex ratio of 1 to 1.

TABLE 36.—*Sex ratio in several lots of diamond-back terrapins hatched and grown to maturity in confinement* [1]

Year of hatching	Number originally in lot	Number on hand, 1927 [2]		Ratio of males to females	Remarks
		Males	*Females*		
1910	171	13	116	1:8.9	All fed first winter, some the second winter; unselected.
1910	119	5	87	1:17.4	Hibernated each winter; unselected.
1911	100	0	78	----------	Fed first three winters; unselected.
1911	100	0	73	----------	Hibernated each winter; unselected.
1912	100	10	54	1:5.4	Some fed first winter, all fed the second winter. Selected at the age of 1 year, the smallest of the entire brood, consisting of 1,221 animals.
1912	100	17	64	1:3.8	Majority fed first winter, all fed the second winter. Selected at the age of 1 year, the largest from the entire brood, consisting of 1,221 animals.
1913	100	4	75	1:18.8	Fed first winter; selected at 1 year of age, the largest from lot consisting of 504 animals.
1914	100	2	83	1:41.5	Fed first winter; selected at age of 1 year, the largest from a lot consisting of 587 animals.
1916	200	40	158	1:4.0	Fed first winter; selected at age of 1 year, the largest from a lot consisting of 1,710 animals.
1917	200	17	73	1:4.3	Fed first winter; selected at 9 months of age, the largest from a brood consisting of 961 animals.
1919	100	22	52	1:2.4	Fed first winter; selected at 8 months of age, the largest from a lot composed of 169 animals.
1919	80	33	18	1:0.5	Hybrids (Texas males and Carolina females). Fed first winter; unselected. Number reduced through depredations by rats when the terrapins were small.
1919	100	13	18	1:1.4	Hybrids (Carolina males and Texas females). Fed first winter; selected at 8 months of age, the largest from a lot consisting of 192 terrapins. Original number much reduced through depredations by rats when the terrapins were small.
1920	200	23	89	1:3.9	Fed first winter; selected at 8 months of age, the largest from several hundred animals.
1920	87	40	20	1:0.5	Hybrids (Carolina males and Texas females). Fed first winter; unselected.
Total	1,857	239	1,058	----------	Ratio for all lots combined, 1 male to 4.4 females.

[1] The animals are Carolina terrapins unless otherwise stated under remarks.

[2] The difference between the number originally in a lot and the number on hand in 1927 does not indicate the natural death rate that has occurred in each group. In a few instances several animals were taken away and used for other purposes; in a few cases some terrapins were lost in a storm; and in several lots rats killed some of the animals while small. Furthermore, the census varies from year to year; for it is extremely difficult to capture all of the animals at one time, because of their highly developed hiding propensities; and therefore the census for any one lot may vary from one to several from one year to the next, even though no deaths have occurred and no animals have been removed.

SUMMARY

The present series of experiments in diamond-back terrapin culture was started in 1909. Two subspecies (Chesapeake and Carolina) of terrapins are used in the experiments. Texas terrapins, too, were used at one time but have been discarded, except as represented in certain hybrid lots. Some of the experiments that have been undertaken have not been carried on long enough to yield results, and upon those no report is given. The discussion is confined to the experiments from which noteworthy results have been secured.

Egg production has fluctuated greatly from year to year within lots and within broods. The number of eggs produced by individual females of the same age is known to vary from 5 to 29 during a single season. Within a single lot, egg production has varied from 7.6 to 23.9 eggs per female. It is concluded that in general terrapin culture an average annual production of 12 eggs per female may be expected.

The degree of fertility of the eggs, too, has fluctuated greatly, for which often no good reasons can be given. In general, the highest percentage of fertility has resulted in the lots having the largest proportionate number of males, although exceptions to this rule are noted. Data are presented that would indicate that with

the proper sex ratio present, which appears to be about one male to five females, at least 90 per cent of the eggs laid should be fertile.

Great fluctuations in the death rate have taken place among the young animals, both among the ones that were kept warm and fed during the winter as well as among the hibernating lots. The cause of the deaths in the hibernating lots is not known, but in the winter-fed lots the mortality has been due principally to two causes, namely, a disease causing sores and to "soft shell." The disease causing sores, which may be of bacterial origin, was not equally severe from year to year, and it, more than anything else, has caused fluctuations in the death rate of winter-fed animals. Soft shell is associated with a failure to eat, causing general emaciation and gradually the softening of the shell, frequently, although not always, followed by death. Soft shell also causes many deaths among terrapins after they emerge from hibernation, and it results in more deaths than all other losses combined in both groups of animals.

The percentage of terrapins that were grown to maturity has been reduced materially in some of the lots on hand through depredations by rats while the animals were small, losses during storms, and apparently by escapes made by the terrapins because of their well-developed climbing propensities.

Evidence is produced that would tend to show that about 60.7 per cent of the animals hatched may be grown to maturity and that winter feeding increases the rate of survival.

Terrapins have an average length of about 27 millimeters at hatching. Young animals, when kept warm—that is, if placed in a brooder house—remain active during the winter, and the majority of them will begin to take food within a month or two after hatching. If the young are left out doors, they do not feed until they are 7 to 8 months old; that is, they go into hibernation soon after hatching or they remain in the nests in which they are hatched to hibernate, and they do not feed until the weather gets warm the following spring.

Generally about 1 year's growth was gained during their first winter by the recently hatched young when placed in the brooder house, in which the temperature was kept as far as possible at 80° F. or higher; that is, an average gain of growth (for all lots that had been fed the first winter) of 4.7 millimeters was made. The advantage in growth attained through winter feeding usually was retained and, furthermore, the winter-fed animals produced eggs a year earlier than the hibernating lots.

Winter feeding, aside from its advantages with respect to earlier maturity when animals are grown in captivity, has the advantage of carrying the animals through the critical stages of life at an earlier age. When terrapin culture is engaged in for the purpose of rebuilding or augmenting the supply in nature, the winter-fed animals apparently are able to take care of themselves and stand just as good a chance of survival at an age of about 8 months as the hibernating ones do a year later. The earlier liberation reduces the amount of care necessary and presumably hastens returns.

Some females reach a length of about 5½ inches and sexual maturity in 5 years; others require a much longer time to reach this size and stage in life. Evidence is produced that tends to show that some females never reach a length as great as 6 inches. Males rarely exceed a length of 4¾ inches. Data are presented that show

that in general terrapins grow rather rapidly during the first 5 or 6 years, followed by a much slower growth, and after an age of 8 to 10 years is attained growth is so slow that it is almost negligible.

The males in all broods of Carolina terrapins grown to maturity have been greatly in the minority. This disproportionate sex ratio has existed in unselected lots as well as in selected ones. A ratio of 1 male to 6.4 females exists among the Carolina terrapins grown in captivity. In certain hybrid lots (crosses between Carolina and Texas terrapins) the males are much more numerous. Since the lots are small ones, this greater proportion of males may have no significance. If the usual 1-to-1 sex ratio exists in young terrapins (which has not been determined), then it apparently would have to be assumed that the males are less resistant to life in captivity than the females, and they simply fail to reach maturity. This supposition does not appear to be tenable, however, because the number of deaths in some of the lots was too few, even if males only had died, to make a ratio of 1 to 1.

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