Abstract: *Individuals of the marine ostracode* Hemicythere conradi *Howe and McGuirt were acclimated in the laboratory at a salinity of 30 parts per thousand and water temperatures of 20–26° C. They were able to survive salinities from 6 to 65 parts per thousand and water temperatures from 6° to 36° C. Individuals of this species also exhibited a positive response to light and preferred silty sand to coarser oolitic sand when given free choice in laboratory experiments. The results are discussed in relation to the distribution of the species in the field.*

Some environmental boundaries of a marine ostracode

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INTRODUCTION

The use of fossil ostracodes to determine the environmental conditions which existed during the time of sediment deposition is limited because of lack of information concerning environmental factors influencing ostracode distribution. Knowledge of the environments in which ostracodes are living in today's seas is useful in that this information can be projected backward in time in order to estimate the environmental conditions present when these same species are found in Tertiary sediments. Ecological field studies of Recent ostracodes include those of Swain (1955), Puri and Hulings (1957), in the Gulf of Mexico area; Hartmann (1959) in South America; Kornicker (1958) in the Bahamas; and Benson (1959) in California.

Ecological studies restricted to field observations provide only limited information because of the difficulty of determining the influence of any part of the environment on species distribution. A similarity between the distribution of a species and one environmental factor is often assumed to indicate that the species is being controlled by that environmental factor. Unfortunately, the similarity may be coincidental, or may be due to some other environmental factor not measured. The field worker is usually limited to measuring only a few environmental factors and often is able to collect data only part of the year.

When one environmental factor can be varied while others are held constant, significant information may be obtained concerning the affect of a specific environmental factor on ostracodes in the laboratory. In the present paper, results are presented of experiments designed to determine the affect of temperature, salinity, sediment type, and light on *Hemicythere conradi* Howe and McGuirt, a marine ostracode abundant in the Laguna Madre and adjacent bays of Texas. The results, relative to the distribution of the species in the field (text-fig. 1), are discussed.

ACKNOWLEDGMENT

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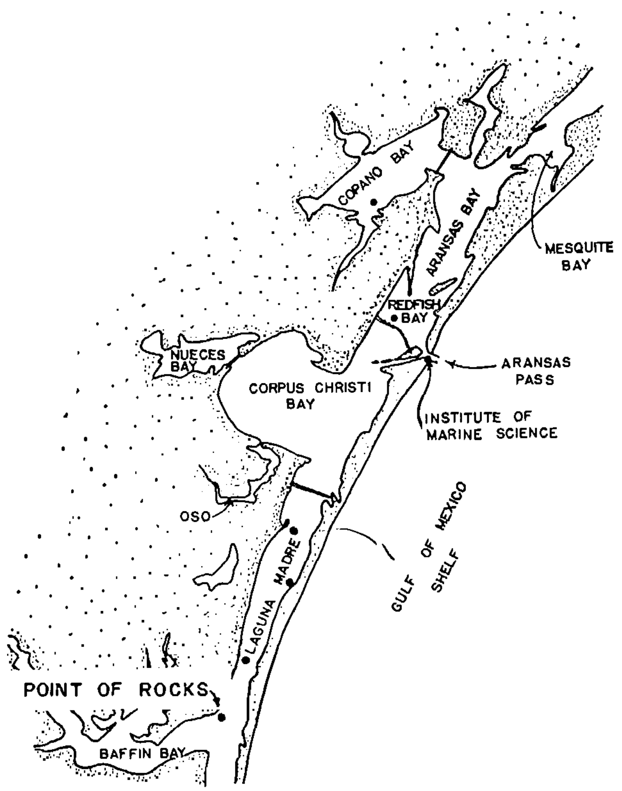
TEMPERATURE TOLERANCE

Water temperatures at twelve stations along the upper Laguna Madre ranged from 4° to 35° C. during the years 1951–1955 (Simmons, 1957). Water temperatures of 2–35° C. were obtained in the upper Laguna Madre during the period from April 1, 1958 to June 14, 1959, by Simmons (1960, written communication). Temperatures below about 9° C. probably seldom persist for more than 2–3 days.

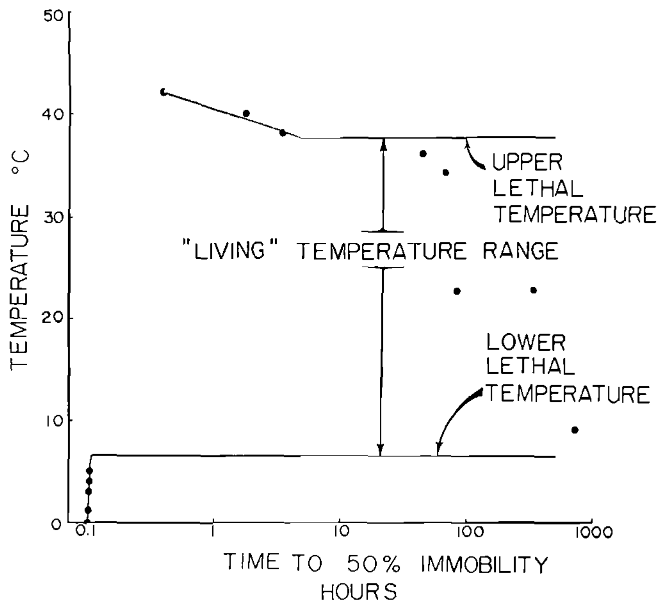
Living individuals of *H. conradi* were found in samples collected monthly in the upper Laguna Madre, Aransas Bay, and Copano Bay during 1958–1959. Water temperatures at the time of collection varied from 10° to 34° C.; however, temperatures obtained in-between sampling indicate the annual temperature range of waters in which *H. conradi* was collected to be 2° to 35° C. *H. conradi* was most abundant during the summer months and was relatively scarce during winter months.

The procedure used for determining the temperature tolerance of *H. conradi* in the laboratory is, briefly, as follows. Ostracodes collected in the upper Laguna Madre were held for a 5-day equilibration period in an aquarium containing water having a salinity of 33 parts per thousand and a water temperature of 20° to 26° C. Ten ostracodes were removed from the aquarium and placed in a culture dish containing water at the experimental temperature. The culture dish was then placed in an incubator in which the temperature could be controlled to $\pm 1/2°$ C. The ostracodes were observed periodically and the time each ostracode became



TEXT-FIGURE 1

Location map showing sample stations.



TEXT-FIGURE 2

Temperature tolerance of *Hemicythere conradi* Howe and McGuirt. Each point represents the time 50 percent of the individuals in each experiment became motionless and stayed motionless until death. Ostracodes were first acclimated for a minimum of 5 days at a temperature of 20–26° C. and a salinity of 33 parts per thousand.

motionless noted. It was necessary to use the time at which the specimens became motionless rather than the time of death because of the difficulty in determining the precise time of death. This technique is considered valid because an inactive animal in nature will eventually die of starvation. Tests were made at temperatures between 0° and 42° C. The time at which 50 percent of the specimens in each test became motionless was then plotted graphically against test temperatures (text-fig. 2).

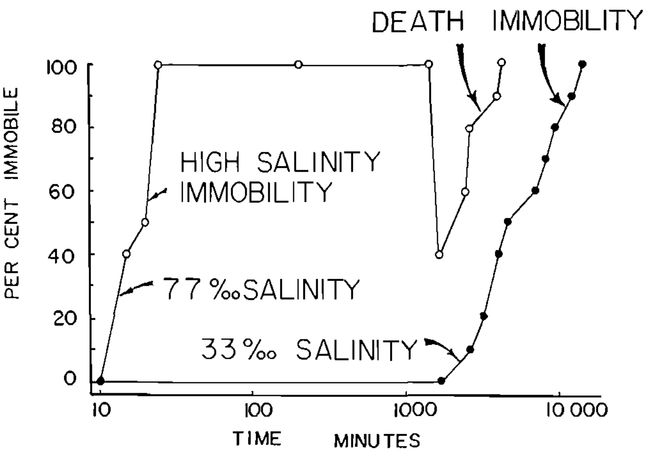
Text-figure 2 shows that below approximately 6° C. and above approximately 36° C. the time to 50 percent immobility was markedly shorter than at temperatures between these limits. The low temperature tolerance limit was also determined by lowering the temperature of water in a culture dish while observing the behavior of ten specimens in the dish; 50 percent immobility occurred at approximately 6° C., the same temperature as estimated from text-figure 2. The tolerance limits, as determined in the laboratory, are quite close to the maximum and minimum temperatures that normally prevail in the waters from which they were collected; however, the minimum tolerance temperature is above the water temperature during unusually cold weather. When the water temperature in the natural environment drops below 6° C., it is likely that *H. conradi* becomes inactive.

Additional laboratory experiments indicate that *H. conradi* is able to survive the short periods of unusually cold water to which they are occasionally exposed in the natural environment. Ten specimens kept for 24 hours at 0° C. and ten specimens kept for 96 hours at 3° C. were alive and vigorous after they were returned to 21° C. Ten specimens kept at –10° C. for one hour (ice formed in the 33 parts per thousand water) became active when brought back to room temperature of 21° C.

In order to determine the limits of the tolerance zone more accurately it would be necessary to repeat these tests after acclimatizing the ostracodes at other temperatures. Salinity may also have an effect on temperature tolerance. In the present tests, mature ostracodes and late instars were used; the tolerance range of other instars is probably different (Runnström, 1928). The reader is referred to Bliss (1937), Fry (1957), and Andrewartha and Birch (1954, chap. 6) for further discussion of methods and the effects of temperature on animals.

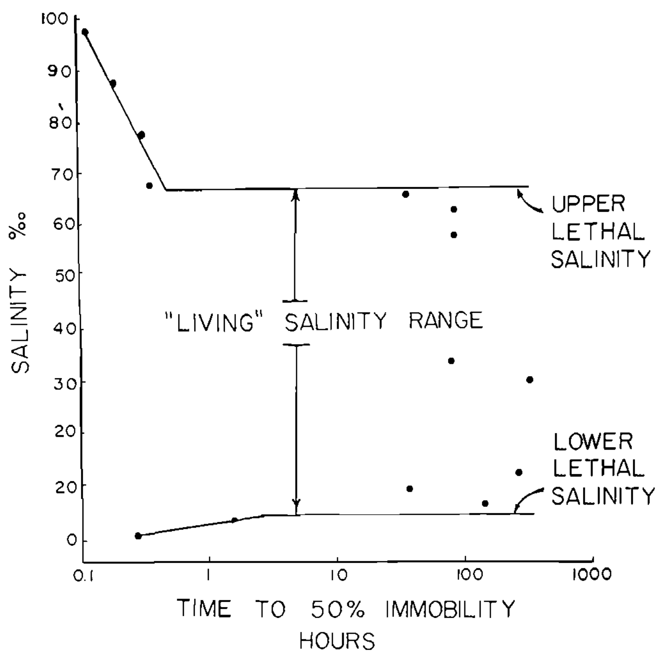
SALINITY TOLERANCE

Specimens of *H. conradi* were collected alive during 1958–1959 from water having salinities ranging from 8 to 51 parts per thousand at the time of collecting. During the years 1952–1955, when there was little rainfall, salinities above 65 parts per thousand were



TEXT-FIGURE 3

Time- "mortality" curves for *Hemicythere conradi* Howe and McGuirt at salinities of 77 and 33 parts per thousand. Temperature during acclimatization period and experiments remained between 20–26° C.



TEXT-FIGURE 4

Salinity tolerance of *Hemicythere conradi* Howe and McGuirt. Each datum point represents the time 50 percent of the individuals became motionless and stayed motionless until death. Ostracodes were first acclimated for a minimum of 5 days at a salinity of 33 parts per thousand. Temperature during acclimatization and experiments remained between 20–26° C.

recorded in the Laguna Madre (Simmons, 1957). Hedgpeth (1953) indicates that during the years 1946–1948 salinities above 70 parts per thousand were common in the Laguna Madre. *H. conradi* was scarce at sampling stations in Copano Bay, where salinities as low as 9 parts per thousand were encountered, and at the two southernmost stations in the Laguna Madre, where salinities of 51 parts per thousand were recorded (text-fig. 1).

The procedure used for determining the salinity tolerance of *H. conradi* in the laboratory was essentially the same as that for temperature, except that specimens were subjected to waters having different salinities rather than different temperatures.

Specimens became inactive quite rapidly at a salinity of 77 parts per thousand but resumed activity shortly before death (text-fig. 3). The reactivation before death is considered to be a physiological response caused by imminent death rather than to acclimatization to the high salinity. The basis for this conclusion is that in all high salinity experiments the ostracodes became reactivated at approximately the same time, and because the time of reactivation coincided with the time at which specimens in the control experiment (at a salinity of 33 parts per thousand) began to die.

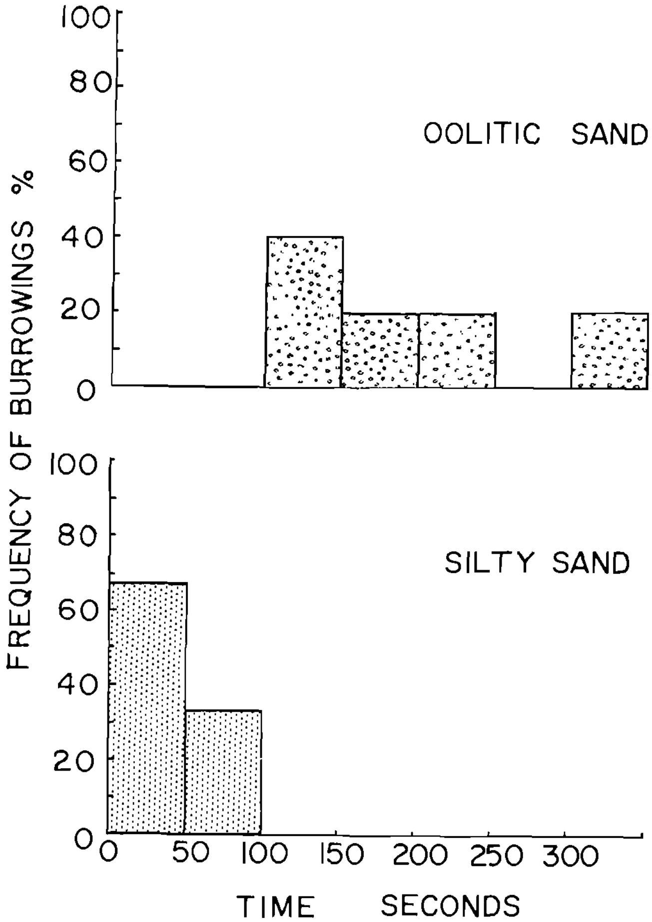
The time at which 50 percent of the specimens became motionless plotted graphically against the test salinity showed the upper salinity tolerance limit of *H. conradi* to be approximately 65 parts per thousand and the lower tolerance limit approximately 6 parts per thousand (text-fig. 4). The salinity ranges in which the species was collected in the field are within the tolerance limits obtained in the laboratory. The laboratory data suggest that in years of little rainfall when salinities in the Laguna Madre rise above 65 parts per thousand, *H. conradi* cannot survive. This suggests that the relative abundance of this species in sediment cores from the Laguna Madre might be used as an indication of climate at time of deposition.

In order to define more accurately the salinity tolerance limits, it would be necessary to determine the effect of acclimatizing the ostracodes at other salinities, and also the tolerance limits of earlier instars.

EFFECT OF SUBSTRATE

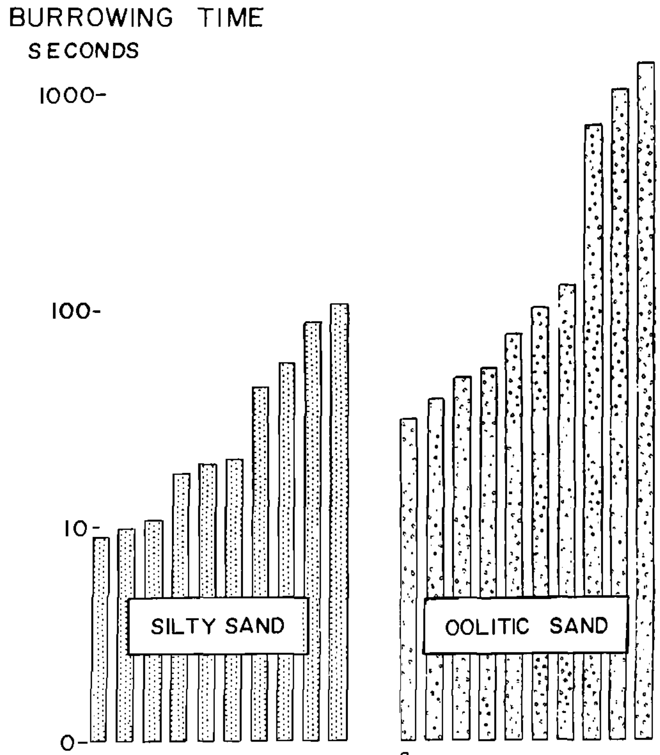
Ecological studies of marine ostracodes indicate that substrate plays a major role in determining ostracode distribution (Benson, 1959). Kornicker (1957) showed experimentally that two myodocopid ostracodes preferred to burrow into poorly-sorted bioclastic sand rather than into well-sorted oolite and attributed this to the ostracodes having physical difficulties in burrowing into well-sorted sand.

Previous to experiments with *H. conradi*, the writers observed that a specimen of *Sarsiella zostericola* Cushman? collected in the Laguna Madre burrowed readily into



TEXT-FIGURE 5

Burrowing speed of *Sarsiella zostericola* Cushman? in oolitic sand and silty sand. The histogram for oolitic sand represents 9 tests and the histogram for silty sand 5 tests; the silty sand tests were performed between two series consisting of 5 and 4 tests each with oolitic sand. The oolitic sand was obtained from the Point of Rocks area of the Laguna Madre; the silty sand was obtained from the upper part of the Laguna Madre where the specimen of *Sarsiella* was collected.



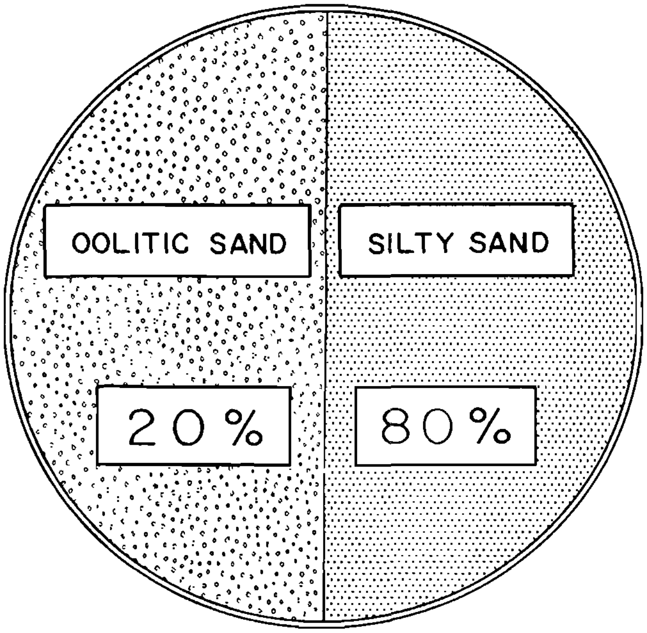
TEXT-FIGURE 6

Burrowing speed of *Hemicythere conradi* Howe and McGuirt on silty sand and oolitic sand. Each bar represents the time in seconds for one specimen to burrow into the sand. Twenty individuals were used in the experiments. Oolitic sand was obtained at the Point of Rocks area of the Laguna Madre; silty sand was obtained from the upper part of the Laguna Madre where the ostracodes were collected.

silty sand of the upper Laguna Madre where the ostracode was collected, but seemed to burrow with difficulty into a well-sorted sand, containing oolites, from the Point of Rocks area of the Laguna Madre. By recording the time for the specimen of *S. zostericola*? to burrow, it was possible to show graphically that the specimen took longer to burrow into the oolitic sand than it did to burrow into the silty sand (text-fig. 5). From observing the specimen at work it is the opinion of the writers that the specimen had physical difficulty in displacing the particles when trying to force its carapace into the oolitic sand, whereas, it had little difficulty in forcing its body into the silty sand. One might compare this with a dog or gopher having more difficulty digging a hole in gravel than in sand.

The experiment was repeated with twenty specimens of *H. conradi*. This species also burrowed more rapidly into the silty sand than into the oolitic sand (text-fig. 6). During the observation period, specimens of *H. conradi* weaved in and out of the sediment, spending more time in the sediment than out. This was in marked contrast with *S. zostericola*?, which usually stayed under the sediment for a considerable time after burrowing.

H. conradi apparently prefers silty sand to oolitic sand. This was demonstrated in experiments in which specimens were placed in a culture dish, 45 mm. in diameter, having silty sand in one half and oolitic sand in the other. Eighty percent (range 60–100 percent) of the ostracodes were found on the side with the silty sand, at the end of 18 hours (text-fig. 7). In view of the greater ease with which the specimens were able to burrow into the silty sand, the authors believe that the physical difference between sediments contributed to more specimens being found in the silty sand.



TEXT-FIGURE 7

Distribution of *Hemicythere conradi* Howe and McGuirt in oolitic sand and silty sand at the end of 18 hours. Tests were repeated 7 times using ten different specimens in each test. Range of values in the silty sand was 60 to 100 percent.

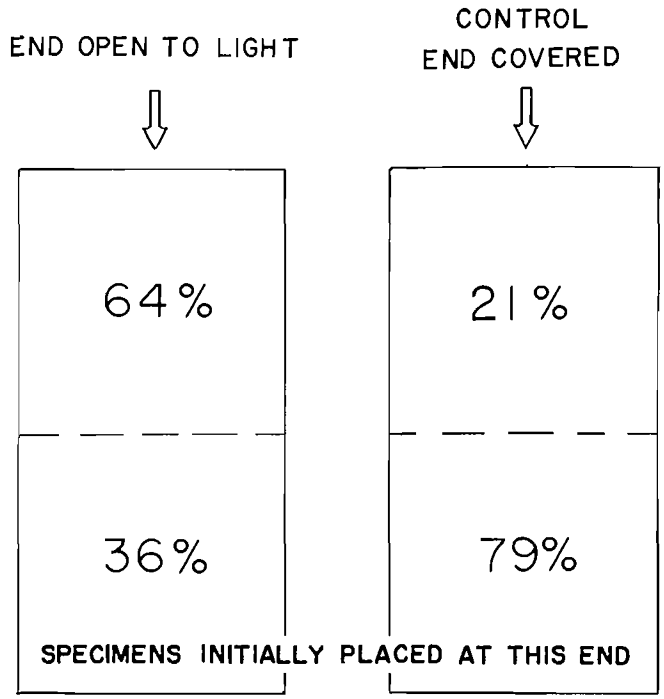
LIGHT RESPONSE

Kesling (1951) reviews the few experiments that have been performed to determine the effect of light on fresh-water ostracodes. Some species of fresh-water ostracodes are attracted to light whereas others are repelled. Kesling (1951) found that specimens of *Cypridopsis vidua* congregated in the unlighted area of a dish away from the light source, but were attracted to light after being held in the dark for an hour. Kornicker (1958) tested the response to light of several species of Myodocopa and found them to be attracted by light.

The effect of light on *H. conradi* was determined by placing specimens in 5 small rectangular plastic boxes and then exposing one end to a light source. Sixty-four percent (range 50–70 percent) of the specimens were found in the lighted ends of the boxes after 18 hours. Only 21 percent (range 0–40 percent) were found at the same end of 4 boxes used as controls (text-fig. 8). In the field, *H. conradi* was more abundant in shallow water than in deep water. It is possible that ostracode abundance is partly light-controlled.

CONCLUSIONS

1) Laboratory experiments in which various environmental conditions can be controlled may be useful in estimating the influence of a single environmental factor on the distribution of ostracodes in the natural environment.



TEXT-FIGURE 8

Behavior of *Hemicythere conradi* Howe and McGuirt to wards light. Plastic boxes having the following dimensions were used in this experiment: length 45 mm. width 22 mm., height 20 mm. Five plastic boxes were covered with black tape except for one end, which was left open to permit the entrance of light. Four boxes used as controls were completely covered with the black tape. The 9 boxes were then placed side by side with the uncovered ends of the 5 test boxes about one foot from a desk lamp. Ten ostracodes were placed in the end of each box away from the light.

2) Adults and late instars of the marine ostracode *H. conradi*, acclimated at 20–26° C. and 33 parts per thousand salinity for a minimum of 5 days, have a temperature range of 6° to 36° C., and a salinity range of 6 to 65 parts per thousand within which they are active.

3) At temperatures below 6° C., which occur periodically in their natural environment, specimens of *H. conradi* probably become motionless, but, because the low temperatures seldom persist for more than 2–3 days, the species may survive.

4) Although specimens of *H. conradi* are able to live in the upper Laguna Madre during wet years, they probably cannot survive dry years when the salinity rises above 65 parts per thousand.

5) Individuals of the species are attracted to light, and seem to prefer silty sand to coarser oolitic sand.

BIBLIOGRAPHY

ANDREWARTHA, H. G., AND BIRCH, L. C.
1954 – *The distribution and abundance of animals.* Chicago: Univ. Chicago Press, 782 pages.

BENSON, R. H.
1959 – *Ecology of Recent ostracodes of the Todos Santos Bay region, Baja California, Mexico.* Kansas, Univ., Pal. Contr., Arthropoda, Art. 1, pp. 1–80, pls. 1–11, text-figs. 1–20.

BLISS, C. I.
1937 – *The calculation of the time-mortality curve.* Annals Applied Biology, vol. 24, no. 4, pp. 815–852, text-figs. 1–5, tables 1–9.

FRY, F. E. J.
1957 – *The lethal temperature as a tool in taxonomy.* Année Biologique, vol. 33, nos. 5–6, pp. 205–219.

HARTMANN, G.
1959 – *Contribution al conocimiento de la region de esteros y manglares de El Salvador y su fauna de ostracodos (I. Parte).* Inst. Trop. Invest. Cient., Comunicaciones, nos. 3–4, pp. 47–83, text-figs. 1–11, tables 1–11.

HEDGPETH, J. W.
1953 – *An introduction to the zoogeography of the northwestern Gulf of Mexico with reference to the invertebrate fauna.* Texas, Univ., Inst. Mar. Sci., Publ., vol. 3(1), pp. 109–224.

KESLING, R. V.
1951 – *The morphology of ostracod molt stages.* Illinois Biological Monographs, vol. 21, nos. 1–3, pp. 1–324, pls. 1–96, text-figs. 1–36, charts 1–5.

KORNICKER, L. S.
1957 – *Ecology and taxonomy of Recent marine ostracodes in the Bimini Area, Great Bahama Bank.* Columbia Univ., Ph. D. thesis, pp. 221.

1958 – *Ecology and taxonomy of Recent marine ostracodes in the Bimini Area, Great Bahama Bank.* Texas, Univ., Inst. Mar. Sci., Publ., vol. 5, pp. 194–300, text-figs. 1–89.

PURI, H. S., AND HULINGS, N. C.
1957 – *Recent ostracode facies from Panama City to Florida.* Gulf Coast Assoc. Geol. Soc., Trans., vol. 7, pp. 167–190, text-figs. 1–11, tables.

RUNNSTRÖM, S.
1928 – *Über die Thermopathie der Fortpflanzung und Entwicklung mariner Tiere in Beziehung zu ihrer geographischen Verbreitung:* Bergens Mus., Arb., 1927, Naturv., Rekke 2, 67 pp.

SIMMONS, E. G.
1957 – *An ecological survey of the upper Laguna Madre of Texas.* Texas, Univ., Inst. Mar. Sci., Publ., vol. 4(2), pp. 156–200, text-figs. 1–13, tables 1–9.

SWAIN, F. M.
1955 – *Ostracods of San Antonio Bay, Texas.* Jour. Pal., vol. 29. no. 4, pp. 561–646, pls. 59–64, text-figs. 1–39, table 1,