NOTES

EFFECTS OF DESICCATION AND AUTOSPASY ON EGG HATCHING SUCCESS IN STONE CRAB, *MENIPPE MERCENARIA*

The stone crab, *Menippe mercenaria,* is found from North Carolina to Yucatan, Mexico, Cuba, Jamaica, and the Bahamas; commercial fishing occurs principally in the State of Florida. Crabs are captured in wooden or plastic traps (40 × 40 × 28 cm) baited with available fish scraps. Present Florida laws allow harvest of both claws from all crabs, including ovigerous females, provided each claw is of legal size (70 mm propodus length). Sale of whole crabs is prohibited, and declawed crabs are released to allow regeneration of lost claws and renewal of fishable stocks. Regeneration of another legal claw can occur within 18 mo (Sullivan[1]).

The commercial season extends from 15 October to 15 May. Spawning occurs during the warmer months (Noe 1967; Cheung 1969), and females with large external egg masses (sponge) of up to 600,000 eggs are observed from early March to late November. Newly extruded eggs, attached to abdominal pleopods, are red-orange and progress to yellow then grey over a 9-12 day maturation period. Larvae generally hatch directly from eggs attached to pleopods. Most commercial operations maximize daily marketable claw yield by pulling traps continuously and declawing crabs only during the return trip to port. This necessitates keeping whole crabs in large fish boxes or containers on deck that are exposed to air for up to 8 h. Claw removal from air-exposed ovigerous females and desiccation of exposed egg masses may reduce larval hatching and recruitment. Since these procedures violate Florida law requiring crabs to be declawed immediately and released in the same area where captured, this study was conducted to provide scientific data to implement change in current fishing methods and protect future stocks.

Methods

Gravid stone crabs were captured in the Gulf of Mexico (5-9 m) west of Pass-A-Grille Beach, St. Petersburg, Fla., between March and September 1977. Females with large egg masses were transported in 4 l containers by ship to the Florida Department of Natural Resources Marine Research Laboratory. St. Petersburg. Container water, exchanged frequently with Gulf water while sampling, was not changed for approximately 1½ h during transport through low salinity waters.

Unfed crabs were kept individually in plywood tanks divided into compartments (45.7 × 30.5 × 30.5 cm), sealed with fiber glass tape and epoxy, and leached 2-4 wk prior to use. Water in the closed system was maintained at 15 cm depth by removable standpipes, and overflows were directed into individual glass tanks where eggs or larvae were retained before water entered two 1,000 l undergravel filter vaults (Dugan et al. 1975) (Figure 1). Overflow splash and two airlift standpipes maintained aeration.
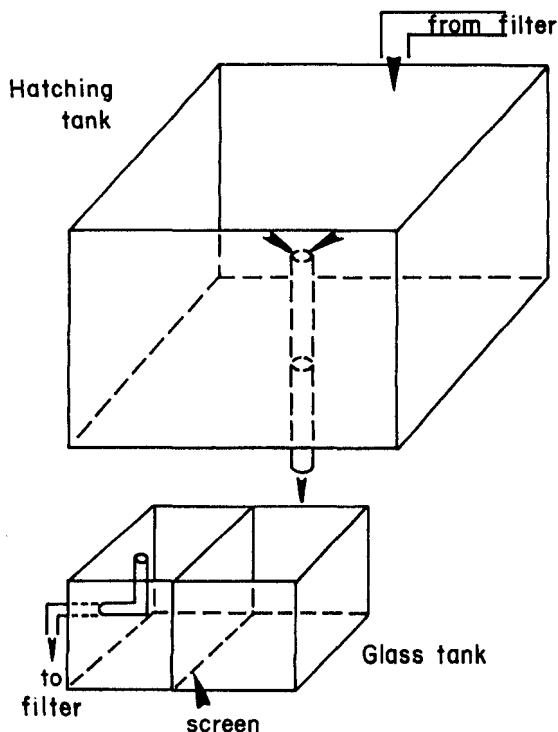

FIGURE 1.—Hatching tank (45.7 × 30.5 × 30.5 cm) and glass larval capture tank (15 × 15 × 30 cm) for desiccation and autospasy experiments with ovigerous stone crabs.

695

Optimum survival conditions for egg development and hatching success for *M. mercenaria* (30° C and 34‰ salinity) were determined by Ong and Costlow (1970). Salinity in the present study varied between 32.0 and 36.0‰ and averaged 34.4‰ in all experiments. Air and water temperatures in the control room fluctuated from 27° to 33° C with water temperature generally 0.5°-1.0° C lower. Dissolved oxygen levels were measured twice monthly. Nitrites and ammonia levels were evaluated weekly and never exceeded 0.089 and 0.073‰, respectively. Lighting was regulated for 16 h light: 8 h dark and utilized Vita-Lite[2] bulbs which simulated the natural spectrum of sunlight (Dugan et al. 1975).

Experiment I (13 April-31 July)

Crabs were divided into three test groups, with similar ranges of animal size and egg mass color (maturity) and were acclimated to tanks for at least 18 h. Initially, individual crabs were exposed to ambient indoor air conditions in separate cages. This procedure was modified after the first series to simulate commercial holding techniques more closely by placing crabs from a single group into loosely covered wooden slat boxes located in direct sunlight. After desiccation, crabs were returned to holding tanks and observed every 24 h until all eggs hatched. Group I (control) crabs remained in water throughout the experiment. Group II and Group III crabs were desiccated for 2 and 5 h, respectively. Total number of crabs for each group was: 35-Group I, 34-Group II, 33-Group III.

Experiment II (5 August-21 September)

Desiccation procedures were identical to modified procedures in Experiment I; added stress from claw removal was introduced after desiccation. Claws were removed using commercial harvesting methods by inducing autospasy (loss of appendage through externally applied pressure). In this technique, claws were grasped firmly and ventral pressure applied until the fused basischium stopped against the coxa. Further flexion strained the autotomizer muscle, and separation of the limb occurred at a natural fracture plane. Excessive hemorrhaging is prevented by swelling

of a hypodermal diaphragm located at the fracture plane.

Group IV (control) crabs remained in water throughout the experiment and had similar treatment as Group I. Group V and Group VI crabs were desiccated for 2 and 5 h, respectively, then declawed. Declawed crabs were placed immediately into holding tanks and observed every 24 h as in Experiment I. Total number of crabs for each group was: 30-Group IV; 34-Group V; and 35-Group VI.

Crabs continuously discarded eggs from egg masses. Single eggs were shed when females raised their bodies on claws and legs and preened (combed) egg masses with rear legs. Egg stalks containing up to several hundred eggs (clumps) were also frequently shed. Aeration of eggs by rapid abdominal movement also occurred at this time. Detached eggs, larvae, and other egg mass products retained in individual glass tanks were removed daily and preserved in 10% Formalin prior to counting.

Analysis

Hatching occurred from 0 to 9 days after day of experimental stress. Complete hatching generally required 24-48 h, and organic matter retained in glass tanks after that time was principally dead eggs, deformed larvae, or empty egg cases cleaned from pleopods.

The day with highest number of normal first-stage larvae was called major hatch. Days before and following major hatch were called prehatch and posthatch.

Eggs from a single ovigerous female were observed microscopically to determine normal hatching process and identify normal first-stage larvae. Initial breaking of the chorion enabled larvae to emerge head first from the egg. Vigorous abdominal flexing by the larvae cast off the egg case and induced shedding of the prezoeal cuticle and full extension of the rostral and lateral spines. In a few instances, spinular extension was delayed until complete seperation from the egg, but all prezoea yielded normal, active free-swimming first-stage larvae within minutes of initial hatch. Eggs removed from the same female after desiccation were observed for comparison. Increased numbers of inviable eggs and partial hatches were evident. Numerous prezoea, unable to cast off prezoeal cuticles, died after continued struggle. Successful first-stage development was reduced, and

larval activity was sluggish, frequently ending in death.

Aliquots from individual daily crab samples (1 or 2 ml; count ≃ 200) were sorted under a dissecting microscope and classified. Normal first-stage larvae (Hyman 1925; Porter 1960) were denoted as viable; whole eggs, partially hatched eggs, prezoea (Hyman 1925; no rostral or lateral extension), and deformed first-stage larvae were denoted as inviable. Stein's two-stage sample test (Steel and Torrie 1960) indicated that six replicate aliquots from each sample provided reliable counts (within 95% confidence limits) of total numbers of viable and inviable eggs and larvae present each day. Because results of aliquot counts were inconsistent when samples contained clumps of eggs, 1-8 ml of chlorine bleach (5.25% sodium hypochlorite) were added to dissolve stalks and dissociate eggs uniformly before aliquots were taken.

Number of eggs carried by individual crabs at time of capture was estimated by combining daily totals of viable and inviable eggs and larvae. Total hatching success was expressed as percent of original egg mass that hatched viably. Total egg mass mortality was expressed as the percent not hatching or hatching inviably. Average daily mortality (per group) was calculated by dividing total mortality per day by the number of crabs yielding inviable eggs and larvae that day. Crabs not yielding any larvae were eliminated from analysis; two crabs in Group I and one crab each in Groups III, IV, and VI were so eliminated.

Comparison among groups was made by presenting prehatch, posthatch, and total egg mass mortality for each group. I chose this method because inviable eggs and larvae were evident in some form in all daily samples, but viable larvae were present for only 24-48 h.

Results and Discussion

Experiment I

Initial egg loss from crabs in Group I (Figure 2) was probably caused by handling at capture and stress from transport to laboratory. With acclimation to holding tanks, average daily mortality decreased until major hatch, when highest egg and larval mortality coincided with maximum first-stage larval survival.

Crabs desiccated for 2 h (Group II) showed immediate preening activity upon return to water and daily prehatch mortality peaked at 3.6%, 3
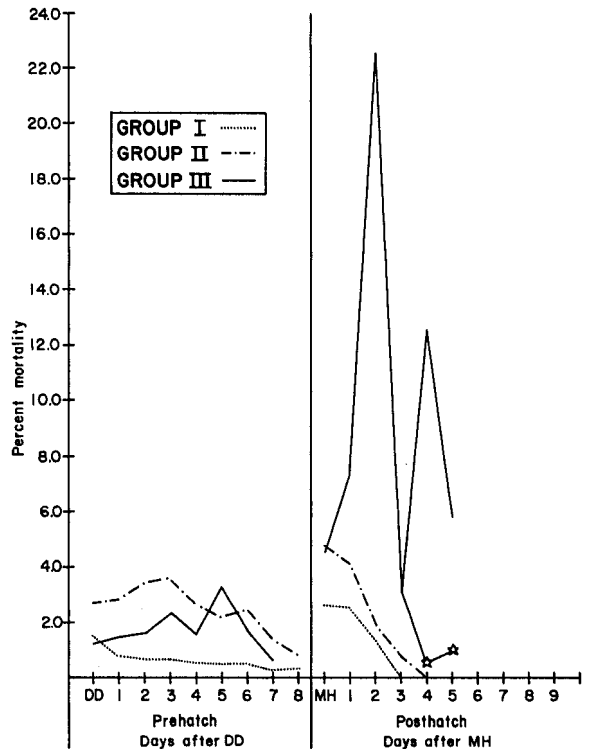

FIGURE 2.—Average daily percent egg mortality in ovigerous stone crabs as related to desiccation. Group I crabs untreated (control), Group II crabs exposed to 2-h desiccation and Group III crabs exposed to 5-h desiccation. DD - day of desiccation; MH - day when major hatching occurred; Prehatch - days following DD; Posthatch - days following MH. Starred points represent percent mortality excluding one of three crabs which accounted for 96% total mortality on posthatch days 4 and 5.

days after desiccation (Figure 2). Thereafter, daily percent mortality decreased until major hatch. Posthatch mortality was similar to, but slightly higher than that of Group I. Total prehatch mortality (12.1%) was four times greater than that of Group I (Table 1) and posthatch mortality (9.3%) was nearly twice that of Group I. Total mortality for Group II (21.4%) was 13.0% higher than control (Group I).

Desiccation for 5 h (Group III) caused temporary lethargy in crab mobility; sponge care and initial mortality were below those of Group I (Figure 2). Crabs recovered slowly during prehatch, resulting in 5 days of generally increasing daily egg mortality. Maximum daily egg and larval mortality usually occurred on the day of major hatch, but was delayed 2 days for most Group III crabs. Improper maternal care of eggs during prehatch and through posthatch may have prolonged oxygen

TABLE 1.—Percent egg mortality in ovigerous stone crabs as related to desiccation and autospasy. Experiment I compares egg mortality after effects of desiccation and experiment II compares egg mortality after desiccation followed by removal of both claws (autospasy).

Group and treatment	Crabs (no.)	Prehatch	Posthatch	Total
Experiment I:				
I (control)	33	3.3	5.1	8.4
II (2-h desiccation)	34	12.1	9.3	21.4
III (5-h desiccation)	32	5.9	33.8	39.7
Experiment II:				
IV (control)	29	7.0	6.7	13.7
V (2-h desiccation/autospasy)	23	8.5	18.1	26.6
VI (5-h desiccation/autospasy)	16	9.8	50.4	60.2

deficiency within the egg mass and lack of abdominal movement may have hindered successful larval hatching. Davis (1965) separated eggs from female blue crab, *Callinectes sapidus,* and noted a decrease in hatching success if eggs remained in small clusters, presumably due to insufficient oxygen. Rice and Williamson (1970) found that decapod larvae hatched from ovigerous females were weakened if oxygenated water could not be replenished.

Prehatch mortality for Group III (5.9%) was less than that of Group II, but was still greater than that of Group I (Table 1). Posthatch mortality (33.8%) was considerably higher than Group I or Group II. Total mortality for Group III (39.7%) represented a mean increase of 18.3% mortality above that of Group II and a mean increase of 31.3% above that of Group I (Table 1).

Experiment II

Autotomizer muscle reflexes were adversely affected in crabs subjected to air exposure, and declawing often resulted in jagged wounds and severance of the artery proximal to the hypodermal diaphragm. Unrestricted hemorrhaging caused death in 8 crabs in Group V and 14 crabs in Group VI. Death in seven additional crabs (three in Group V, four in Group VI) could not be explained as above, but also occurred after declawing. Resulting 100% egg mass mortality for 34.4% of Group V and 52.9% of Group VI notably reduced group mean hatching success related to control Group IV (Table 1).

Wood and Wood (1932) found any treatment which weakened brachyurans affected muscular responses, preventing normal autotomic reflex; they further stated that American crayfish (Astacidae) held captive for any length of time were

vitiated and lacked normal reflex. Davis[3] related wound size and body fluid loss in reporting 53.7% death in *M. mercenaria* held for 10 days in laboratory tanks and then declawed using commercial methods.

Loss of both claws after desiccation reduced preening of eggs by surviving crabs, resulting in an apparent initial egg mass mortality below that of Group IV (Figure 3).

Group V crabs (2-h desiccation) recovered quickly and compensated for claw loss by propping themselves against sides of compartments; rocks and shells common where stone crabs occur may be used similarly in nature. Prehatch mortality peaked 3 days after desiccation. Posthatch mortality was higher and more erratic than that of control Group IV. Prehatch mortality (8.5%) was slightly higher than that of Group IV (7.0%), but posthatch mortality (18.1%) was almost three times higher than that of control group (Table 1). Total mortality for Group V (26.6%) was 12.9% above control (Group IV).
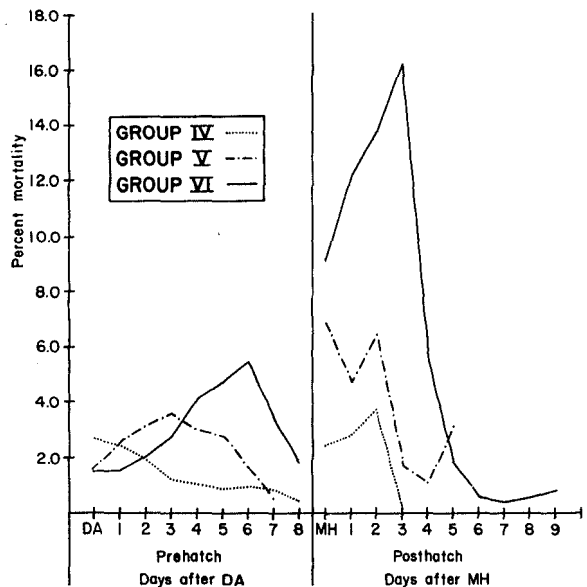
FIGURE 3.—Average daily percent egg mortality in ovigerous stone crabs as related to desiccation and autospasy. Group IV crabs were untreated (control), Group V crabs had both claws removed (autospasy) after 2-h desiccation, and Group VI crabs had both claws removed after 5-h desiccation. DA - day of desiccation and autospasy; MH - day when major hatching occurred; Prehatch - days following DA; Posthatch - days following MH.

After 5-h desiccation, surviving declawed crabs (Group VI) recovered more slowly than did crabs of Group V. Maternal preening was delayed and egg mortality during prehatch did not peak until 6 days after desiccation (Figure 3). As noted previously, maximum egg and larval mortality normally occurred at major hatch, but difficulty in maintaining body elevation probably inhibited preening for Group VI during posthatch. Consequently, maximum egg and larval mortality occurred 3 days after major hatch and time needed to clean pleopods was extended to 9 days.

Group VI recovery from stress was sufficient to produce prehatch mortality of 9.8%, an increase of 2.8% above control Group IV (Table 1). Extended posthatch yielded 50.4% egg and larval mortality, the highest of any group. Total mortality for surviving crabs in Group VI (60.2%) was a marked increase of 46.5% above that of control Group IV (Table 1) even excluding 100% mortality values from 18 dead crabs.

Mean Hatching Success

Mean hatching success for control crabs in Experiment I (Group I) was 91.6%. Desiccation from air exposure for 2 h (Group II) decreased success to 78.6% and desiccation from 5-h air exposure (Group III) decreased success to 60.3%. Mean hatching success for control crabs in Experiment II (Group IV) was 86.3%. Stress from 2-h desiccation plus autospasy (Group V) decreased success from Group IV to 49.6% and stress form 5-h desiccation plus autospasy (Group VI) decreased success to 18.8% (Figure 4).

Summary

Desiccation of eggs by air exposure of ovigerous females caused reduction in larval hatching success that was directly related to length of exposure. Desiccation weakened normal crab autotomic muscular reflex, and experimental declawing resulted in death of 34.4% of crabs exposed 2 h and 52.9% of crabs exposed 5 h.

Stress from autospasy after 2-h desiccation did not increase mean egg and larval mortality for surviving crabs above that for crabs desiccated only. Related to controls, Group II (2-h desiccation) and Group V (2-h desiccation/autospasy) had nearly identical total mortalities, 12.9% and 13.0%, respectively. Claw loss delayed maternal egg mass preening, and reversed the prehatch/
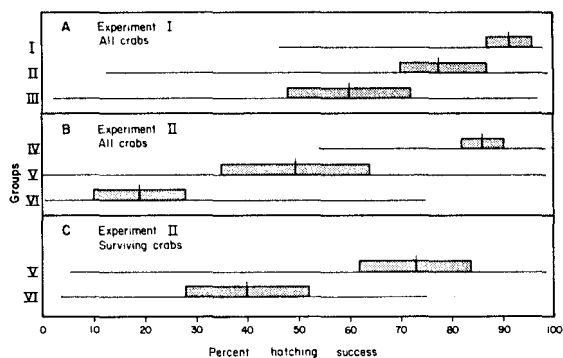

FIGURE 4.—Hatching success in ovigerous stone crabs as related to desiccation and autospasy. Mean (vertical line), range (horizontal line) and 95% confidence intervals (bar) about the mean. Set A includes untreated Group I crabs, Group II crabs exposed to 2-h desiccation and Group III crabs exposed to 5-h desiccation; Set B includes untreated Group IV crabs, Group V crabs, both claws removed after 2-h desiccation and Group VI crabs, both claws removed after 5-h desiccation; Set C includes only crabs that survived desiccation and autospasy in Groups V and VI.

posthatch egg mortality ratio of crabs desiccated 2 h from 12.1:9.3 (Group II) to 8.5:18.1 (Group V).

Effects of stress after 5-h air exposure were less definitive. Egg and larval mortality for surviving declawed crabs exposed to 5-h desiccation was 15.5% higher than was mortality for similarly exposed whole crabs when related to controls. Maternal egg preening by declawed crabs was obviously affected by claw loss, but small sample size (16) in surviving declawed crabs and overlap in confidence intervals for the 5-h desiccation groups made differences in mortalities inconclusive.

The stone crab fishery, unlike the blue crab fishery which allows permanent removal of whole animals, realizes high stability and recruitment by release of reproductively active crabs capable of claw regeneration. Present harvesting techniques adversely affect this stability by subjecting crabs to air exposure and desiccation. When crabs are ovigerous, desiccation causes a definite reduction in larval hatching success and is related to crab death and reduced overall population recruitment. Protection of ovigerous females by immediate release or by use of methods to dampen crabs while on deck is therefore warranted.

2-278-R. I thank F. S. Kennedy, Jr., M. E. Berrigan, J. R. Sullivan, D. G. Barber, and S. M. Foster for helping to collect and process the data, J. Hinkle and D. Richardson for laboratory assistance, and W. G. Lyons, D. K. Camp, and J. A. Huff for editorial review. Special thanks to Deb, my wife, who spent immeasurable time assisting me on weekends.

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FIRST RECORDS OFF OREGON OF THE PELAGIC FISHES *PARALEPIS ATLANTICA*, *GONOSTOMA ATLANTICUM*, AND *APHANOPUS CARBO*, WITH NOTES ON THE ANATOMY OF *APHANOPUS CARBO*[1]

The species covered in this report are common in parts of the Atlantic Ocean and all are known to occur in the Pacific Ocean. We fill a gap in knowledge of the distribution of two species known formerly only north and south of Oregon, extend the northward range of *Gonostoma atlanticum* Norman, and report inshore occurrences of *Paralepis atlantica* Krøyer. The unusual gross anatomy surrounding the gas bladder of *Aphanopus carbo* Lowe is worthy of description.

Methods

Counts and measurements followed those of Hubbs and Lagler (1958) and all measurements were taken to the nearest 0.1 mm. Specimens are catalogued in the fish collections of the Department of Fisheries and Wildlife (OS) or the School of Oceanography (OSUO), Oregon State University. Anatomical terminology follows that of Lagger et al. (1962) and Romer (1970). Four specimens of *A. carbo* from Oregon were dissected ånd two were radiographed. Two specimens from the Atlantic Ocean off Madeira were dissected and radiographed. Complete vertebral counts could not be made from the radiographs due to poor resolution of the small posterior caudal vertebrae.

Notes on Distribution and Morphology

Paralepis atlantica has been recorded in the eastern Pacific from Baja California and California (Rofen 1966) and from the vicinity of Willapa Bay, Wash. (Kajimura 1969). Bakkala (1971) reported the species from surface waters of the central Pacific at lat. 48°00' N, long. 165°00' W.

Two specimens of *P. atlantica* were found on shore in northwestern Oregon. One (OS 956:456 mm SL) was taken alive on the beach at Netarts, Tillamook County, on 7 October 1963. Another (OS 5160:466 mm SL) was found dead on the beach 29 km north of Seaside, Clatsop County, on 16 May 1960. A specimen of *G. atlanticum* (OSUO 2402:59 mm SL) was captured on 30 July 1977, 65