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EXPERIMENTAL TAPHONOMY OF *CALLINECTES SAPIDUS* AND CUTICULAR CONTROLS ON PRESERVATION

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ABSTRACT

Examination of remains of *Callinectes sapidus* deployed in several depth and environmental settings in the Bahamas and Gulf of Mexico as part of the Shelf and Slope Experimental Taphonomy Initiative project revealed that all specimens were uniformly and strongly degraded except those in brine-seep settings. Fragmentation and loss of cuticular material at all sites was correlated to the degree of calcification within the cuticle of different skeletal elements as observed in the undeployed specimens. Claws, tips of the last anterolateral spine, and mandibles were the most durable remains. In brine-seep areas, extraordinary preservation yielded articulated skeletal elements and some soft tissue. Examination of the cuticle in control specimens with cross-polarized light and computed tomographic scanning documents the correspondence of high degrees of calcification with portions of the exoskeleton remaining after deployment.

INTRODUCTION

Decapods are integral parts of many marine ecosystems, and their remains are a component of the fossil record. Despite their importance, they have not received the same level of attention in taphonomic studies as have mollusks and other hard-shelled taxa. Research on the relationship between intrinsic factors (molt stage, cuticle thickness, amount and distribution of calcite in the cuticle, overall size of the crab, gender) and the taphonomy of arthropods is generally absent and is in need (Plotnick et al., 1988). Previous studies provide data on the initial stages of decay but do not track decay over multiyear time periods.

This study investigated the taphonomy of the blue crab, *Callinectes sapidus*, by critically examining experimentally deployed extant crab remains over longer time periods than previously attempted. Decay patterns were compared to the distribution of calcite within the cuticle, providing needed data to test the hypothesis that the degree of calcification within the cuticle controls preservation potential. Results of this study, when combined with the results of previous work, form a more complete understanding of decapod taphonomy in marine environments.

Previous experimental taphonomic studies of decapods (e.g., Schäfer, 1972; Allison, 1986, 1988; Plotnick, 1986, 1988; Poulicek et al., 1986; Briggs and Kear, 1994; Stempien, 2005) have provided much to our understanding of decapod taphonomy and have shown that disarticulation, fragmentation, and decay are generally rapid. Remains become fragile to the point that any disturbance, natural or experimental, further breaks up remaining material (Schäfer, 1972; Harding, 1973; Plotnick, 1986; Allison, 1988). Decay and dismemberment of the uncalcified membranes joining exoskeletal articles occurs rapidly (Hof and Briggs, 1997); studies of the mud crab show significant loss of arthrodial membranes within 6 days (Plotnick et al., 1988). As the cuticle becomes increasingly fragile, the damaging effects of bioturbation, scavenging, and abrasion are intensified (Bishop, 1986). Generally, only fragments of the claws are found to survive for any significant length of time at the sediment-water interface. Scavenging of corpses and molts may also play a large role in preventing preservation of decapod remains before burial (Tshudy et al., 1989).

Taphonomic experiments therefore must account for the unavoidable damage imparted by retrieval and subsequent examination. Other taxonomic groups such as mollusks are intrinsically more robust. The scope and taxonomic breadth of the Shelf and Slope Experimental Taphonomy Initiative (SSETI) experiment, the source of our study material, was necessarily a compromise, given the nature of the various taxa deployed, the mechanics of deployment, and the methods of retrieval in remote locations. In observing the deployed crabs, we thus must necessarily acknowledge experimental limitations and extract the maximum amount of data from the material at the time of examination. We therefore tailor this paper to report what may be inferred from the material within the limits of the experimental design.

The fragility of the deployed crabs makes reliable interpretation of their taphonomy difficult at a fine scale. The crabs deployed and later recollected during the SSETI experiment, however, do provide considerable insight into the study of decapod taphonomy, especially with the long deployment times afforded in this study.

MATERIALS AND METHODS

Deployment

In 1993, SSETI was established to experimentally study the taphonomy of modern organisms in marine environments (Parsons et al., 1997; Parsons-Hubbard et al., 1999; Powell et al., 2002). In-depth analyses of other taxa deployed by SSETI are found in Parsons et al. (1997), Parsons-Hubbard et al. (1999), Callender et al. (2002), Powell et al. (2002), and Staff et al. (2002).

The blue crab, *Callinectes sapidus* Rathbun, 1896, was selected for these experiments because specimens are readily available and well studied and, thus, were thought to provide a suitable modern analog for an experimental taphonomic study. Specimens were deployed directly on the sediment-water interface in mesh bags and collected after multiple years of exposure. Environments were selected on the Texas–Louisiana continental shelf and slope and in the Bahamas to provide a variety of depositional settings, sediment types, light levels, and water depths. This paper examines the taphonomic degradation of 97 crab specimens deployed and subsequently collected during the SSETI experiments. Commercially purchased, frozen *Callinectes sapidus* specimens were deployed by submersible at the sediment-water interface in 21 marine locations in the Gulf of Mexico and the Bahamas. Every experimental location received four identical mesh bags, each containing two crabs, resulting in a total deployment of 168 specimens. To minimize fragment loss, the bags were made from 3 × 3 mm mesh encased within a larger 1 × 1.5 cm mesh bag. Bags were attached to a single, weighted, 1.5-m PVC pole at each site to aid in retrieval (Fig. 1). Specimens remained underwater for a minimum of 1 year, after which they were collected by submersible and assessed for taphonomic change. The period of deployment depended upon the experimental site and included 1-, 2-, 3-, 6-, and 8-year periods

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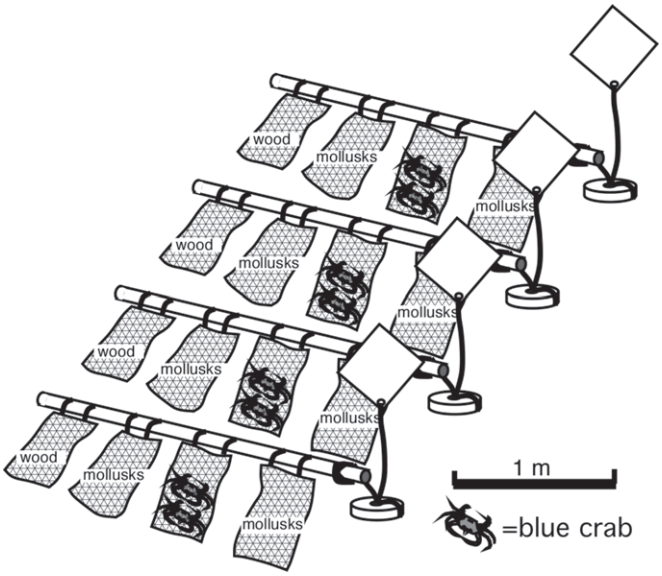

FIGURE 1—Experimental design showing mesh-bag arrays on the seafloor. One bag in each row contained two *Callinectes sapidus*, other bags contained mollusks and wood. At each site, four replicate bag arrays were deployed in 1993 for multiple-year collections.

(see Parsons et al., 1997; Parsons-Hubbard et al., 1999; and Powell et al., 2002, for more complete descriptions of SSETI techniques and site information).

The deployment sites encompassed a range of depositional environments in both siliciclastic and carbonate settings ranging from 50 m to 680 m water depths (Fig. 2). The 14 sites, at the 7 locations depicted on the map, on the Texas–Louisiana shelf and slope included brine and petroleum seeps, a collapsed carbonate bank, carbonate sands, hardgrounds, and deep-water reefs. The remaining seven sites were arranged along two SW–NE-trending transects on the eastern side of Lee Stocking Island, Bahamas. Environments included shallow coral reefs (15–33 m), near-vertical walls (73 m), carbonate slopes (210 m), and deep-water carbonate sands (292 m). The *Johnson Sea Link* submersible was used for all deployment and collection operations within the Gulf. *Nekton Gamma* and *Gamma* submersibles were used for all work in the Bahamas.

The experimentally deployed material was examined and the level of taphonomic degradation was scored using a qualitative scale in a manner similar to the previously published results of the mollusks deployed by SSETI (Davies et al., 1990). Although such factors as the mass of skeletal material remaining and level of breakage after deployment are attractive metrics in a taphonomic study, these same metrics are so highly dependant on both the loss of material through the mesh bags and postcollection breakage that they cannot be used here. Handling of the crab remains from the time the mesh bags were removed from the seafloor, separated from other taxa deployed in the same mesh bags, and transported to the lab from the Gulf of Mexico and the Bahamas was extensive enough to damage specimens. In addition, crab material was able to fall through the mesh bag. Although fragmentation can be recorded, causation cannot be adequately assigned to actual taphonomic forces on the seafloor versus postdeployment damage and material loss. Merely opening the plastic bags containing the deployed material for examination resulted in further fragmentation.

The level of macroscopic decomposition was measured using a qualitative system adapted from Davies et al. (1990), Lincoln and Parsons-Hubbard (2000), and Powell et al. (2002). This method ranked prominent macroscopic alterations using numerical estimates based on the lowest level of degradation in each bag. The most reliable alterations, indicated

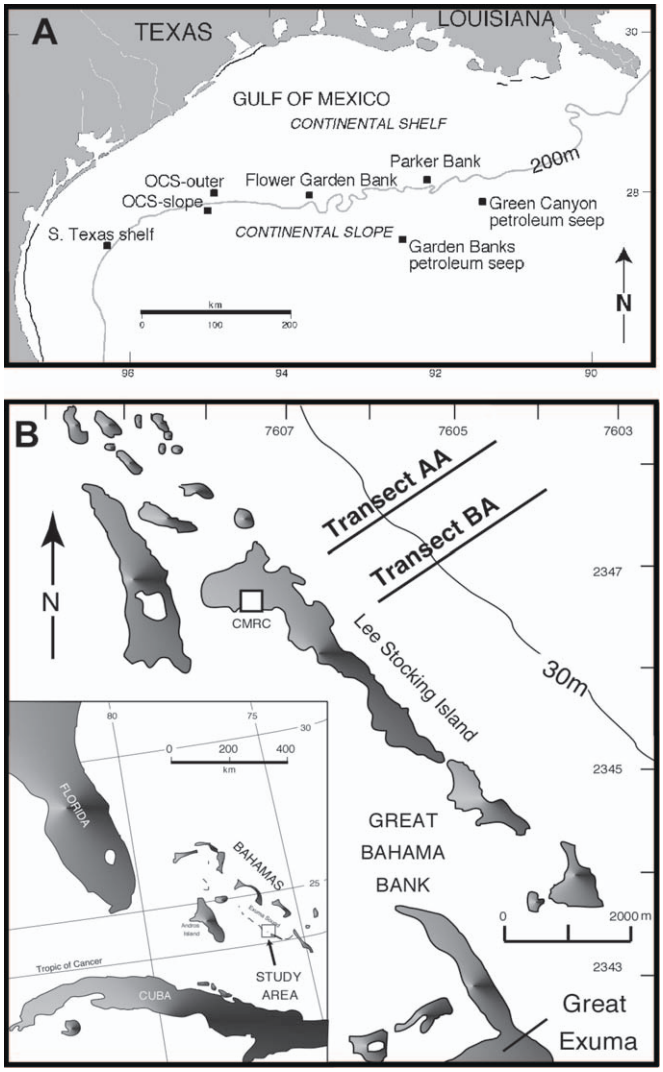

FIGURE 2—Location maps showing deployment locations. A) The Gulf of Mexico; several locations have multiple, closely spaced sites. B) The Bahamas; two transects where specimens were deployed. Modified from Parsons et al. (1997).

in Table 1 and the Supplementary Data[1], were chosen to assess overall taphonomic degradation. A single researcher (MHEM) assigned all estimated values to ensure consistent results.

Several factors, extrinsic and intrinsic, preclude precise quantification. When the samples were deployed, they were not weighed and measured. Further, their molt stage was not determined. Crabs are intrinsically different from the other test organisms used in the SSETI experiment (mollusks and wood). The strength of the cuticle of crabs varies throughout their growth cycle so that they are most durable during the intermolt interval and much more fragile during the molt interval. Another difference in experimental animals is that the crab exoskeleton is composed of numerous calcified elements held together by an organic arthrodial membrane. This membrane decomposes rapidly, separating the elements of the exoskeleton. Finally, the exoskeleton is formed of an organic framework that is variably calcified. This condition may facilitate fragmentation as decomposition of the organic chitinous material proceeds.

Calcification Mapping

Additional specimens of *Callinectes sapidus* were purchased to use as experimental controls. For examination with the light microscope, cuticle

[1] www.paleo.ku.edu/palaios

TABLE 1—Qualities measured in semiquantitative taphonomic key.

Taphonomic observation	Numeric scoring
Mass remaining	0 = small, 1 = medium, 2 = large
Presence of nonclaw cuticle	0 = no, 1 = yes
Presence of small sheets of thinned carapace	0 = no, 1 = yes
Presence of maceration structures	0 = no, 1 = yes
Presence of soft parts	0 = no, 1 = yes
Condition of claw exocuticle	0 = completely missing, 1 = little remaining, 2 = much remaining, 3 = complete or nearly complete
Original color remaining on claw	0 = none, 1 = some, 2 = nearly all, all
Claw denticles	0 = none, 1 = some, 2 = most, all articulated
Degree of claw degradation	0 = absent, 1 = fully fragmented, 2 = disarticulated, 3 = articulated

sections were defleshed, dehydrated in alcohol, embedded in epoxy, and thin sectioned using standard techniques. In an attempt to test previous hypotheses linking preferential preservation of claws to increased levels of calcification, several transects across the claws of nondeployed specimens were sectioned to determine the extent of calcification under cross-polarized light. Mandibles, legs, and sections of the dorsal carapace were handled in the same manner to determine the level of calcification. Additionally, claws were scanned using computed tomography (CT) in a Stratec Research M QCT CT scanner with a resolution of 0.07 mm voxels housed at the Northeastern Ohio Universities College of Medicine, Rootstown, Ohio. Raw image stacks produced by the scanner were imported into NIH Image-J (National Institutes of Health; Rasband, 1997–2007) and adjusted for brightness and contrast. The data collected from these scans confirmed, and added to, observations made with the light microscope. CT scanning provided data on the calcification in three dimensions without the need for making serial sections and revealed subtle changes in the amount of calcite within the cuticle that could not be resolved under cross-polarized light, a technique that only provided presence or absence data on the calcite.

RESULTS AND DISCUSSION

Deployed Material

Two striking trends appeared during analysis of the experimentally deployed *Callinectes sapidus*. The first is the generally similar appearance of samples regardless of the duration of deployment (1–8 years); the second is the remarkable preservation of samples that were deployed within brine seeps.

All remains deployed in sites of normal salinity lacked an intact dorsal carapace, and all soft parts were lost (Figs. 3B–D). Only pieces of the claw, mandibles, last anterolateral spines, and small sheets of cuticle were discernable in the recovered material. Within the parameters of the experiment, differences between recovered material deployed in the range of depths, sediment types, basin, and duration of deployment could not be reliably discerned. Although depth (and parameters linked to depth), time of deployment, and sediment type must have some effect on preservation, the similarity of the recovered remains is more significant than the differences in material from the different deployment sites and times. Differences between deployed samples could be evaluated qualitatively, but fragility, uncertainty regarding damage during recovery, and the fact that only two crabs were recovered per site, in addition to absence of control on stage of the molt cycle of deployed crabs, makes assigning small differences between recovered samples tenuous.

The level of material loss from all deployment sites of normal salinity is in contrast to the more complete preservation displayed in the material recovered from brine seeps (K.M. Parsons-Hubbard et al., personal communication, 2008). Specimens recovered from the brine sites included claws articulated with the carapace, internal musculature, and other partially intact soft parts (Fig. 3A). Remarkably, taphonomic differences between remains exposed for 1 year were not discernable from those deployed for 8 years (Fig. 4).

Claws were the most common component of the exoskeleton to survive deployment and were certainly the most recognizable fractions within the recovered material at all sites. Recovered claws, excluding those deployed in brine seeps, exhibited specific patterns of degradation, including loss of denticles and claw tips, V-shaped reentrants on the proximal regions of the fingers, and holes in the cuticle of the dactylus (Fig. 5). The most poorly preserved claws were composed of only middle sections of the fingers that were incomplete in cross section and lacked denticles and claw tips.

Calcification of Control Specimens

Anecdotally, the parts of the crabs that did survive deployment—the claw and mandibles—are considered to be the most heavily calcified regions of decapod cuticle. Previous studies have shown that calcification within decapods is complex. Variation is present between taxa and within regions of the exoskeleton of the same taxon, even at millimeter scales (Roer and Dillaman, 1984; C. Amato, D.A. Waugh, R.M. Feldmann, and C.E. Schweitzer, personal communication, 2008). To test the generally accepted notion that level of calcification controls preservation of decapod cuticle, we examined and compared the distribution of calcite in the control samples of *Callinectes sapidus* to the remains from the experimentally deployed specimens.

Thin sections of control specimens were made from various locations on the dorsal carapace, claws, legs, and mandibles. Under cross-polarized light the presence and distribution of calcite within the organic matrix of the cuticle could be mapped. CT scans of the claws provided additional information on both the distribution and the relative amount of calcite present in the cuticle. Whereas examination of thin sections in cross-polarized light reveals distribution of calcite, it does not indicate density of calcification. CT scanning is required to document density differences.

CT scans of claws from the manus to the claw tips of the two control specimens showed a distal progression of increased mineralization (Fig. 6A). Dense regions on the CT scans corresponded to the birefringence of mineralized portions visible under cross-polarized light (Fig. 6B). Calcified regions of the denticles and claw tips have a markedly higher density than other parts of the claw, although under cross-polarized light these other parts can be seen to contain calcite within the entire thickness of the cuticle (Fig. 6A). The V-shaped decay patterns formed on the proximal part of the fingers observed on deployed specimens correspond to the variable margins of the more densely calcified regions within the CT scans.

On the dorsal carapace, the upper layers of the cuticle (epicuticle and upper exocuticle) were consistently calcified. The lower part of the endocuticle ranged from having a continuous layer of calcite to isolated spherical masses of calcite within the organic framework of the cuticle (Fig. 6C). In some regions of the dorsal carapace, irregular columns of calcite were observed that varied in height and width. The remaining portions of the carapace are purely organic. The terminal anterolateral spines showed variability in the distribution of calcite, ranging from calcification of just the exocuticle to complete calcification of the entire

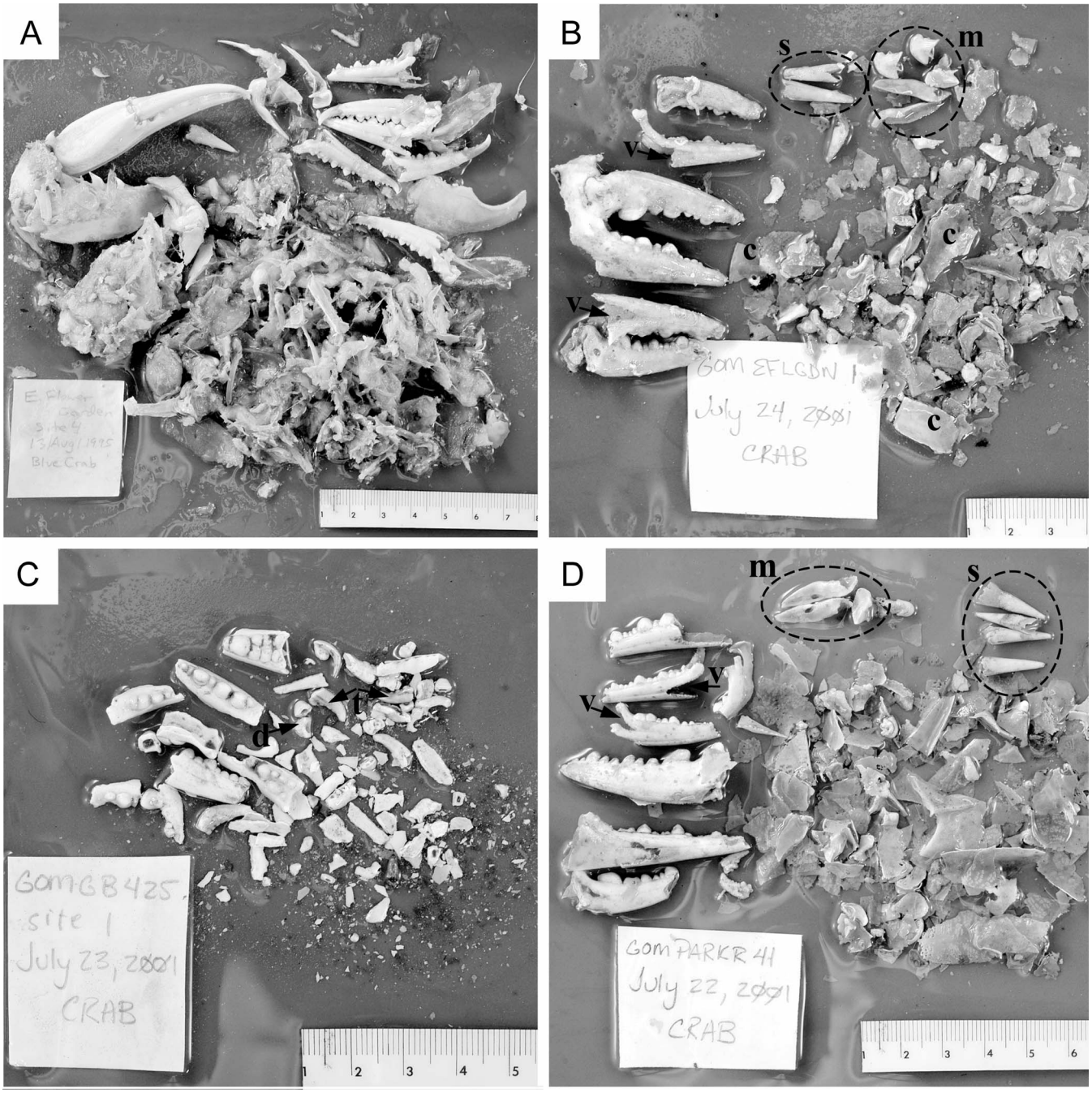

FIGURE 3—Deployed crabs from the Gulf of Mexico. A) GOM EFG site 4 (brine pool), 2-year deployment. Note partial articulation, dorsal carapace fragments, and preservation of soft-parts. B) GOM EFG site 1, 8-year deployment. Note partial claw articulation, loss of claw tips, dissolution Vs (v; see Fig. 5), anterolateral spines (s), fractured mandibles (m), and thinned carapace fragments (c). C) GOM Garden Banks site 1 (petroleum seep), 8-year deployment. Note highly fragmented claws, disassociated claw tips (t), dislocated denticles (d), and lack of carapace fragments. D) GOM Parker Bank site 4, pole 1, 8-year deployment. Note disarticulated claws with V-shaped reentrants (v), fractured mandibles (m), anterolateral spines (s), and thinned carapace fragments. GOM = Gulf of Mexico; EFG = East Flower Garden.

cuticular thickness (Fig. 6D). Variability in the level of calcification of the dorsal carapace and the last anterolateral spines may be attributed to control specimens that were in different stages of the molt cycle. The single mandible sectioned was heavily calcified except for the central region of the cuticle (Fig. 6E).

Correspondence of calcite within the cuticle of the control specimens and material preserved after deployment confirms the role that calcification plays in cuticular preservation. Claws were preferentially preserved owing to the higher level of calcification relative to other regions; increased thickness of the claws may further add to their stability. A similar correspondence of the preserved material and distribution of calcite within the cuticle is observed in the mandibles and terminal anterolateral spines. Legs, which displayed low levels of calcification, were not recognized in any of the deployed material except those samples deployed in high-salinity conditions. The dorsal carapace, which is incompletely calcified, was lost or reduced to small fragments.

Flat cuticle fragments, presumably remnants of the dorsal carapace, are variably composed of 1 mm discs, each with a central vertical canal 10 μm in diameter. These disks appeared in isolation and in varying states of coalescence (Fig. 7). Isolated disks are smaller than holes in the mesh

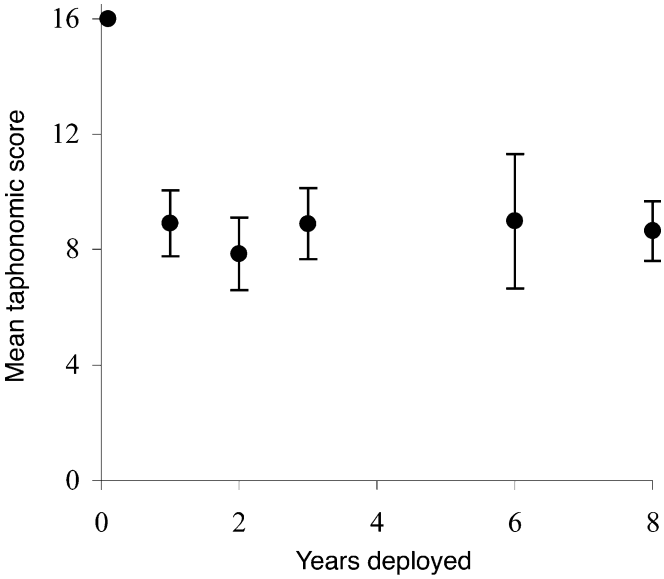

FIGURE 4—Graph of mean taphonomic score by year and undeployed control specimen. Error bars indicate 95% confidence intervals. Data from the brine-seep locality is not included (see text for details).

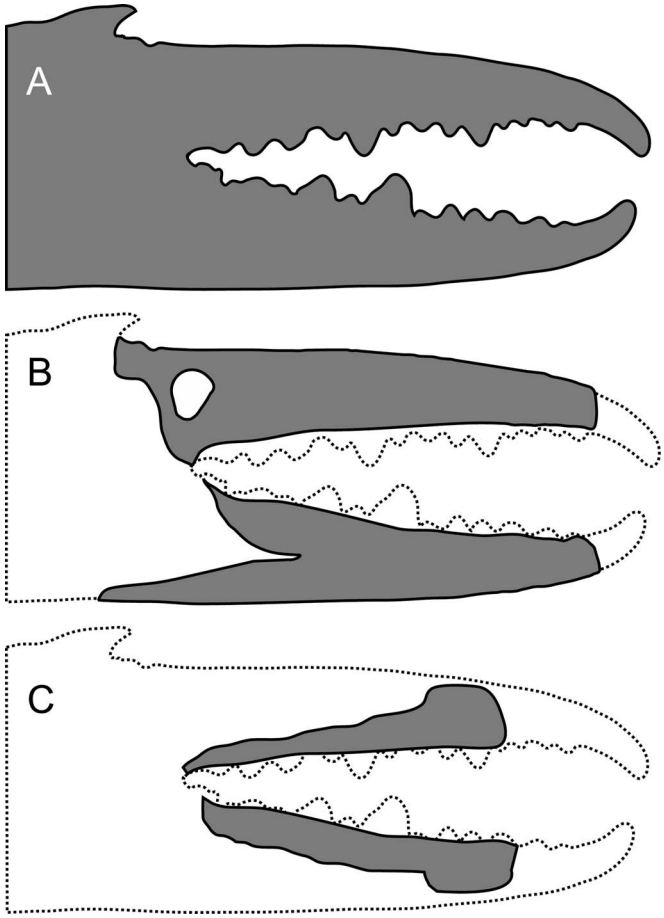

FIGURE 5—Types of claw degradation in deployed specimens. A) Complete claw, found only in brine seep sites. B) Moderately fragmented claw, most commonly found. Patterns include tooth separation, tips removed, reentrant V pattern, and a hole in the dactylus. C) Completely fragmented claw, found in some poorly preserved sites. Dark areas denote the remaining cuticle.

bags used during deployment and were therefore likely detached after collection. Projections resembling shelf fungi (Figs. 6B–C) on degraded claw edges are similar in morphology to the disks.

The disks and thin cuticle fragments are not simply fragments of the carapace; rather, they are the calcified layers within the cuticle of the dorsal carapace. This partial preservation is in contrast to the preservation of the cuticle of the claws, which are calcified throughout their entire thickness. The claws, therefore, retained their full thickness after deployment. The disks, either separate or attached to thin portions of cuticle, contain a central canal that represents the location of tegumental ducts that would have delivered calcifying fluids to the organic matrix of the cuticle after molting. Pore canals would serve the same function. Calcifying fluids emanating from a vertical canal explain the circular distribution of calcite surrounding the canal. Subsequent loss of organics during decay exposes these calcified regions, which normally are internal structures. The disks, therefore, represent the extent that calcifying fluids moved from the tegumental canal within a thin plane of the cuticle. Coalesced disks simply represent the intersections of these calcified zones. The fungiform surfaces are similar in origin in that they represent calcification originating from the tegumental canals, but with a more extensive vertical component.

In addition to patterns of decay controlled by locations of calcite within the cuticle, denticles and the distal tips of the claws were often found to have detached from the claws. This fragmentation is also an expression of the intrinsic properties of the cuticle. These zones of fracture are associated with an abrupt change in the density of calcite along which the denticles and tips could easily separate from the claw (Waugh et al., 2006). Denticles and claw tips are the most densely calcified parts of claws. Sharp folding of the laminations at tooth-claw boundaries (Waugh et al., 2006) may further create instability between these regions of the cuticle. Claw tips and denticles could be relatively common components of sediments; however, rounding of these fragments during transport would quickly render them unrecognizable.

Taphonomic Signatures

Degradation observed on a fossil specimen may provide clues to the degree and mechanism of transport, scavenging, and other factors. These taphonomic signatures can in turn be used to examine such factors as time averaging and community mixing that a particular fossil assemblage has undergone. Margins of recovered remains are controlled by initial morphology and the level of calcification, secondarily expressed after decay of organic phases. Recognition of fragment margins controlled by calcification may offer some taphonomic information. If the margins of fragments can be shown to correspond to calcification patterns, especially if delicate structures of the calcified-to-noncalcified transition are present, the fragmentation is more likely to have been caused by decay than by physical forces. Fractures of the cuticle formed during attack by a predator, or even compaction during burial, would not likely mimic the unique margins formed during decay.

Interpretations

Almost total loss of carapace material from *Callinectes sapidus* in most experimental conditions suggests that fossil crabs with a level of calcification similar to that of *C. sapidus* that are preserved with an intact dorsal carapace are the result of preservational conditions that either did not include extensive exposure on the seafloor, or the animals were otherwise protected by environmental conditions, such as exposure to high salinity. Differences in depth and sediment type did not provide conditions even at the minimal deployment time of 1 year to preserve significant portions of the dorsal carapace. The short time periods that weakly calcified remains can survive on the sediment surface as seen in this study strongly supports the notion that rapid burial and mineralization during diagenesis is necessary for preservation of poorly calcified cuticle (Feldmann and McPherson, 1980; Allison, 1988). Because calcification is not

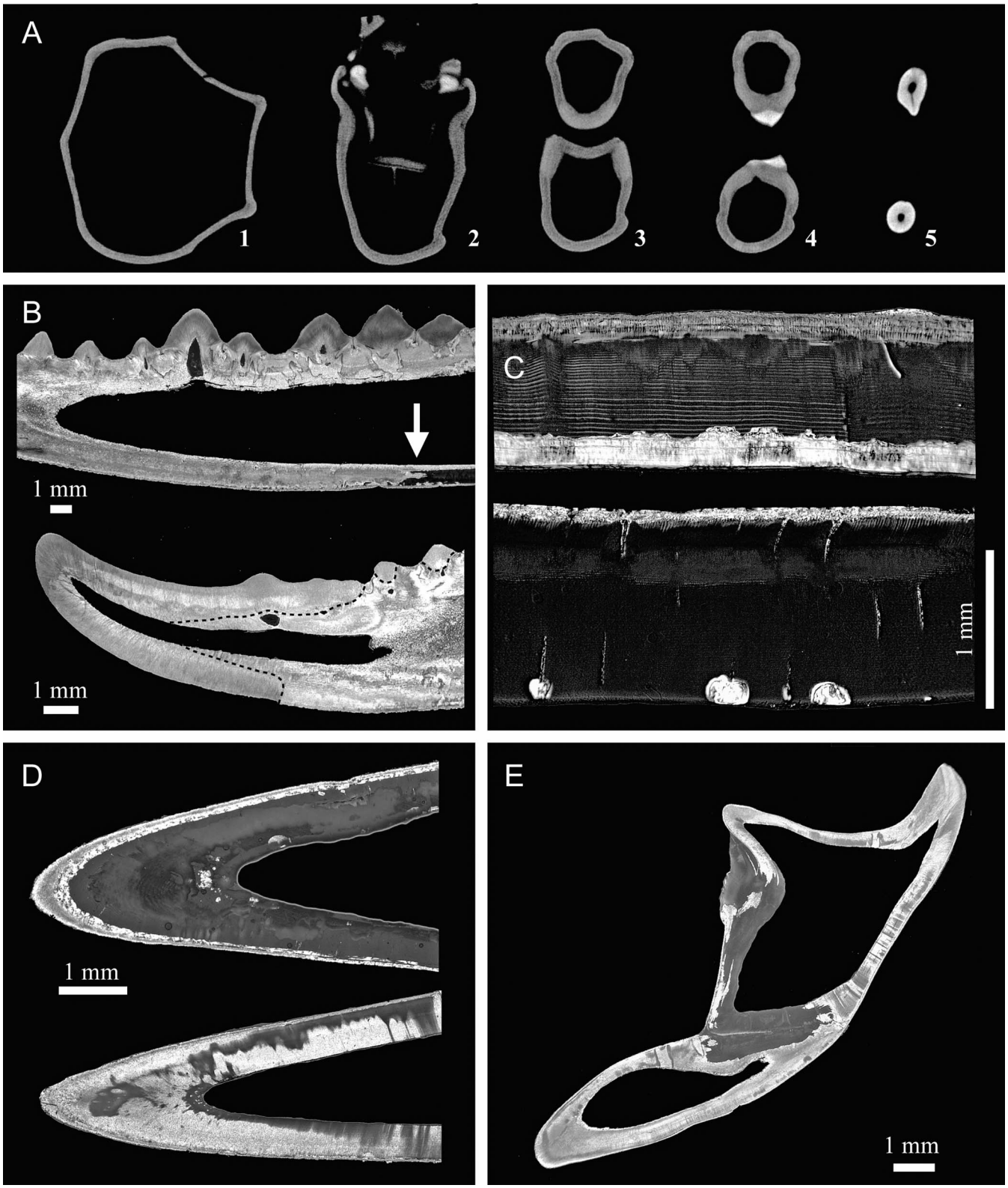

FIGURE 6—Distribution of calcified cuticle in *Callinectes sapidus*. A) Computed tomographic scans showing internal density of claw, palm (1) to claw tip (5). Regions of highest density are lightest. Notice that the denticles (scan 4) and claw tips (scan 5) are much more dense than the surrounding cuticle and that the transition is sharp. Scan 2 shows point of articulation of palm and finger. B) Micrographs of fingers under cross-polarized light; top is proximal end of finger, bottom is distal end of finger. Arrow on proximal part of the finger indicates the transition from fully calcified cuticle (left) to region of partial calcification (right). Black dashed line on distal finger tip delimits denticle-type cuticle on the denticles and claw tip. C) Two micrographs under cross-polarized light of cuticle from the dorsal carapace. Upper section shows sample with calcification present in the exocuticle (top) and lower endocuticle (bottom); lower section shows a different specimen with less calcite in the exocuticle and discontinuous calcification of the lower endocuticle. D) Two micrographs under cross-polarized light showing the anterolateral spines from two individuals illustrating the variability of calcification. E) Micrograph under cross-polarized light showing a longitudinal section through a mandible; note extensive calcification.

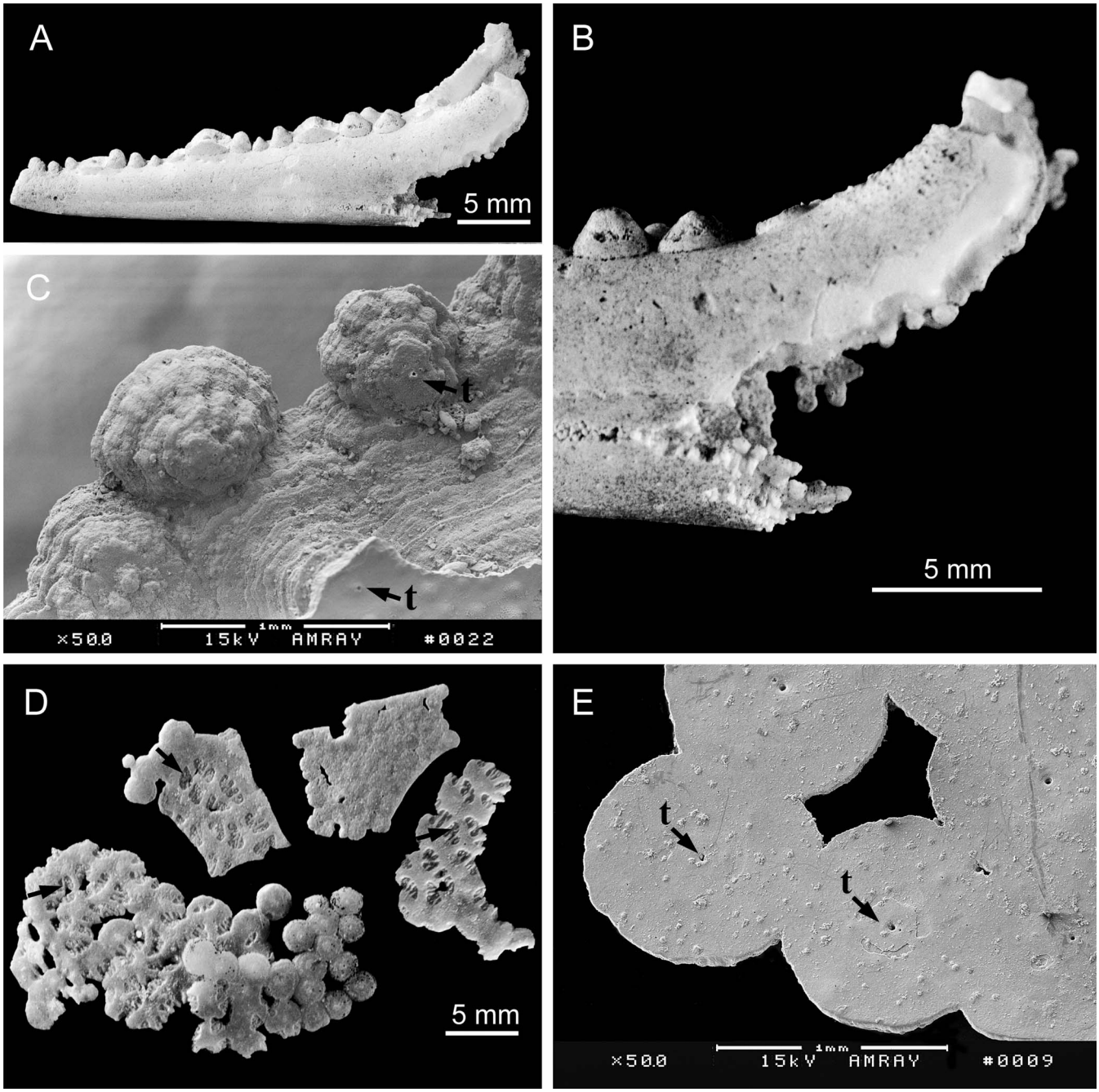

FIGURE 7—Maceration of uncalcified cuticle and exposure of underlying calcified regions in deployed specimens. A) Deployed movable finger showing loss of distal tip (left) and V-shaped reentrant on proximal side (right). B) Close-up of A showing V-shaped reentrant, disks, and fungiform projections. C) Scanning electron photomicrograph of fungiform projections. Note tegumental canals (t). D) Close-up photograph of conglomerated disks. Arrows indicate muscle scars typical of claw. E) Scanning electron micrograph showing disks, with tegumental canals (t).

uniform within the cuticle, heavily calcified parts such as claws may survive for relatively long periods (<8 years) before burial. Although a great deal of material was preserved within the brine, the remains were fragile and were readily broken when handled. Transport or scavenging of material from these sites would likely fragment and scatter the material remaining.

Although claws, mandibles, and terminal anterolateral spines were preserved and recognized in most samples, they were often extensively fragmented and fragile, suggesting a poor preservation potential as relatively intact fragments, especially if subject to transport. Samples in this study were deployed in tethered mesh bags, and the recovered material was not subject to damaging forces of transport or scavenging that would likely have resulted in further fragmentation. In this respect the long residence time demonstrated by this study may be somewhat longer than expected under natural conditions.

Allison (1986) postulated that short-term (days) survival during transport might be reduced by variations in calcification because as noncalcified areas decay, holes in the otherwise calcified cuticle create zones of weakness that could preferentially fracture. This observation may hold during stages of initial decay, but the longer that portions of the exoskeleton remain intact, the greater the odds of burial and preservation.

The concept that mineralized tissues are more likely to be preserved is not new, and this observation has been logically extended to arthropods (e.g., Brooks, 1957; Glaessner, 1969; Schäfer, 1972). It is important to

note that the cuticle of arthropods, including fully calcified cuticle, is fundamentally different than the shells of brachiopods, mollusks, and corals because of the larger amounts of organic matrix within arthropod cuticle. Cuticle need not contain calcite, and most arthropods lack calcite or other mineral salts completely (Richards, 1951). Among the crabs, the distribution and density of calcite varies with location on the specimen, stage of the molt cycle, instar, and taxon (Roer and Dillaman, 1984; Greenaway, 1985; Plotnick, 1990; Amato et al., in press). This variability occurs at all scales and has important taphonomic implications that cannot be realized without a better understanding of calcite distribution within the cuticle. Using one species as a model for understanding the taphonomy of decapods, therefore, cannot be complete considering the taxonomic variation of cuticular calcification.

A preliminary survey of calcification within the carapace of decapod cuticle suggests that the extent of calcification is not consistent across decapod taxa (Amato et al., in press). Data on the degree and distribution of calcite in one taxon shows that the variability can be high (Waugh et al., 2007). Control specimens examined not only contain variation in the distribution of calcite within the dorsal carapace and the last anterolateral spines but also variability in the degree of calcification present at the claw-denticle interface. Two carapaces from different taxa, or even two individuals within the same species, may contain similar amounts of calcite, but the continuity of the calcified regions may play the most important role in the effect of the calcification on preservation. Other controls on decapod calcification may include geographic location, environment, sex, stage of the molt cycle, and age. Future work may allow taxon-specific predictive models of preservation potential based on these factors. *Callinectes sapidus* provides a baseline and insight into the complexity of calcite distribution within the cuticle and its effect on preservation.

CONCLUSIONS

Specimens of *Callinectes sapidus* deployed in a variety of sedimentary environments and at varying depths in the Gulf of Mexico and the Bahamas suffered uniform and generally high degrees of degradation except those deployed in brine-seep areas. High-salinity conditions in brine seeps result in partial soft-part preservation and exceptional hard-part preservation. Such sites may result in instances of exceptional decapod preservation. Almost total loss of carapace material in most experimental conditions suggests that fossil crabs with a distribution of calcite similar to *C. sapidus* that are well enough preserved for taxonomic work are the result of either rapid burial or extreme environmental conditions.

Claws, mandibles, and the last anterolateral spines are preferentially preserved in experimentally deployed specimens. Thin sections and CT scans show that preservational bias is controlled by calcite distribution within the cuticle. Tips and denticles of the claw are commonly disarticulated on deployed specimens. Sharp chemical and density contrast along the contacts of tips and denticles with the cheliped fingers may result in structural instability.

A preliminary survey of calcification of the decapod carapace suggests that the extent of calcification is not consistent across taxa. The effect of these other factors has not been studied to date. Possible controls on decapod calcification may include genetic signals, geographic location, environment, sex, and age. Future work may allow predictive models of preservation potential based on these factors. Thin discs, mandibles, and anterolateral spines may be preserved in the fossil record and should become more commonly recognized by researchers sorting through fossil sediments to enhance faunal analyses.

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