

Prospective ecological effects of poleward mangrove planting on crab communities at Chongming Dongtan: a mechanistic review

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Abstract. Poleward mangrove planting is increasingly discussed as a coastal-restoration response to warming and habitat loss, yet planting at temperate estuarine sites may create trade-offs with existing tidal-flat and salt-marsh functions. This narrative review evaluates a prospective mangrove-planting scenario at Chongming Dongtan, with particular attention to crab-community reassembly and crab-mediated sediment and carbon processes. Evidence is separated into direct Chongming observations, adjacent evidence from eastern China, and mechanistic evidence from tropical and subtropical mangroves. Direct surveys show that the Dongtan crab assemblage is already dominated by the sesarmid *Orisarma dehaani* and the varunid *Helice tientsinensis*, while diking studies demonstrate that macrobenthic responses depend strongly on tidal connectivity. Mangrove planting could add structural and detrital resources, but dense or continuous stands could also contract open-flat habitat and redistribute rather than increase ecological functions. Three outcomes are proposed: habitat complementarity, functional substitution, and low-establishment engineering effects. Crabs may in turn alter planting trajectories through propagule consumption, bioturbation, and organic-matter redistribution. The review recommends replicated, reversible planting experiments that separate vegetation from engineering, retain mudflat and tidal-channel controls, and integrate crab traits, hydrology, sediment chemistry, greenhouse-gas fluxes, and remote sensing. The present evidence supports a testable adaptive experiment, not large-scale habitat conversion based on assumed benefits.

Keywords: Chongming Dongtan, mangrove planting, crab communities, habitat filtering, bioturbation

1. Introduction: review scope and evidence hierarchy

This narrative review evaluates a prospective poleward mangrove-planting scenario at Chongming Dongtan rather than reporting the outcome of an established mangrove restoration there. The distinction is essential. The Chongming literature used here documents existing tidal-flat and salt-marsh communities, crab population dynamics, and the consequences of hydrological engineering; it does not provide post-planting observations from a mature local mangrove stand. Accordingly, statements about future crab responses are framed as hypotheses and testable predictions.

Evidence is organized in three tiers. Direct evidence comprises studies conducted at Chongming Dongtan, including historical macrobenthic surveys, a year-round crab survey, and before-after analyses of diking effects [1-4]. Adjacent evidence comes from salt marshes, tidal flats, and poleward mangrove stands elsewhere in eastern China. Mechanistic evidence comes from tropical and subtropical mangrove research on root-mediated habitat structure, litter processing, bioturbation, and propagule consumption. Mechanistic evidence can identify plausible pathways, but it cannot by itself establish their magnitude or even their net direction at Chongming.

The central question is therefore conditional: if cold-tolerant mangroves were experimentally planted at Chongming, under what planting and engineering configurations would they add habitat functions, substitute for existing functions, or degrade both? This framing preserves the original focus on crabs while making the boundary between observation and inference explicit.

2. Poleward mangrove planting as a habitat-engineering force

2.1. From open tidal flats to three-dimensional vegetation

Chongming Dongtan contains fine-grained intertidal flats and salt marshes exposed to irregular semidiurnal tides. These environments support a diverse crab assemblage, including the locally dominant *Orisarma dehaani* (reported as *Chiromantes dehaani* in older literature) and *Helice tientsinensis* [1, 2]. The assemblage is already structured by vegetation, elevation, inundation, sediment properties, and tidal channels; the site should not be treated as an ecologically empty mud surface.

Mangrove establishment would add persistent above-ground and below-ground structure. The geometry of that structure is species-specific: *Kandelia obovata* develops prop-root structures, whereas *Sonneratia* and *Avicennia* species produce pneumatophores. These root-form distinctions should be retained when predicting sediment trapping, porewater exchange, refuge availability, and burrowing constraints. Once trees establish, roots, stems, canopy shade, and litter can increase surface roughness and microtopographic heterogeneity, reduce near-ground light, and buffer short-term temperature variation [5, 6].

These changes can have opposing effects on crabs. Added structure may provide refuges and feeding surfaces for some taxa, while dense roots and accumulated litter may obstruct surface activity or change burrow construction for others. Structure is gained only by occupying space: continuous expansion of planted patches necessarily reduces the area or connectivity of open flats. The relevant predictor is therefore not mangrove presence alone, but the spatial combination of stem density, patch continuity, retained open-flat area, and tidal connectivity.

2.2. From microphytobenthos to leaf detritus

Crabs on unvegetated intertidal flats can consume microphytobenthos, sedimentary organic matter, suspended particles deposited by tides, plant material, and animal prey. Their diets vary among species and sites [7]. Mangrove establishment would introduce a new and seasonally variable carbon source in the form of leaf litter; it would not automatically replace all pre-existing food sources.

Fresh mangrove leaves often contain structural compounds and secondary metabolites that limit immediate assimilation. Microbial conditioning, leaching, fragmentation, and gut passage change litter quality over time. Leaf-eating sesarmid crabs can retain, bury, macerate, and ingest substantial quantities of litter, but reported removal varies markedly among forests and species. A synthesis of published studies [8] places published removal or burial estimates broadly between 30% and 90% of annual litterfall in some tropical systems. This

range should not be presented as a universal consumption rate for all sesarmids or transferred directly to Chongming.

At a poleward site, low winter temperature, short stand age, and uncertain plant survival could delay both litter production and microbial conditioning. The development of a litter-crab-microbe pathway is therefore a hypothesis. It requires measurements of litterfall, microbial decomposition, crab ingestion and removal, and stable-isotope assimilation rather than inference from forest cover alone.

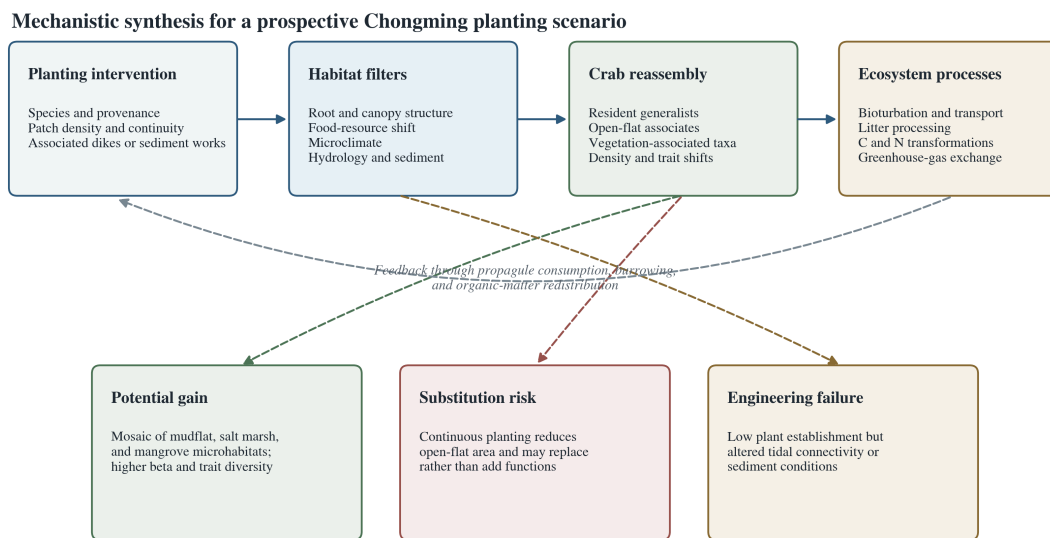
2.3. Hydrology, sediment and substrate as filters

Mangrove vegetation can alter hydrodynamics indirectly. Stems and aerial roots may attenuate currents and waves, promote deposition of fine particles, and change porewater exchange, but the magnitude and direction depend on water depth, stand density, root form, geomorphology, and external engineering [5]. These physical changes can affect the ease and stability of crab burrowing.

Chongming provides a direct warning against conflating vegetation effects with engineering effects. In the *Spartina alterniflora* control project, fully enclosed diked areas experienced significant losses in macrobenthic richness and mean density, whereas partially enclosed areas that retained tidal canals showed increases [3, 4]. The contrast is most directly associated with retained versus interrupted tidal connectivity; microbial and redox pathways were not measured in those studies.

Any mangrove field experiment must therefore separate vegetation from construction. At minimum, the design should include unmanipulated reference flats, planting without major hydrological modification, engineering-only controls where relevant, and planted plots exposed to the same engineering. Without these contrasts, a change in crab abundance cannot be assigned confidently to mangrove vegetation.

2.4. Synthesis: mangroves are not a single variable



Solid arrows: established mechanism classes. Dashed arrows: context-dependent pathways or feedbacks that require local testing.

Figure 1. Mechanistic synthesis of how planting design and associated engineering could filter crab assemblages and alter ecosystem processes. The diagram is an original synthesis based on sources [4, 5, 8-11]

A poleward planting intervention would simultaneously alter structural complexity, food inputs, microclimate, hydrodynamics, and sediment properties. Crab responses integrate these co-varying filters. Figure 1 summarizes the causal structure and the three principal outcome classes developed in this review.

3. Crab-community reassembly under habitat filtering

3.1. The resident assemblage is the starting point

A year-round survey at Chongming Dongtan recorded 2,945 crabs representing 12 species. As shown in Figure 2, *Orisarma dehaani* and *Helice tientsinensis* accounted for 67.57% and 17.28% of individuals, respectively [2]. This direct evidence changes the interpretation of prospective mangrove effects. A sesarmid crab is already the dominant local taxon; mangrove planting would not simply introduce a previously absent "mangrove-crab guild." It could instead redistribute resident generalists, change their densities, or alter the balance between resident species.

Current taxonomy recognizes *Ilyoplax tansuiensis* and *Ilyoplax deschampsi* as separate species, so the names should not be used interchangeably. Neither species replaces the direct year-round evidence that identifies *O. dehaani* and *H. tientsinensis* as the dominant Chongming taxa. Functional guilds should therefore be assigned from local habitat use, diet, burrow traits, and movement data, not from family identity or analogy alone.

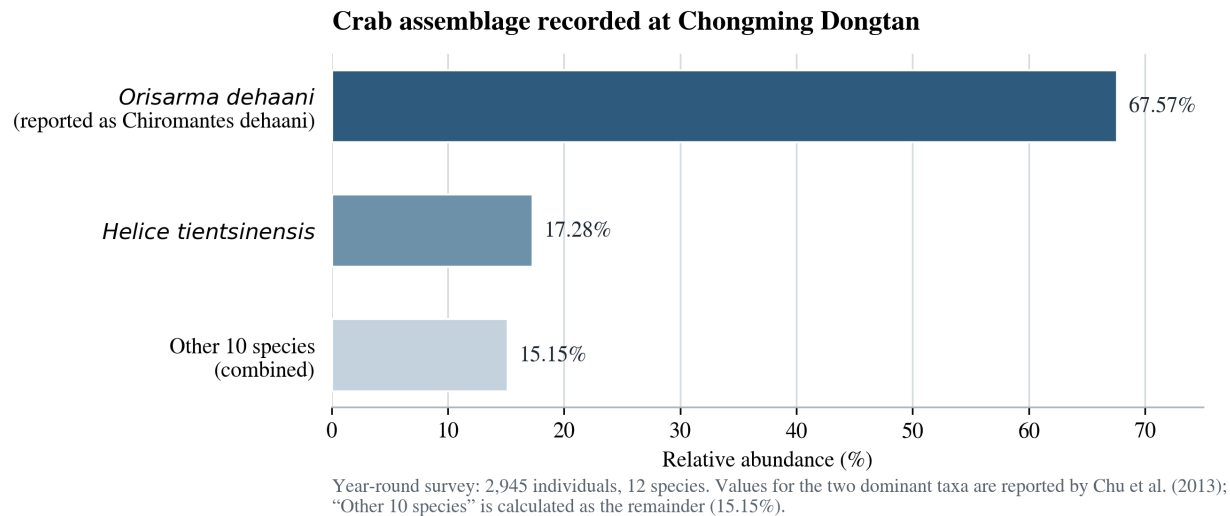


Figure 2. Relative abundance of the two dominant crab taxa and all other species combined in a year-round Chongming Dongtan survey. Data source: [2]; the other-species value is the calculated remainder

3.2. Open-flat associates and vegetation-tolerant taxa

Loss of open-flat area is a plausible pressure on species whose feeding, signalling, or burrowing depends on unobstructed surfaces. However, no published Chongming threshold identifies the proportion of open flat below which a given crab population becomes non-viable. The existence and location of such a threshold should be tested across replicated gradients of planting density and patch configuration.

Vegetation-tolerant taxa may benefit from additional shelter, moderated microclimate, or detrital resources. Yet increased abundance has two distinct interpretations: habitat complementarity, in which new microhabitats are added while resident functions persist; or functional substitution, in which vegetation-tolerant taxa

dominate after open-flat associates decline. Distinguishing these outcomes requires simultaneous monitoring inside planted patches, at edges, in retained open flats, and in unplanted reference areas.

3.3. Three testable reassembly scenarios

The literature supports three conditional scenarios rather than a single forecast. In the habitat-complementarity scenario, dispersed planting retains open flats and tidal channels, allowing resident and vegetation-associated functions to coexist. In the substitution scenario, dense continuous planting contracts open-flat habitat and shifts the assemblage toward vegetation-tolerant taxa. In the low-establishment engineering scenario, plant survival remains poor while construction has already changed hydrology or sediment, so neither the original assemblage nor a stable mangrove-associated assemblage is maintained. These scenarios may occur in different zones or at different times, and they must be treated as hypotheses rather than ranked predictions. The boundary conditions, predicted biological responses, and decisive measurements for the three scenarios are summarized in Table 1.

Table 1. Testable community-reassembly scenarios for a prospective planting experiment at Chongming Dongtan

Scenario	Boundary conditions	Predicted biological response	Decisive measurements
Habitat-complementarity gain	Dispersed patches; retained mudflat and tidal creeks; moderate stem density; no loss of tidal exchange.	Resident mudflat and salt-marsh taxa persist while additional vegetation-associated taxa or microhabitat users appear; beta and trait diversity may rise.	Area and connectivity of each habitat; occupancy and density of resident taxa; trait and beta diversity; tidal exchange.
Functional substitution	Continuous or dense planting; contraction of open flats; simplified understory; possible sediment fining.	Open-flat associates decline while vegetation-tolerant generalists dominate. Richness may remain stable even as functional composition shifts.	Guild ratios, species-specific density, burrow traits, open-flat area, litter removal, sediment grain size and redox potential.
Low-establishment engineering effect	Low mangrove survival, but dikes, fences, grading or sediment works alter hydrology and deposition.	Neither a stable mangrove-associated assemblage nor the original open-flat assemblage is maintained; macrobenthic density or richness may decline.	Plant survival; hydrological connectivity; sediment elevation and oxygen conditions; paired vegetation-only and engineering-only controls.

4. From species change to process change: crabs as ecosystem engineers

4.1. Burrowing, sediment exchange and redox conditions

Crab burrows enlarge the sediment-water and sediment-air interfaces and create preferential pathways for porewater exchange. Burrowing can redistribute particles and organic matter, change sediment erodibility, and modify oxygen, iron, and sulfur gradients [8, 12]. Because these effects vary among crab species and environmental settings, they cannot be translated into a universal decomposition multiplier.

The net carbon and greenhouse-gas consequences are context dependent. Burrow aeration can stimulate organic-carbon oxidation, while burrows can also trap organic matter and alter burial. A multi-site study found higher CO₂ and CH₄ production in crab-burrow sediments than in the surrounding matrix in sampled

mangrove and salt-marsh systems [13]. The net flux direction at Chongming therefore cannot be inferred without local measurements.

4.2. Litter processing and organic-carbon transfer

Mangrove litter can be exported by tides, decomposed in place, fragmented by fauna, or transported into burrows. Sesarmid crabs link primary production to detrital pathways by consuming and burying leaves and by producing fragmented faecal material [8, 9]. The effect on carbon storage is not equivalent to the amount of litter removed from the surface: transport, assimilation, respiration, burial, and tidal export are separate fluxes.

If resident or colonizing crabs at Chongming assimilate mangrove-derived material, they could accelerate its entry into animal and microbial food webs. If they do not, litter processing may be dominated by microorganisms and hydrodynamic export. Both pathways are plausible, and neither can be inferred from the presence of leaf litter alone.

4.3. Carbon-nitrogen coupling and microbial processes

Burrows change physical transport and redox zonation, thereby affecting nitrification, denitrification, sulfate reduction, and the availability of ammonium and dissolved organic carbon [8]. Faeces and feeding fragments can also create localized substrates for microbial activity. Nevertheless, Chongming currently lacks a baseline linking crab density and burrow traits to carbon and nitrogen fluxes under a mangrove-planting treatment.

Increased organic-carbon input should not be equated with increased storage. Input, decomposition, export, gaseous loss, and long-term burial must be measured separately. The net effect of a crab-community shift depends on how these fluxes balance across seasons and habitat zones.

4.4. Bidirectional feedback on mangrove establishment

Crabs can also affect the vegetation that restructures their habitat. Sesarmid consumption of mangrove propagules and seedlings has reduced recruitment in some Indo-Pacific settings, particularly where predator density is high [11, 14, 15]. Burrowing and sediment reworking may also modify root-zone aeration, porewater exchange, and seedling anchorage. The net effect therefore depends on crab species, density, propagule size, inundation, and sediment properties.

For a poleward planting experiment, this feedback should be measured directly using caged and uncaged propagule trials, seedling survival, damage attribution, and burrow mapping. Mangroves may reorganize crab habitat, and crabs may then reinforce or impede vegetation establishment. Figure 1 represents this feedback as context dependent rather than inherently negative.

5. Discussion: the central tension: habitat gain or functional replacement

5.1. Potential ecological gains

Where patches establish without removing tidal exchange or all open-flat habitat, mangroves can add shade, refuge, structural surfaces, and detrital resources. Restored mangroves can recover important ecological functions, but recovery varies with stand age, hydrology, species composition, and landscape context [16, 17].

Evidence from subtropical East Asia also cautions against assuming a monotonic benefit of increasing tree density. In western Taiwan, some macrobenthic taxa occurred only in mangroves, yet crab density was consistently lower in mangroves than on adjacent mudflats, and high *Kandelia obovata* stem density was

negatively associated with infaunal density [18]. This supports a testable intermediate-density hypothesis, not a guarantee that mangroves increase crab diversity.

5.2. Potential costs to the existing tidal-flat system

Open tidal flats are functioning habitats rather than vacant land. They support macrobenthos, sedimentary processes, and food resources for migratory shorebirds. Coastal reclamation and habitat conversion across China have already reduced tidal-flat availability along the East Asian-Australasian Flyway [19, 20]. At Chongming, the effects of diking on macrobenthos further demonstrate that apparently restorative engineering can produce contrasting outcomes depending on connectivity [4].

Crabs may be useful early-warning indicators because they are abundant, functionally important, and measurable through both individuals and burrows. However, the proposition that crab declines necessarily precede detectable bird or sediment responses has not been demonstrated at Chongming. It should be tested as an indicator hypothesis, not stated as an established temporal sequence.

5.3. Why richness alone is insufficient

Species richness and the Shannon index can remain stable while functional composition changes. If several open-flat taxa decline and a small number of vegetation-tolerant taxa become dominant, taxonomic diversity may obscure loss of trait diversity or functional redundancy [21]. Evaluation should therefore combine richness and evenness with functional groups, body size, feeding mode, burrow architecture, habitat occupancy, and beta diversity among patches.

The relevant management outcome is the preservation or recovery of ecological processes across the habitat mosaic. Plant survival and cover remain necessary measurements, but they cannot substitute for evidence on faunal composition, bioturbation, detrital processing, hydrology, and sediment chemistry.

6. A restoration and monitoring framework

6.1. Preserve and test a mudflat-salt-marsh-mangrove mosaic

A prospective Chongming experiment should compare planting configurations rather than begin with a target of maximizing mangrove area. The safest testable principle is to retain reference mudflats and tidal channels while establishing replicated low- and moderate-density patches in suitable upper-intertidal positions. High-density continuous planting should be treated as an experimental treatment with explicit stopping rules, not as the default endpoint.

Studies elsewhere show that the response of macrobenthos to mangrove cover and density can be non-linear and taxon specific [18, 22]. Those results justify testing habitat mosaics, but they do not provide a transferable "optimal ratio" for Chongming crabs. Local elevation, hydrodynamics, bird use, and existing vegetation must determine the spatial design.

6.2. Use crabs as one component of process-based monitoring

Crab monitoring can extend evaluation from plant establishment to ecosystem processes. Core variables should include species identity and density; functional-group composition; burrow density, diameter, depth and spatial distribution; habitat-specific occupancy; litter removal and feeding trials; sediment grain size, organic carbon, redox potential and porewater nutrients; propagule and seedling survival; and the use of habitat patches by shorebirds.

A before-after-control-impact design is appropriate when multiple pre-intervention observations and replicated controls are available [23]. Sampling should span seasons and continue for multiple years, with frequency and duration determined by expected effect sizes and statistical power. A single post-planting species list cannot distinguish intervention effects from seasonal or regional variation.

6.3. Adaptive management under uncertainty

Monitoring should be linked to predefined decisions. A sustained decline in open-flat taxa, loss of tidal connectivity, or worsening sediment oxygen conditions should trigger modification of patch boundaries or engineering structures. Strong propagule consumption should trigger a targeted seedling-protection experiment rather than indiscriminate crab removal. Failure of plants to establish should prompt assessment of whether physical works are continuing to alter the site without ecological benefit.

The intervention should be managed as a long-term, reversible ecological experiment. This approach accepts uncertainty while preventing uncertain benefits from being used to justify irreversible habitat conversion.

7. Priority research directions

7.1. Establish a true local baseline and long-term series

Historical studies at Chongming provide valuable reference conditions, but they are not a formal pre-treatment baseline for a future planting experiment because climate, invasion, engineering, and community composition have changed over time. New baseline sampling must repeat compatible methods across planned treatment and control sites before intervention. Follow-up should track the same locations, seasons, and response variables over multiple years [1, 2].

7.2. Compare cold-tolerant species and provenances cautiously

Species selection should begin with climatic feasibility and ecological risk. *Kandelia obovata* has the widest latitudinal range among Chinese mangroves and is strongly associated with poleward expansion and low-temperature tolerance [24]. By contrast, *Sonneratia apetala* is non-native in China and has shown invasive behavior in some southern locations [25]. Current evidence does not identify either species as an established principal planting taxon at Chongming.

For Chongming, provenance or genotype trials within cold-tolerant native species may be more defensible than assuming that fast-growing southern species are suitable. Comparisons should measure winter survival, growth, root form, litter production and quality, effects on sediment, and responses of resident fauna.

7.3. Trace carbon pathways with stable isotopes

Observation of leaf handling does not establish assimilation. Stable carbon and nitrogen isotopes can compare mangrove leaves, microphytobenthos, sedimentary organic matter, crab tissues, and potential animal prey. Mixing models must use taxon- and diet-appropriate fractionation factors because general trophic-enrichment factors may underestimate mangrove-leaf contributions to sesarmid diets [26, 27].

7.4. Integrate remote sensing with field measurements

Remote sensing can quantify changes in vegetation patches, tidal-flat area, elevation proxies, and tidal-channel configuration, complementing plot-scale surveys [20, 28]. It cannot determine crab function or sediment

biogeochemistry without field calibration. Spatial habitat maps should therefore be linked to repeated crab, burrow, sediment and hydrological measurements to identify where habitat contraction and functional change coincide.

8. Conclusion

Prospective poleward mangrove planting at Chongming Dongtan should be understood as habitat reconstruction rather than simple tree introduction. The intervention could alter physical structure, food resources, microclimate, hydrodynamics, and sediment conditions simultaneously. Crab responses would reflect the combined filters and could include complementarity, functional substitution, or loss associated with unsuccessful planting and engineering effects.

The strongest direct evidence currently describes the resident Chongming assemblage and the importance of tidal connectivity, not crab responses to a local mature mangrove stand. *O. dehaani* is already the dominant crab in the Dongtan salt marsh, so future change cannot be reduced to replacement of mudflat crabs by newly arriving sesarmids. The relevant questions concern species-specific density, habitat occupancy, trait composition, and ecosystem processes.

Management should preserve reversible comparisons among open flats, salt marsh, planted patches, and transition zones; separate vegetation effects from construction effects; and couple plant monitoring with faunal, hydrological and biogeochemical measurements. Under the present evidence gap, a replicated and adaptive field experiment is scientifically defensible. Large-scale conversion based on assumed benefits is not.

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