

Natural Diet Composition and Feeding Ecology of *Panulirus* Lobsters: A Systematic Literature Review of Prey Diversity, Trophic Interactions, and Ecological Drivers

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ABSTRACT

Spiny lobsters of the genus *Panulirus* are valuable fishery resources and ecologically important benthic predators, yet evidence on their natural diets remains fragmented across species, life stages, habitats, and analytical methods. This systematic review synthesizes natural diet composition, ontogenetic shifts, trophic interactions, prey selectivity, and ecological drivers of *Panulirus* feeding ecology. Searches used Scopus as the primary database, supported by Web of Science and supplementary sources, with explicit eligibility criteria for studies of wild or naturally occurring populations. Twenty-five studies were retained for qualitative synthesis. The evidence indicates that *Panulirus* lobsters are trophically flexible consumers rather than strict specialists. Early stages rely mainly on pelagic and planktonic resources, whereas post-settlement juveniles and adults exploit molluscs, crustaceans, echinoderms, polychaetes, algae, detritus, and other benthic resources. Realized diets are shaped by life stage, body size, sensory capacity, prey handling ability, habitat structure, and local prey availability. Habitat degradation and changing prey fields may increase trophic overlap and interspecific competition. Integrating stomach content analysis, metabarcoding, stable isotopes, fatty acids, and field observations will improve estimates of trophic roles and support ecosystem-based fisheries management, habitat conservation, and biologically informed aquaculture.

INTRODUCTION

Spiny lobsters are ecologically important benthic consumers and valuable fishery resources in tropical and subtropical coastal ecosystems. Species of the genus *Panulirus* occupy coral reefs, rocky bottoms, seagrass-associated habitats, and other structurally complex environments where feeding, shelter, movement, and predation risk are closely linked; consequently, fishing pressure and habitat degradation can alter both lobster

populations and their ecological functions (Briones-Fourzán, 2025; Butler *et al.*, 2024; Divu *et al.*, 2023; Divu *et al.*, 2024). Evidence from *Panulirus argus* shows a broad diet that includes molluscs, crustaceans, echinoderms, polychaetes, sponges, hydrozoans, fish remains, and plant material, although selectivity analyses indicate preferential consumption of particular gastropods, bivalves, and stomatopods (Martínez-Coello *et al.*, 2022a; Martínez-Coello *et al.*, 2022b). Mixed diets have also been reported for *Palinurus mauritanicus* and *Sagmariasus verreauxi* (Baaloudj & Kerfouf, 2023; Day *et al.*, 2021), while trophic tracers show overlapping use of crustaceans, echinoids, algae, and molluscs by *P. longipes*, *P. penicillatus*, and *P. versicolor* (Sardenne *et al.*, 2021; Sabino *et al.*, 2021). *Panulirus* lobsters should therefore be regarded as trophically flexible consumers whose realized diets reflect prey availability, prey traits, habitat conditions, and selective feeding rather than indiscriminate generalism.

Feeding ecology changes markedly across the complex *Panulirus* life cycle. Pelagic phyllosomas depend on oceanic resources, the puerulus is a transitional stage with limited or absent external feeding, and post-settlement juveniles progressively exploit benthic prey; stable-isotope patterns in *P. argus* and changes in energy reserves during settlement support this ontogenetic transition (Sánchez *et al.*, 2021; Espinosa-Magaña *et al.*, 2022). Indonesian studies likewise found diverse plankton in wild *P. homarus* post-larvae and an increase from 10 detected dietary taxa at the puerulus stage to 34 at the juvenile stage in *P. ornatus*, with copepods and other plankton available in settlement habitats (Amin *et al.*, 2022a; Amin *et al.*, 2022b; Masithah *et al.*, 2023). This expanding trophic breadth is consistent with stage-specific changes in digestive enzymes around hatching, feeding, and moulting (Genodepa *et al.*, 2022a; Genodepa *et al.*, 2022b; Genodepa *et al.*, 2022c; Genodepa *et al.*, 2023), comparable evidence of developmental digestive constraints in other decapods (Goncalves *et al.*, 2022; Baudet *et al.*, 2024; Kalacheva *et al.*, 2024), and ontogenetic changes in mouthpart aperture, calcification, setation, and robustness (Kropielnicka-Kruk *et al.*, 2025). Behaviour also filters available prey, rock lobsters use chemoreception and may prefer soft sediment bivalves over some reef prey and sea urchins (Flood *et al.*, 2025); *P. ornatus* responds to conspecific moulting cues through antennular chemoreception (Kelly *et al.*, 2022; Kelly *et al.*, 2023b); and feeding responses vary with time of day, attractants, particle properties, and visual context (Kropielnicka-Kruk *et al.*, 2022; Peters *et al.*, 2024; Ihsan *et al.*, 2025; Teoh *et al.*, 2023). Evidence from other crustaceans further emphasizes chemosensory, mechanosensory, and learned components of prey choice (Chen *et al.*, 2023; Cole *et al.*, 2023; Hovland *et al.*, 2023; Alexander *et al.*, 2022).

Environmental change can modify both trophic breadth and realized selectivity. Coral bleaching and reef degradation have been associated with increased trophic overlap among sympatric *Panulirus* species, suggesting compressed resource partitioning as habitat and prey structure deteriorate (Sabino *et al.*, 2021; Sardenne *et al.*, 2021). Climate driven redistribution may also create novel competitors and prey, as shown by food competition between resident *Jasus edwardsii* and range shifting *S. verreauxi* and by experience dependent responses to range extending or introduced prey (Twinaime *et al.*, 2022; Smith *et al.*, 2022; Van Volkom *et al.*, 2025; Alexander *et al.*, 2022). Temperature, salinity, and acidification can further alter metabolism, activity, appetite, and starvation risk (Uy *et al.*, 2023; Spencer *et al.*, 2023; Spencer *et al.*, 2025; Niemisto *et al.*, 2025; Noisette *et al.*, 2021; Raveendran *et al.*, 2026). Interpretation is also method-dependent: stomach contents identify recent ingestion, whereas stable isotopes and fatty acids integrate assimilated resources over longer periods but require appropriate calibration (Day *et al.*, 2023; Smith *et al.*, 2023b; Wirtz *et al.*, 2022a; Sardenne *et al.*, 2021). eDNA metabarcoding can reveal cryptic prey without directly

quantifying biomass or energetic contribution (Amin *et al.*, 2022b), and multi-method studies demonstrate the complementary value of stomach contents, faecal DNA, isotopes, and field observations (Smith *et al.*, 2023a; Day *et al.*, 2024a). Dietary pathways also mediate exposure to microplastics (Morris *et al.*, 2026; Cau *et al.*, 2023) and paralytic shellfish toxins (Turnbull *et al.*, 2021a; Turnbull *et al.*, 2021b; Turnbull *et al.*, 2021c), extending the relevance of feeding ecology to environmental health.

Despite this expanding evidence base, no synthesis has integrated natural prey identity, ontogenetic dietary change, prey selectivity, trophic interactions, ecological drivers, and methodological differences across *Panulirus*. This systematic review therefore addresses five linked questions: which prey groups dominate natural diets; whether species function as generalists or selective consumers; how feeding changes across pelagic, settlement, juvenile, and adult stages; which habitat and environmental factors modify trophic strategies; and how analytical methods influence inferred diets. The primary focus is wild and naturally occurring *Panulirus* populations, while studies of related palinurids and decapods are used only to clarify mechanisms where direct evidence is limited. By linking life stage, habitat, resource availability, sensory and physiological capacity, realized diet, and ecosystem effects, the review aims to support ecosystem-based fisheries management, habitat conservation, and biologically informed aquaculture. This connection is justified because feed studies show that protein level, lipid source, texture, meal timing, and nutrient assimilation constrain lobster performance (Rodríguez-Viera *et al.*, 2022; Hammel *et al.*, 2024; Wang *et al.*, 2021a; Saputra & Fotedar, 2024a; Landman *et al.*, 2021a; Landman *et al.*, 2024), although captive nutrition trials should not be treated as direct evidence of wild diet composition.

METHODS

Place and Time

This systematic literature review was conducted in May–June 2026 as a desk-based study by authors affiliated with the Aquaculture Study Program, Department of Fisheries and Marine Science, Faculty of Agriculture, University of Mataram, Mataram, Indonesia. Literature was searched online through Scopus and the Web of Science Core Collection. No field sampling was conducted for this review.

Search Strategy

This systematic qualitative review followed PRISMA 2020 transparency principles (Page, 2021). Literature published between 1990 and 2026 was searched primarily in Scopus, supported by the Web of Science Core Collection, while Google Scholar was used for supplementary identification and citation checking. Search terms covered four concepts: organism (*Panulirus*, “spiny lobster,” and “rock lobster”), dietary ecology (diet, feeding, food habit, prey, and trophic), dietary methods (stomach content, gut content, metabarcoding, stable isotope, and fatty acid), and natural settings (wild, natural habitat, marine ecosystem, reef, and benthic). ChatGPT assisted in identifying synonyms and structuring the initial Boolean search string. All AI generated suggestions were independently reviewed, modified, and tested by the authors, and ChatGPT was not used for screening, data extraction, or evidence interpretation. The core search expression was (“*Panulirus*” OR “spiny lobster” OR “rock lobster”) AND (diet OR feeding OR “feeding ecology” OR “food habit” OR “natural diet”), supplemented with methodological and habitat terms when necessary.

Broader common names were included because taxonomic terminology and database indexing vary. However, the primary synthesis remained focused on *Panulirus*, while studies

on related palinurids were included only when they clarified dietary methods, prey selection, or ecological mechanisms. Experimental nutrition, sensory, physiological, and aquaculture studies were treated as contextual evidence rather than proof of wild prey composition. The review accommodated methodological variation involving stomach content analysis, stable isotopes, fatty acids, molecular detection, behavioural assays, and non lethal tissue sampling (Martínez-Coello *et al.*, 2022b; Sardenne *et al.*, 2021; Amin *et al.*, 2022b; Day *et al.*, 2023).

Eligibility Criteria

Studies were eligible for the primary review when they: (1) investigated one or more *Panulirus* species; (2) examined natural diet, prey identity, trophic position, prey selection, or feeding ecology; (3) involved wild populations, field derived specimens, or observations interpretable in relation to natural habitats; (4) reported empirical dietary or trophic evidence; and (5) were published as peer reviewed scientific articles. Studies were excluded when they dealt solely with production performance, disease, reproduction, engineering, or formulated feed optimization without a defensible link to natural feeding ecology; lacked empirical dietary or trophic information; or were non peer reviewed. Experimental work on related lobsters and other decapods was retained as supporting literature for Sections 1, 3, and 5, but was not treated as part of the core diet evidence denominator.

Because methods capture different temporal and biological windows, eligibility did not privilege one dietary technique. Stomach and gut contents were accepted as evidence of recent ingestion; environmental DNA metabarcoding as evidence of taxonomic dietary signatures; stable carbon and nitrogen isotopes as evidence of assimilated resource pathways and trophic position; fatty acids as complementary trophic tracers; and direct behavioural observations as evidence of prey choice or handling. This method inclusive strategy reflects the fact that no single approach resolves every aspect of lobster feeding. For example, dietary indices can quantify occurrence, mass contribution, and selectivity (Martínez-Coello *et al.*, 2022a; Martínez-Coello *et al.*, 2022b), whereas isotope studies require attention to discrimination factors and tissue specific variation (Smith *et al.*, 2023b; Day *et al.*, 2023). Molecular and multi method approaches can recover prey signals that morphology alone may miss, but detection strength is not equivalent to energetic contribution (Amin *et al.*, 2022b; Smith *et al.*, 2023a).

Screening, Selection, and Risk-of-Bias Analysis

Screening followed the staged sequence represented in Figure 1: identification, duplicate handling, title/abstract screening, full text eligibility assessment, and final inclusion. The supplied review log reports 1,228 records identified from the two principal databases, comprising 781 Web of Science and 447 Scopus records, and a final set of 25 studies retained for qualitative synthesis. Intermediate screening categories including removal of older records, duplicate records, and out of scope reports were reproduced from the supplied PRISMA record rather than recalculated during manuscript drafting. Accordingly, the flow diagram should be treated as the authoritative screening log for this draft and should be cross checked against the original database exports before journal submission if any counts are subsequently updated.

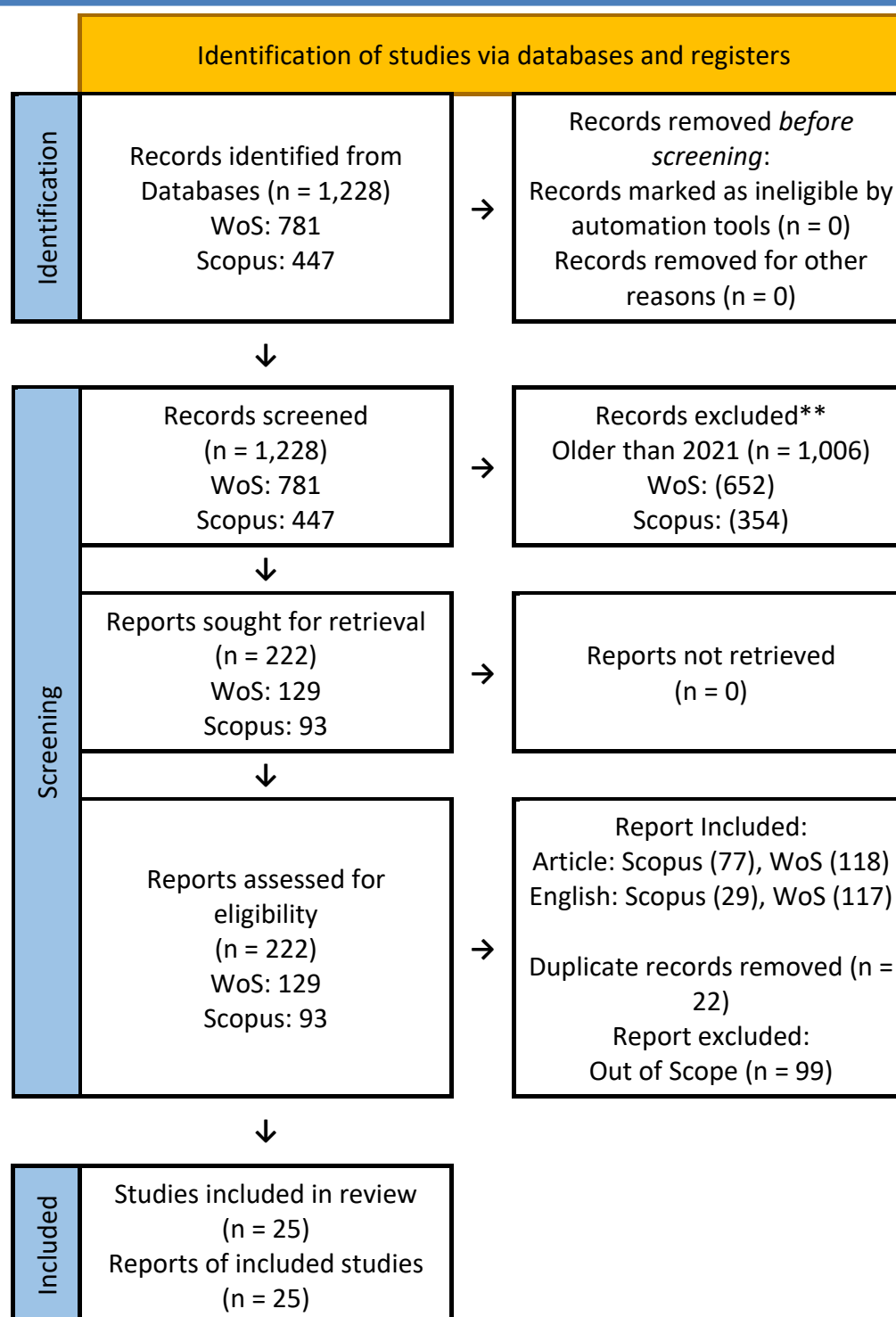


Figure 1. PRISMA Flow Diagram for Study Identification, Screening, Eligibility, and Inclusion

Data extraction was organized around four analytic themes derived from the review questions: natural prey composition; ontogenetic dietary shifts; trophic interactions and prey selectivity; and ecological drivers of feeding. For each study, the extraction framework captured species, location or habitat, life stage, dietary method, major food resources, and the principal ecological inference. Thematic synthesis was selected instead of meta-analysis because the evidence combined frequencies of occurrence, relative sequence or eDNA abundance, isotope values, fatty acid niches, behavioural outcomes, and qualitative prey

records, which are not directly poolable as a common effect size. This heterogeneity is itself informative because it identifies where apparent differences among diets may reflect method specific resolution rather than biological contradiction (Wirtz *et al.*, 2022a; Smith *et al.*, 2023b; Sardenne *et al.*, 2021).

Risk of bias was evaluated qualitatively across five domains specified in the review framework: sampling representativeness, dietary identification method, sample size, geographic coverage, and analytical transparency. Greater confidence was assigned to studies that sampled multiple sites or seasons, used explicit quantitative diet metrics, validated trophic tracers, or triangulated independent methods. Particular caution was applied to small samples, single site experiments, laboratory preference trials extrapolated to field diets, and methods vulnerable to differential digestion or uncertain trophic discrimination. No study was excluded solely because of a single methodological limitation; instead, limitations were carried into the interpretation of each theme. This approach preserves ecologically valuable evidence while preventing laboratory feeding performance, tracer calibration, or sensory response from being treated as equivalent to direct evidence of what wild *Panulirus* populations consume.

Theoretical Background

Ecological Theory of Predator Feeding Strategies

Predator feeding theory provides a useful starting point for interpreting *Panulirus* diets because a broad trophic niche can coexist with strong local prey preferences. A generalist predator is capable of exploiting multiple resource classes, whereas realized feeding at a given site can still be selective if prey differ in encounter probability, handling cost, nutritional quality, defence, or sensory detectability. Cuban *P. argus* illustrates this distinction: stomach contents span many trophic categories, yet selectivity indices identify particular gastropods, bivalves, and stomatopods as positively selected (Martínez-Coello *et al.*, 2022a; Martínez-Coello *et al.*, 2022b). Similarly, experimental rock lobster studies show that native molluscan prey may be preferred over range extending urchins and that preference can change with experience or local prey history (Smith *et al.*, 2022; Alexander *et al.*, 2022). These findings are consistent with an optimal foraging interpretation in which lobsters maximize net returns subject to prey availability, handling constraints, predation risk, and information.

Sensory ecology specifies how those trade offs are translated into behaviour. Lobsters forage in structurally complex and often low light environments, making chemical information particularly important. Large *Jasus edwardsii* males preferentially selected soft sediment bivalves in choice tests, and sensory ablation identified chemoreception as a major mechanism of prey detection (Flood *et al.*, 2025). In *P. ornatus*, antennular chemosensory structures mediate responses to moulting conspecifics, and flume studies show that chemical cues alter orientation, speed, and space use (Kelly *et al.*, 2022; Kelly *et al.*, 2023b). Broader crustacean experiments similarly show specialized roles of antennules, walking leg setae, mouthpart setae, and mechanoreceptors during food detection and manipulation (Chen *et al.*, 2023; Hovland *et al.*, 2023). Feed attraction experiments further demonstrate that amino acids, oils, pellet properties, and repeated cue delivery can alter searching and feeding responses (Cole *et al.*, 2023; Teoh *et al.*, 2023; Ihsan *et al.*, 2025; Kropielnicka-Kruk *et al.*, 2022). Thus, prey selection emerges from an information processing system, not simply from relative prey abundance.

Life History Development and Ontogenetic Dietary Shifts

Ontogenetic niche theory predicts that trophic roles change when morphology, physiology, movement, and habitat change through development. In *Panulirus*, the contrast

between pelagic phyllosoma, transitional puerulus, benthic juvenile, and adult stages is especially pronounced. Isotopic evidence from *P. argus* phyllosomas indicates pelagic carbon sources and an ontogenetic change in nitrogen enrichment during early larval development (Sánchez *et al.*, 2021). The non feeding or weakly feeding puerulus then depends heavily on stored reserves during onshore migration and settlement; in *P. argus*, lipid and protein reserves decline through the transparent puerulus, pigmented puerulus, and first juvenile transition (Espinosa-Magaña *et al.*, 2022). Once active feeding resumes, local plankton and benthic prey fields become increasingly important (Amin *et al.*, 2022a; Amin *et al.*, 2022b; Masithah *et al.*, 2023).

Physiological capacity changes in parallel. Newly hatched *P. ornatus* shows stage and food dependent changes in amylase, esterase, and trypsin like protease activity, while digestive responses can adjust within hours to prey appearance or deprivation (Genodepa *et al.*, 2022a; Genodepa *et al.*, 2022b; Genodepa *et al.*, 2022c). Molt cycles add further temporal structure to digestion and food demand (Genodepa *et al.*, 2023). Comparable ontogenetic shifts in digestive enzymes, lipid requirements, and performance have been observed in European lobster larvae and other decapods (Goncalves *et al.*, 2022; Lund, 2025; Baudet *et al.*, 2024; Kalacheva *et al.*, 2024). Mouthpart development in *P. ornatus* and *S. verreauxi* indicates increasing calcification and changing setation and aperture through ontogeny, which likely modifies prey handling and particle size constraints (Kropielnicka-Kruk *et al.*, 2025). The theoretical implication is that dietary shifts are driven by a moving intersection between available prey and the prey that a given life stage can detect, capture, process, and assimilate.

Experimental nutrition provides mechanistic context for this intersection, although it should not be mistaken for direct evidence of wild diet. Protein level, protein source, lipid source, cholesterol, phospholipids, carbohydrate to lipid ratio, and feed physical form alter growth, intake, digestion, and postprandial metabolism in lobsters (Wang *et al.*, 2021a; Wang *et al.*, 2021b; Saputra & Fotedar, 2024a; Rodríguez-Viera *et al.*, 2022; Landman *et al.*, 2024; Landman *et al.*, 2021b; Williamson *et al.*, 2024; Williamson *et al.*, 2026; Yeap *et al.*, 2026; Hammel *et al.*, 2024). Fresh mussel can outperform some formulated diets in juvenile slipper lobster, and protein assimilation can be tracked using stable isotopes and gastrointestinal evacuation measures (Landman *et al.*, 2021a; Wirtz *et al.*, 2022b; Wirtz *et al.*, 2022a). These findings help explain why natural prey quality, not only prey abundance, may shape prey profitability and trophic choice.

A final ontogenetic complication is that feeding opportunity changes around moulting. Juvenile *P. ornatus* is vulnerable to cannibalism during ecdysis, and population level observations have linked cannibalistic events to moult stage, biomass, and elevated activity before attacks (Kelly *et al.*, 2023a; Trotter *et al.*, 2026). Technologies developed to detect approaching ecdysis emphasize how large the physiological transition is beneath the exoskeleton (Sutherland *et al.*, 2023; Sutherland *et al.*, 2024). Although these studies arise from culture systems, they reinforce a broader ecological point: feeding motivation, prey vulnerability, and risk are temporally structured across the moult cycle. Natural diet observations collected at one time point may therefore integrate individuals with different energetic states and foraging propensities, contributing to within population variation that is often attributed only to habitat or prey supply.

Habitat-Driven Trophic Interactions and Environmental Influence

Habitat driven trophic theory predicts that consumer niches expand, contract, or overlap as resource landscapes change. In Seychelles, *P. penicillatus*, *P. longipes*, and *P. versicolor* showed substantial dietary overlap, with fatty acid niche overlap reported as high as 71.2–

99.5% for some comparisons, and overlap increased under reef degradation (Sabino *et al.*, 2021). Bayesian trophic tracer estimates from the same regional system indicate crustaceans as major dietary contributors, with echinoids, algae, and molluscs also important (Sardenne *et al.*, 2021). In the Caribbean, habitat condition is similarly relevant because *P. argus* and *P. guttatus* use different habitat mosaics through their benthic lives, exposing them to different combinations of shelter and prey (Briones-Fourzán, 2025). Mangrove and nursery food webs can also influence early life resource fields through local primary production, detrital pathways, and zooplankton structure (Pontón-Cevallos *et al.*, 2025).

Environmental change can reshape trophic interactions through both resource supply and consumer physiology. Warming alters species ranges and competitive encounters, as shown when resident *Jasus edwardsii* dominated food competition with range shifting *S. verreauxi* across experimental temperatures (Twine *et al.*, 2022). Temperature, salinity, and acidification also modify metabolic demand, feeding response, or starvation vulnerability in lobsters (Uy *et al.*, 2023; Spencer *et al.*, 2025; Raveendran *et al.*, 2026; Niemisto *et al.*, 2025; Noisette *et al.*, 2021). At the prey level, chemical cues from lobsters can reduce urchin grazing even without consumption, demonstrating that lobster ecological effects include non consumptive pathways (Curtis & Wing, 2024; Knight *et al.*, 2022). Trophic consequences are therefore generated by both who is eaten and how prey alter behaviour in response to predator presence.

Human pressures add another layer. Benthic omnivory and scavenging can expose lobsters to microplastics, with species specific burdens observed among sympatric *Panulirus* and related palinurids (Morris *et al.*, 2026; Cau *et al.*, 2023). Other environmental and management studies show that culture density, alkalinity, water quality, disease, and confinement can alter stress or feeding opportunity (Minjoyo *et al.*, 2024; Supriyono *et al.*, 2022; Supriyono *et al.*, 2023; Jiang *et al.*, 2026; Butler *et al.*, 2024). These are not direct natural diet observations, but they illustrate a general mechanism: feeding ecology is constrained by the physical and biological environment in which foraging occurs. Accordingly, trophic plasticity should be interpreted as conditional resilience an ability to switch among resources when alternatives exist not as evidence that habitat degradation or prey loss is ecologically inconsequential.

RESULTS

Diversity and Composition of Natural Prey Consumed by *Panulirus* Lobsters

The most consistent pattern across direct diet studies was taxonomic breadth rather than dependence on a single prey class. Wild *P. homarus* post larvae collected from three Indonesian fishing grounds contained diverse plankton. At Prigi Bay, *Tintinnopsis* sp. (37.5%), *Grammatophora* sp. (25.0%), and *Synedra* sp. (18.8%) were prominent; *Ochromonas* sp. (32.3%) and *Synedra* sp. (20.6%) were important at Tawang Bay; and *Synedra* sp. and *Chlorococcum* sp. each accounted for approximately one third of identified items at Gerupuk Bay (Amin *et al.*, 2022a). This early-stage pattern contrasts with the much broader benthic resource spectrum documented in adults. In Cuban *P. argus*, stomach analyses recorded opercula, crustacean remains, shell material, plant matter, and numerous identified molluscs, while a complementary trophic spectrum study identified gastropods, bivalves, polyplacophorans, echinoids, stomatopods, brachyurans, anomurans, polychaetes, ophiuroids, sponges, foraminiferans, hydrozoans, fish, and plant material (Martínez-Coello *et al.*, 2022a; Martínez-Coello *et al.*, 2022b).

Molecular evidence indicates that dietary breadth can increase rapidly through early benthic development. eDNA metabarcoding of wild *P. ornatus* detected 10 dietary taxa at puerulus, 17 at post puerulus, and 34 at juvenile stages; *Oithona* taxa were repeatedly prominent, and the juvenile samples contained a markedly larger taxonomic set (Amin *et al.*, 2022b). This pattern supports a transition from relatively constrained early resource use toward broader opportunistic feeding as mobility and prey handling capacity increase. Adult palinurid comparisons reinforce the generalist interpretation but also reveal geographic and species level variation. *Palinurus mauritanicus* from Algeria had fish (46.42%), crustaceans (34.28%), polychaetes (23.33%), and molluscs (18.57%) as major diet components, with sex and season affecting prey occurrence (Baaloudj & Kerfouf, 2023). In eastern rock lobster, detritus (51%), bivalves (34%), gastropods (28%), and algae (26%) occurred more frequently than urchins (19%), challenging an overly narrow characterization of large spiny lobsters as primarily urchin predators (Day *et al.*, 2021). Table 1 therefore shows that “generalist” is the most defensible genus level descriptor, but the actual composition of that generalism is life-stage and habitat dependent.

Table 1. Essential Summary of Natural Diet Composition and Prey Diversity Among *Panulirus* Lobsters

Reference	Species	Location	Life Stage	Dietary Method	Major Prey Categories Identified	Main Dietary Findings
Amin et al., 2022a	<i>Panulirus homarus</i>	Indonesia	Post-larvae	Stomach content analysis	Plankton (diatoms, ciliates, dinoflagellates)	Wild scalloped spiny lobster post larvae consumed diverse plankton communities. <i>Synedra</i> sp. and <i>Rhizosolenia</i> sp. were common prey across sampling locations. Early stages showed increasing dietary diversity with development. Juveniles consumed a wider range of prey species compared with puerulus stages.
Amin et al., 2022b	<i>Panulirus ornatus</i>	Indonesia	Puerulus, post- puerulus, juvenile	eDNA metabarcoding	Copepods, plankton, crustaceans	

Reference	Species	Location	Life Stage	Dietary Method	Major Prey Categories Identified	Main Dietary Findings
Martínez-Coello et al., 2022a	<i>Panulirus argus</i>	Cuba	Adult	Stomach content analysis	Gastropods, bivalves, crustaceans, echinoderms, algae	Diet consisted of 13 trophic categories. Molluscs and crustaceans were dominant, indicating broad omnivorous feeding behaviour. Positive selection occurred for several
Martínez-Coello et al., 2022b	<i>Panulirus argus</i>	Cuba	Adult	Stomach content indices (FO, G, IIR, selectivity indices)	Gastropods, bivalves, stomatopods	gastropods, bivalves, and stomatopods, suggesting selective feeding within a generalist strategy. Demonstrated omnivorous opportunistic feeding, with fish and crustaceans as major dietary components. Lobsters acted as generalist predators; detritus and molluscs occurred more frequently than sea urchins.
Baaloudj & Kerfouf, 2023	<i>Palinurus mauritanicus</i> (related <i>Palinuridae</i>)	Algeria	Adult	Stomach content analysis	Fish, crustaceans, polychaetes, molluscs	
Day et al., 2021	<i>Sagmariasus verreauxi</i> (related spiny lobster)	Australia	Adult	Stomach analysis + feeding trials	Detritus, bivalves, gastropods, algae, echinoderms	

*Note. eDNA = environmental DNA; FO = frequency of occurrence; G = gravimetric contribution; IIR = index of relative importance.

The contrast among methods also explains part of the apparent variation in prey breadth. Morphological stomach analysis tends to privilege hard parts, whereas trophic

tracers can integrate assimilated material over longer periods and molecular assays can detect taxa that leave few recognizable remains. For example, Seychelles tracer work estimated crustaceans particularly anomuran hermit crabs as major contributors to the diets of three *Panulirus* species, alongside echinoids, algae, and molluscs (Sardenne *et al.*, 2021). Thus, Table 1 should be read as evidence of recurring prey guilds rather than a universal rank order. Molluscs and crustaceans are repeatedly important in benthic stages, but their relative prominence depends on consumer species, habitat, season, and analytical window.

Ontogenetic Changes in Feeding Strategies from Larvae to Adults

Ontogenetic evidence indicates a sequence from pelagic resource acquisition, through an energetically demanding settlement transition, toward diversified benthic feeding. In *P. argus* phyllosomas, $\delta^{13}\text{C}$ values of approximately 18‰ to –22‰ were consistent with pelagic food resources, while $\delta^{15}\text{N}$ increased by about 2.8‰ from stages I to IV before stabilizing across intermediate stages, indicating a developmental change in trophic position (Sánchez *et al.*, 2021). Settlement then imposes a temporary energetic bottleneck: transparent pueruli migrate shoreward without normal external feeding, become pigmented, and subsequently moult into the first juvenile stage in which feeding resumes. Measurements of *P. argus* showed declines in total lipid and protein reserves through this transition, although settlers retained comparatively high nutritional condition (Espinosa-Magaña *et al.*, 2022).

The Indonesian evidence provides a complementary resource-based view. Plankton surveys in Prigi and Tawang Bays documented 11–17 taxa depending on depth and location, with *Acartia*, *Calanus*, *Paracyclopina*, and *Oithona* among abundant potential food resources (Masithah *et al.*, 2023). Stomach contents of post-larval *P. homarus* confirm that such planktonic communities are actually ingested after settlement (Amin *et al.*, 2022a), while eDNA profiles of *P. ornatus* demonstrate a large expansion in detected diet diversity from puerulus to juvenile (Amin *et al.*, 2022b). Physiological evidence is consistent with this ecological transition: *P. ornatus* embryos and newly hatched phyllosomas show sequential shifts in digestive enzyme activities associated with lipid, protein, and carbohydrate use, and trypsin like protease peaks around first feeding (Genodepa *et al.*, 2022b). Table 2 therefore suggests that ontogeny changes both the resource field and the consumer’s capacity to exploit it. Rather than a simple switch from “plankton” to “benthos,” the transition is a coordinated reorganization of energy reserves, habitat, prey encounter, digestive machinery, and prey handling ability.

Table 2. Essential Summary of Ontogenetic Dietary Shifts in *Panulirus* Lobsters

Reference	Species	Development Stage	Habitat Phase	Dietary Method	Food Resources	Main Ontogenetic Pattern
Sánchez <i>et al.</i> , 2021	<i>Panulirus argus</i>	Phyllosoma larvae	Oceanic pelagic phase	Stable isotope analysis	Pelagic plankton resources	Larvae occupied pelagic trophic pathways and showed increasing $\delta^{15}\text{N}$ values during development, indicating trophic progression.

Reference	Species	Development Stage	Habitat Phase	Dietary Method	Food Resources	Main Ontogenetic Pattern
Amin <i>et al.</i> , 2022b	<i>Panulirus ornatus</i>	Puerulus → Post- puerulus → Juvenile	Settlement transition	eDNA metabarcoding	Plankton, copepods, small crustaceans	Dietary diversity increased strongly with development, from limited plankton dependence to broader prey utilisation. Post-larvae depended on planktonic food resources immediately after settlement. Physiological evidence indicated changing nutritional requirements during early development. Settlement habitats provide potential live food resources supporting early lobster recruitment. Transition from non-feeding puerulus to feeding juvenile represents a major nutritional shift.
Amin <i>et al.</i> , 2022a	<i>Panulirus homarus</i>	Post-larvae	Settlement habitat	Stomach content analysis	Microplankton	
Genodepa <i>et al.</i> , 2022b	<i>Panulirus ornatus</i>	Embryo → Phyllosoma larvae	Pelagic larval phase	Digestive enzyme analysis	Protein-, lipid-, carbohydrate-based resources	
Masithah <i>et al.</i> , 2023	<i>Panulirus spp.</i>	Larval settlement stages	Coastal nursery habitat	Plankton community analysis	Copepods and plankton	
Espinosa-Magaña <i>et al.</i> , 2022	<i>Panulirus argus</i>	Puerulus → Juvenile	Coastal settlement	Nutritional condition analysis	Endogenous energy reserves before feeding	

The ontogenetic evidence also cautions against interpreting early-life diet from laboratory nutritional requirements alone. Culture studies show that food density, lipid supply, protein to energy balance, and meal properties can strongly influence larval or juvenile performance (Lund, 2025; Saputra & Fotedar, 2024a; Hammel *et al.*, 2024), but these variables indicate physiological demand rather than the realized taxonomic diet in nature. The strongest

inference therefore comes from convergence: field stomach contents and molecular detections identify consumed taxa, isotope data locate trophic pathways, and physiological studies explain why certain resources may become profitable at particular stages.

Trophic Interactions, Prey Selectivity, and Ecological Roles

The reviewed evidence also shows that broad diet does not eliminate prey selectivity or ecological effects. In southern Cuba, *P. argus* exerted measurable predation pressure on gastropod communities. Estimated consumption was 0.92 gastropods lobster⁻¹ in Santa Cruz del Sur and 3.31 gastropods lobster⁻¹ in the Gulf of Batabanó, corresponding to estimated removal of 0.087% and 0.887% of local gastropod communities, respectively (Martínez-Coello *et al.*, 2022a). Selectivity indices from other Cuban sampling showed positive selection for several gastropods, bivalves, and stomatopods despite differences in benthic community composition, and diet overlap between sexes remained high (Martínez-Coello *et al.*, 2022b). These results imply that *P. argus* can remain broadly omnivorous while repeatedly targeting profitable prey.

Trophic interactions can become more complex when multiple lobster species share resources or when management assumes a particular prey is strongly controlled by lobster predation. In Seychelles, fatty acid and stable isotope analyses identified high niche overlap among *P. penicillatus*, *P. longipes*, and *P. versicolor*, with some overlap estimates reaching 71.2–99.5%, indicating substantial potential for resource competition (Sabino *et al.*, 2021). Behavioural work on *J. edwardsii* showed a marked preference for soft sediment bivalves and comparatively low preference for urchins, with chemoreception central to locating buried prey (Flood *et al.*, 2025). For *S. verreauxi*, recent field and experimental work similarly questions the assumption that large lobsters are uniformly strong controllers of barrens forming urchins: predation rates can be low and the relationship with predator and prey size is not always the expected one (Day *et al.*, 2024c; Day *et al.*, 2024a). Importantly, ecological effects need not require consumption. Chemical cues from rock lobsters reduced per-capita kelp consumption by New Zealand urchins by about 30%, demonstrating a non consumptive pathway through which lobsters can influence grazing (Curtis & Wing, 2024). Table 3 therefore positions lobsters as trophically influential consumers whose effects depend on prey identity, behaviour, habitat, and the distinction between consumptive and risk-mediated interactions.

Table 3. Summary of Trophic Interactions and Ecological Functions of *Panulirus* and Related Spiny Lobsters

Reference	Species	Prey/Interaction	Ecological Context	Analytical Approach	Main Findings
Martínez-Coello <i>et al.</i> , 2022a	<i>Panulirus argus</i>	Gastropods and benthic molluscs	Caribbean benthic ecosystems	Predation pressure analysis	Lobsters exert measurable predation pressure on gastropod communities.
Martínez-Coello <i>et al.</i> , 2022b	<i>Panulirus argus</i>	Molluscs, crustaceans, echinoderms	Different benthic habitats	Diet similarity and selectivity indices	Diet overlap between sexes remained high despite habitat differences.

Reference	Species	Prey/Interaction	Ecological Context	Analytical Approach	Main Findings
Sabino <i>et al.</i> , 2021	<i>Panulirus penicillatus</i> , <i>P. longipes</i> , <i>P. versicolor</i>	Shared resources	prey Coral reef degradation	Fatty acids + stable isotopes	Species showed high dietary overlap, indicating potential interspecific competition under habitat degradation.
Flood <i>et al.</i> , 2025	<i>Jasus edwardsii</i> (related rock lobster)	Bivalves, reef prey, urchins	Rocky reef ecosystems	Behavioural feeding experiments	Chemoreception influenced prey detection and selection.
Day <i>et al.</i> , 2024c	<i>Sagmariasus verreauxi</i>	Sea urchins	Temperate reef ecosystems	Feeding trials and field observation	Lobster predation on urchins was lower than traditionally assumed.
Curtis & Wing, 2024	<i>Jasus edwardsii</i>	Sea urchin indirect effects	Kelp ecosystem	Predator cue experiments	Lobster presence reduced urchin grazing behaviour, demonstrating non consumptive ecological effects.

The emerging picture is especially relevant to claims of top-down control. Sea urchins are consumed by several large lobster taxa, but preference experiments, field tethering, and multi method diet studies demonstrate that predation intensity is context dependent (Smith *et al.*, 2022; Smith *et al.*, 2023a). Management strategies that rebuild lobster biomass to suppress urchin barrens may therefore work differently among regions, prey size structures, and predator species. Trophic function cannot be inferred from predator abundance alone, it requires evidence that target prey are encountered, selected, successfully handled, and consumed at ecologically meaningful rates.

Ecological Drivers Shaping *Panulirus* Feeding Ecology

Habitat condition emerged as a major modifier of feeding ecology. In Seychelles, trophic overlap among three *Panulirus* species was greater in some degraded or post bleaching reef contexts, suggesting that resource compression can intensify potential competition (Sabino *et al.*, 2021). The Caribbean literature likewise emphasizes that *P. argus* and *P. guttatus* depend on habitat mosaics that change across benthic life stages, degradation of seagrass, shallow hard bottom, and coral reef habitats can alter both shelter and the prey communities

encountered during foraging (Briones-Fourzán, 2025). Yet *P. argus* also demonstrates dietary flexibility: Cuban populations maintained moderate to high similarity in diet across subzones whose benthic community composition differed, indicating that opportunistic prey switching can partly buffer spatial variation (Martínez-Coello *et al.*, 2022b).

Environmental drivers act from the pelagic phase onward. Isotopic variation in *P. argus* phyllosomas links early trophic pathways to oceanic food resources and developmental timing (Sánchez *et al.*, 2021); settlement habitats then determine which plankton and benthic resources are locally available (Masithah *et al.*, 2023). Anthropogenic stress can also enter through the diet. A multi species assessment of tropical *Panulirus* reported microplastics in gastrointestinal tissues at approximately 0.18–1.05 particles g⁻¹, with *P. versicolor* showing the highest density among the sampled species (Morris *et al.*, 2026). In *Palinurus elephas*, microplastics occurred in all examined individuals, with a mean burden of 9.1 ± 1.75 particles individual⁻¹ compared with 3.2 ± 0.45 in the co-sampled *Nephrops norvegicus*; the authors linked exposure partly to scavenging-based feeding (Cau *et al.*, 2023). Table 4 therefore extends “ecological drivers” beyond prey supply alone: habitat degradation, geographic prey fields, oceanographic conditions, climate-related stress, and pollution can all alter either the foods available to lobsters or the consequences of consuming them.

Table 4. Environmental Drivers Influencing Diet Composition and Feeding Behaviour

Reference	Species	Environmental Driver	Habitat Condition	Dietary Response	Ecological Implication
Sabino <i>et al.</i> , 2021	<i>Panulirus penicillatus</i> , <i>P. longipes</i> , <i>P. versicolor</i>	Coral reef degradation	Healthy vs degraded reefs	Increased dietary overlap among species	Habitat degradation may increase competition through resource limitation.
Briones-Fourzán, 2025	<i>Panulirus argus</i> , <i>P. guttatus</i>	Habitat alteration and climate change	Caribbean reef and coastal habitats	Feeding availability influenced by habitat quality	Shelter availability and habitat structure strongly influence lobster populations.
Martínez-Coello <i>et al.</i> , 2022b	<i>Panulirus argus</i>	Geographic variation in benthic communities	Different fishing zones	Similar diet despite differences in prey community	Indicates dietary flexibility and opportunistic feeding.
Sánchez <i>et al.</i> , 2021	<i>Panulirus argus</i>	Oceanographic conditions	Pelagic larval environment	Changes in trophic position during larval development	Ocean conditions influence larval nutritional pathways.

Reference	Species	Environmental Driver	Habitat Condition	Dietary Response	Ecological Implication
Morris <i>et al.</i> , 2026	<i>Panulirus spp.</i>	Human-derived pollution exposure	Tropical marine habitats	Feeding ecology influences microplastic exposure	Omnivorous benthic feeding increases exposure pathways to contaminants.
Cau <i>et al.</i> , 2023	<i>Palinurus elephas (related Palinuridae)</i>	Marine plastic contamination	Deep benthic habitats	Scavenging feeding increased microplastic ingestion	Feeding strategy influences contaminant accumulation risk.

Finally, ecological drivers can interact rather than operate independently. Warming may reorganize prey distributions and competitor ranges while simultaneously changing lobster metabolism, salinity anomalies can suppress feeding responses, and reef degradation can reduce resource partitioning among co-occurring species (Twinaime *et al.*, 2022; Uy *et al.*, 2023; Raveendran *et al.*, 2026; Sabino *et al.*, 2021). Such interactions are likely to generate spatially heterogeneous diets even within a single species. This helps explain why geographically separated studies should not be pooled as though they sampled a fixed trophic phenotype and why future monitoring should pair diet data with standardized habitat and environmental measurements.

DISCUSSION

The synthesis supports a qualified generalist model of *Panulirus* feeding ecology. Across life stages and regions, recurring food groups include planktonic organisms, molluscs, crustaceans, echinoderms, algae, detrital material, polychaetes, and occasional vertebrate remains, but the proportional contribution of those groups is not constant. Adult *P. argus* can maintain a broad trophic spectrum while selecting particular molluscs and stomatopods (Martínez-Coello *et al.*, 2022a; Martínez-Coello *et al.*, 2022b); Seychelles species show extensive overlap yet retain species-level differences in niche width and prey contribution (Sardenne *et al.*, 2021; Sabino *et al.*, 2021). The theoretical implication is that dietary plasticity should be defined as the capacity to reweight a broad prey repertoire, not as the absence of preference. This distinction reconciles seemingly conflicting evidence in which stomachs contain many taxa but behavioural trials reveal strong choices among simultaneously available prey (Flood *et al.*, 2025; Smith *et al.*, 2022).

Ontogeny provides the clearest organizing principle for this plasticity. Early pelagic and settlement stages face food fields fundamentally different from those of benthic adults, while digestive and mechanical capacities change rapidly. Field evidence of plankton consumption and eDNA detected prey diversification (Amin *et al.*, 2022a; Amin *et al.*, 2022b) converges with isotope evidence of changing larval trophic position (Sánchez *et al.*, 2021) and with physiological studies of digestive enzyme ontogeny (Genodepa *et al.*, 2022b; Goncalves *et al.*, 2022). Experimental lobster nutrition reinforces the principle that nutritional performance

depends on the interaction between developmental stage and diet composition: krill replacement, dietary carbohydrate and lipid balance, and formulated feed substitution can alter digestive activity or energy metabolism even when survival responses are modest (Goncalves *et al.*, 2021b; Goncalves *et al.*, 2021a; Goncalves *et al.*, 2024). These captive studies do not identify wild prey, but they make the observed stage specific field diets physiologically plausible.

Foraging behaviour supplies a second mechanism connecting potential and realized diet. Lobsters do not sample the benthos uniformly, they move through habitat, respond to chemical information, manipulate food with stage dependent mouthparts, and alter activity over diel and moult cycles. Telemetry and movement studies of spiny lobsters show strong spatiotemporal structure in habitat use, while movement models for juvenile *P. cygnus* frame foraging paths as energetic decisions (Sasaki *et al.*, 2025; Pardo-Igúzquiza & Dowd, 2026). Laboratory work on mantis shrimp and other crustaceans similarly shows that prey attractiveness, shelter use, and sensory pathways can reshape feeding choices (Lee *et al.*, 2022; Chen *et al.*, 2023). In lobster culture, pellet dimensions, texture, amino acid supplementation, and feed frequency influence attraction, handling, waste, and intake (Kropielnicka-Kruk *et al.*, 2023; Teoh *et al.*, 2025; Kropielnicka-Kruk *et al.*, 2022). The ecological inference is that local prey abundance must be paired with measures of accessibility and behavioural profitability before it can be interpreted as dietary availability.

The evidence also refines the ecological role of lobsters as benthic predators. Sea urchins provide an instructive case, they are present in lobster diets and may mediate important top down effects, yet several recent studies find that predation rates are lower or more context dependent than simplified “lobster controls urchin” models imply (Day *et al.*, 2021; Day *et al.*, 2024c; Day *et al.*, 2024a; Smith *et al.*, 2023a). The prey themselves also display trophic flexibility, long spined urchins in barrens and macroalgal habitats can maintain diverse diets and comparable gut fullness, which may reduce their dependence on standing macroalgal biomass (Day *et al.*, 2024b). Consequently, trophic cascades involving lobsters, urchins, and kelp should be treated as interaction networks in which predator choice, prey condition, competitor abundance, and non consumptive risk effects all matter (Curtis & Wing, 2024; Knight *et al.*, 2022).

Habitat degradation and climate change may intensify these contingencies. Reef degradation can increase dietary overlap among sympatric *Panulirus*, while warming can introduce novel competitors and prey and simultaneously change metabolic demand (Sabino *et al.*, 2021; Twiname *et al.*, 2022; Briones-Fourzán, 2025). Studies of temperature, salinity, and acidification demonstrate that environmental stress can influence lobster physiology, starvation risk, or feeding response (Uy *et al.*, 2023; Niemisto *et al.*, 2025; Raveendran *et al.*, 2026). Related decapod studies show that starvation and refeeding can modify growth and moulting, and that early food limitation can carry effects into later stages (Saathoff *et al.*, 2025; Baudet *et al.*, 2024; Supono *et al.*, 2022). Dietary plasticity may therefore buffer short term resource variability, but it cannot be assumed to compensate indefinitely for habitat loss, altered prey quality, or increasing energetic costs.

Methodological triangulation is essential for resolving these context effects. Stomach contents provide high taxonomic specificity for recent meals but are biased toward identifiable hard remains. Stable isotopes integrate assimilation but depend on discrimination factors and tissue turnover, fatty acids offer source signatures but can overlap among prey, molecular assays increase taxonomic sensitivity but do not directly measure assimilated biomass. Non lethal tissue sampling and calibrated discrimination studies show that isotope

inference can be strengthened when tissue effects are quantified (Day *et al.*, 2023; Smith *et al.*, 2023b). Stable isotopes can also evaluate assimilation of known protein sources in experimental settings, supporting method validation (Wirtz *et al.*, 2022a). Future field studies should combine at least two temporally complementary methods and report prey availability, consumer size, sex, moult stage, season, and habitat. Without those covariates, methodological and ecological variation remain confounded.

The natural diet synthesis also has a translational implication for aquaculture, provided the distinction between ecological evidence and feed trials is maintained. Cultured *Panulirus* and related lobsters often perform better when diets and feeding systems match their digestive physiology and feeding behaviour. Studies report effects of fresh versus formulated food, protein level, black soldier fly substitution, fish protein hydrolysate supplementation, feed texture, and natural food components on intake or growth (Giri *et al.*, 2023; Klahan *et al.*, 2025; Saputra & Fotedar, 2024b; Saputra *et al.*, 2024c; Lubis & Puari, 2023). Bioenergetic approaches further quantify how protein and energy are allocated during growth and postprandial metabolism (Williamson *et al.*, 2023; Yung *et al.*, 2026). Integrated systems research, including nitrogen excretion and macroalgal uptake, shows that feeding decisions also determine waste fluxes in production systems (Edwards *et al.*, 2024). Natural prey data can guide ingredient selection and feeding presentation, but aquaculture performance should not be used retrospectively to infer what wild lobsters normally eat.

Broader crustacean nutrition studies reinforce this caution. Dietary lipid level, probiotics, microbial biomass, and carbohydrate to lipid ratios can alter performance or physiological state under controlled conditions (Chuphal *et al.*, 2021; Nedaei *et al.*, 2023; Simon *et al.*, 2024; Cole *et al.*, 2025). Larval sea urchin feeding experiments likewise demonstrate that food quantity and quality can strongly influence development (Chu *et al.*, 2024). These studies are useful mechanistically, but the wild *Panulirus* question remains ecological: which resources are encountered and selected under natural constraints? The systematic evidence indicates that resource identity, not merely macronutrient composition, is necessary to explain food web effects and habitat dependence. Comparative work on omnivorous shrimps further illustrates that realized trophic position can vary with resource structure even among broadly opportunistic decapods (Viozzi *et al.*, 2024). Likewise, biology informed welfare guidance for captive lobsters emphasizes that shelter, lighting, stocking conditions, and natural behavioural requirements interact with feeding opportunities (Fruscella *et al.*, 2025), reinforcing the need to interpret feeding responses within their environmental context.

Pollution adds urgency to this distinction because ingested material can be both food and an exposure vector. Microplastics occur in *Panulirus* gastrointestinal tracts and in related benthic crustaceans (Morris *et al.*, 2026; Cau *et al.*, 2023); experimental shrimp work shows that microplastic exposure can itself alter feeding behaviour, highlighting the potential for feedback between contamination and foraging (Shan *et al.*, 2025). At the same time, trophically acquired biotoxins can enter lobster tissues without necessarily producing severe acute health effects under all conditions, underscoring the importance of exposure pathway monitoring (Turnbull *et al.*, 2021a; Turnbull *et al.*, 2021b). Incorporating contaminants into trophic studies would therefore connect feeding ecology with seafood safety and ecosystem health.

Several limitations constrain inference. First, the primary evidence is geographically uneven, with strong representation from the Caribbean, Australia, Indonesia, and Seychelles but fewer comparable studies across other parts of the genus' range. Second, early life feeding

remains difficult to sample directly, and molecular detection, isotopes, and laboratory physiology do not measure identical dietary processes. Third, many studies are snapshots rather than multi season or multi year assessments, making it difficult to separate persistent preferences from transient prey pulses. Fourth, related species evidence was necessary to interpret sensory and physiological mechanisms, but those mechanisms should be tested directly in more *Panulirus* species. Finally, the supplied PRISMA screening log should be audited against the original exports before submission so that all intermediate counts reconcile exactly. Future studies should prioritize coordinated multi site sampling, paired prey field surveys, non lethal isotope sampling, metabarcoding with quantitative controls, behavioural observations, and explicit models linking environmental change to prey switching. Such integration would allow the field to move from cataloguing stomach items toward predicting when, where, and why lobster trophic roles change.

CONCLUSION

This systematic review shows that the natural feeding ecology of *Panulirus* is best characterized by trophic flexibility constrained by life stage, habitat, sensory capacity, and local prey fields. Across the available evidence, early stages are associated with pelagic and planktonic resources, whereas post settlement juveniles and adults progressively exploit a broader benthic spectrum that includes molluscs, crustaceans, echinoderms, polychaetes, algae, detrital material, and other resources. The recurrent importance of molluscs and crustaceans supports a generalist predator model, but quantitative selectivity and behavioural studies demonstrate that generalism does not imply indiscriminate consumption.

The review further indicates that ontogenetic transitions reorganize diet through simultaneous changes in habitat, energy reserves, digestive physiology, morphology, and prey handling ability. Habitat degradation, warming, altered prey distributions, and pollution can then modify realized trophic niches by changing resource availability, competition, metabolic demand, or exposure pathways. These effects help explain why the same species may display different diets across locations and why single method studies can produce incomplete interpretations.

The principal limitation of the evidence base is methodological and geographic heterogeneity. Future work should integrate stomach or gut contents with metabarcoding, stable isotopes or fatty acids, prey field surveys, and field behaviour across standardized spatial and seasonal designs. Such studies should explicitly account for size, sex, moult stage, and habitat condition. By linking natural diet to trophic function rather than treating prey lists as isolated observations, future research can improve predictions of lobster responses to environmental change and strengthen ecosystem-based fisheries management, habitat conservation, and biologically informed aquaculture.

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