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Nesting Behaviour in Animals

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Abstract

Nesting behaviour in animals is widespread and diverse throughout the Animal Kingdom. A considerable number of groups rely, to varying degrees, on spatially confined sites in which to reproduce. The construction of nests, both by males and females, occurs across many taxa. This review provides evidence of nesting behaviours among major classes of animals with particular emphasis on birds, reptiles, mammals, fishes and insects. The discussion clarifies both similarities and contrasts between the divergent taxa. Nest building is charted through several related topics: nest architecture and the materials employed; nest-site selection and seasonality; parental care and mating systems; the threat of predation and surviving strategies; physiology and genetics that control behaviour. A concentrated review of the literature uses three illustrative examples to demonstrate the variability of the behaviour of species presenting widely different ecological affiliations and natural history. Land-use change, climate change and pollution have direct and indirect effects on nest-building organisms and the habitats on which they rely. The potential for conservation prescriptions is discussed. Nesting behaviour plays a crucial role in an animal's life cycles and evolutionary history. Elaborate structures are widespread throughout the Animal Kingdom, revealing high levels of taxonomic and structural diversity to be found among isolated populations and between the divergent classes, from the least-active builders such as frogs and fish that simply modify preconstructions, to the elaborate nest architectures of rodents and spiders, mammals, fishes, passerine and social birds within which individuals may remain for extended periods.

Keywords: nesting behaviour, taxonomy, ecology, parental care, conservation.

Introduction

Nesting behaviour comprises the suite of behaviours involved in constructing or choosing a nest, which may be built, excavated, or an existing structure. Nesting is the basis for parental care in many taxa, ensuring a safe and suitable environment for offspring. A diverse array of animals, from a variety of taxonomic groups, display nesting behaviour. The most diverse and well-studied nest-builders, both within and across taxa, are birds. Different taxa build a variety of nests with various architectural features and different construction methods (C Mainwaring et al., 2014). Factors influencing nest site selection also differ widely across taxonomic groups, as well as the materials used during nest construction. Many other taxa display parenting behaviours involving nesting, including reptiles, mammals, fishes, and insects. In some instances, social behaviours related to nesting, such as cooperative breeding and colonial breeding, also arise. Whether nest-building is a trait conserved from a common ancestor or if origins of nesting behaviour have evolved multiple times independently across taxa remains unclear; however, the similarities in nesting behaviour across taxa suggest common selective forces favour its acquisition. Several significant changes in habitat and climate in the coming years due to human activities are expected to affect nesting behaviours and associated behaviours in many taxa, with consequences for population-divergence and extinction rates.

Evolutionary and Ecological Significance

Nesting behaviours are widespread throughout the animal kingdom and serve a variety of functions. These range from protecting eggs and offspring from predators (C Mainwaring et al., 2014), decreasing energetic costs of incubation and lowering physiological stress (Medina, 2019) to facilitating courtship and maintaining social cohesion. Diverse architectures and strategic placement demonstrate that nests play adaptive roles across taxa. They establish microhabitats that modulate thermal conditions and shield offspring from predators. Construction involves excavation or manipulation of materials and substrate, reflecting adaptations to specific environmental situations. Associated features such as nesting sites, timing, parental care, physiology, and genetics showcase intricate behavioural differentiation within and across groups. Variation enables adjustments to evolving environments, while facilitating dispersal into novel habitats, underscoring broader ecological and evolutionary significance.

Taxonomic Comparisons

Nests provide protected and resource-rich environments that facilitate reproduction, enhance offspring survival, and reduce parental energy expenditure (Medina, 2019). Birds, the most intensively studied nest-building animals, show remarkable diversity in their nesting habits. The approximately 10,000 bird species use virtually every mode of reproduction and site imaginable for nesting, from hanging suspended nests attached by a single twig to the canopy to cavity nests hidden or exposed in steep cliffs, and ground nests covered by dense vegetation or fully exposed and incubated by the parents. Cavity nests and domed nests are strongly correlated with cooler environments that protect the vulnerable eggs from adverse conditions. Mussel-building weavers (Ploceus spp.) cooperate to build suspended spherical nests that protect their young from predatory snakes under the glare of African sunlight (Minias, 2014). Swallows (Hirundinidae spp.) use material collected on transit flights to construct cup nests on exposed building ledges. Furthermore, nest-site selection is influenced by mating system and parental care strategies. In most avian species, nest-building activities are predominantly performed by males, potentially serving as an additional signal during sexual display. Generally, males build nests either to attract potential mates, enable successful mating with already chosen mates, or stimulate additional and earlier egg laying by females. Predation pressure has frequently been proposed to influence various aspects of parental behaviour, including nest-guarding, which serves to protect the female and the nest from predators.

About 30% of fish species spawn on plants, rocks, other fishes, in nests they build, or in cavities, grass, or in shallow holes. Among fishes that build nests, a large proportion of species protect the offspring. Some of the best-studied examples of nest-building behaviours are found in cichlids (Mchenga conophoros) in Lake Malawi. In Zambia, this species builds sand castles 1–2 m in diameter in breeding colonies where several nests are located less than 1.5 m apart. In some species, even if nest construction is not a requirement, such as in Neolamprologus multifasciatus, fossils of its ancestors indicate that they built bowers and this behaviour could be an adaptation to secure territorial defence. Parental care in fishes is largely male dominated.

(i) Birds: Birds construct a remarkable diversity of nests, ranging from simple scrapes to elaborate structures highly visible or hidden in vegetation. Nests also provide opportunities to barter or signal quality. All nests must provide the environment for incubating eggs and rearing young with the appropriate levels of temperature, humidity and protection. They also reflect a balance of costs and benefits; both early and late breeders benefit from carefully constructed nests even though material collection and construction are time-consuming activities (C Mainwaring et al., 2014). Studies of bird nests have been limited, despite nests being sophisticated structures requiring cognitive abilities to construct. Recent research has increased understanding of nest design and function, influenced by natural and sexual selection, parasites, and environmental factors. Natural selection favors individuals with effective antipredator defenses, affecting nest design and location. Birds select nest sites to minimize predation risk; for example, dusky warblers choose higher, isolated sites despite environmental costs, veeries select low activity sites, and Inca Terns prefer inaccessible crevices on cliffs which lower predation rates. Different nest types typically appear within specific taxa, described as scrape, platform, cup, simple enclosure, dome, and burrow.

(ii) Reptiles: Reptiles are a highly diverse group, with species exhibiting a wide range of nesting behaviours. Many oviparous species construct nests, either by digging a hole in sand or dirt and depositing their eggs within, or by actively building a nest above ground. In contrast, viviparous species, along with oviparous species whose eggs develop inside the female and which produce no calcareous eggshell, do not build nests. Reptile nests vary in size and complexity, from small holes to large mounds, and the mode of nesting (above- or belowground) can change as the timing of egg-laying approaches (B. Moss et al., 2020). Communal nesting occurs in some crocodilians and squamates. Physical nesting sites can also be used by reptiles that do not make or attend to their own nests, such as some snakes, which deposit eggs into moisture-retaining debris or within the nests of other species.

(iii) Mammals: Mammals build a diverse range of closed nests according to functional, environmental, morphological, and physiological constraints. These are usually excavated into the substrate, which provides protection against wind, temperature fluctuations and access by terrestrial predators. Nest type is strongly related to body size and diet, extending the same relationship observed more generally for mammals. Nesting behaviour is highly camouflaged, and construction forms an important part of the individual's behavioural repertoire. Day nests provide shelter during non-lactating periods, whereas nursery burrows typically remain sealed until the young are weaned and mobile. Mammalian nests provide stable microclimates for the facilitation of infant physical development and protection from predators. As a result, reproductive success is often tied to the availability of a suitable nesting site. Nest construction usually begins before pregnancy, and nest design can be adjusted in response to the presence of parasites, access to food, stage of the lunar cycle or ambient temperature. Nest camouflage is acquired by appropriate site selection, fitting the entrance with an inconspicuous closure, or by the use of vegetation and debris. When foraging, the parent regularly defecates away from the nest site, pigs passing fresh faeces to the offspring to transmit information on the mother's diet and local food resources. Mammalian nests often represent long-term commitments, as the survival of young can depend directly on the presence of a secure site. Construction is typically used as part of a long-term strategy for the rearing of neonates, and time spent in nest-building activities indicates the relative importance of a reproductive event. Furthermore, the ability to relocate is limited by both predation risk and the availability of alternative settlements (Hudson & Distel, 1982).

(iv) Fishes: The majority of known fish species spawn in aggregations or scatter their eggs randomly around the chosen site. Nesting species carefully place their eggs at the breeding location and defend the young until they are capable of surviving independently (Ota & Kohda, 2014). Among these taxa, nesting is found in species inhabiting a variety of habitats, including fresh, brackish, marine, and very occasionally terrestrial waters (Kawase et al., 2013). The degree of parental care also varies widely, ranging from no care to extensive provisioning and forms including broadcast spawning and internal viviparity, as well as construction of elaborate nests.

(v) Insects: For the majority, with mobile young feeding themselves externally in the terrestrial environment, the nest is a protected site for eggs and immature young (e.g. terrestrial insects, ants and some wasps). The often large investment of time and energy in construction and parental care reflects the vulnerability of external eggs laid in non-aquatic environments and in many cases the large quantity or size of the eggs. The diversity of nest type is again very great, including burrows in soil or wood; mineralsubstrate nests constructed from water-dissolved calcium, silica and metals; bubble nests; silken nests; modified leaves; specialised termite structures; and nests of soil mixed with faeces (Staab et al., 2014). Nearly all insects have diverse, sometimes complex and highly adapted mating systems, with strong and often changing selection on conditions which enhance survival of the young. Surface brood-balls are periodically re-measured and relocated to a more favourable temperature or humidity; the provisioned cells of a solitary wasp become more elaborate with increasing period of development; long tunnel nests of bumblebees are sealed at every sixth cell within a brood chamber; and clutch size, which is normally markedly less than a maximum value, is actively controlled by provisioning efficiency. Because the nests vary in form and location, the costs of nest construction and provisioning also vary widely. The interplay of different environmental pressures can therefore be expected to generate diverse behavioural adaptations.

Nest Architecture & Materials

Nest architecture varies enormously, from species excavating burrows to others weaving nests with saliva and environmental materials. Many insect and bird species build a nest, home or refuge for themselves and their young. Nests may also be tools that aid the function of a species' reproductive strategy, such as ant-plant mutualisms where ants use domatia as nest sites in exchange for protection of the plant host. Nests have been modified extensively throughout evolution. Architectural diversity suggests that nests occur where various ecological conditions promote the need to remove offspring from hazards in the environment (R. Tschinkel, 2003). Nest structure clearly contributes to the overall fitness of the offspring, and nest architecture has evolved to accommodate environmental pressures.

Site Selection & Seasonality

Thousands of studies have addressed nest-site selection by animals. The value of a nest site depends on various factors; different types of nests can be more suited to one site than another (Baumbach et al., 2020). Animals may be selective about where their nests are constructed. Some prefer sites where the eggs will not be flooded and where the offspring are concealed from predators. Established sites that the animals return to regularly may signify a successful choice; sea turtles, for example, return annually to the same beach where their nests have been successful. Some species are capable of assessing the suitability of a site and adjust the kind of nest they build accordingly. The year in which the nest is built can determine the species of materials used: in a dry year, for instance, birds more commonly line their nests with feathers than with mud. The degree of concealment can also be a determinant for the selection of a building site: on the northern gull island, the higher degree of vegetation cover and greater concealment allow some species with poor defence towards predation to nest safely, thus affecting population dynamics and nesting preferences. Near tide or water levels, anticipation of the next tidal cycle is relevant; birds such as the Arctic tern, the common tern, and the black guillemot typically select nest material of large size or weight because of strong coastal winds. Human intervention and the placement of certain materials such as styrofoam or other refuse at construction sites can enhance an individuals' nest site fidelity and the long-term survivorship of such sites, due to the increased spacing and reduction of territorial competition these materials provide. Site selection can be influenced by other factors such as beach sand temperature and beach slope, which can influence the eventual nest strategy of species such as the loggerhead sea turtle. Timing of nesting, or seasonality, can be flexible and dependent on external cues. Sea turtles remain in their mating sites until a certain month, determining the end of mating season for the turtle population in a specific beach. Site fidelity and seasonality deeply influence the reproductive success and demography of the species. When the location's resources become insufficient to accommodate a given population, it becomes advantageous to select an alternative site; once the new site is chosen, there is an increase in the number of eggs laid. Despite this, the existence of plasticity in site selection and seasonality is rarely considered when evaluating the long-term success of the reproductive strategy of a given population.

Parental Care & Mating Systems

Nesting and parental-care behaviour constitute some of the most striking examples of phyletic continuity among taxa. The strategies animals adopt to incubate and protect their young have far-reaching implications for the determination of fitness, even though many species neglect their offspring altogether. Many animals do not build nests, but they all share common motivations in the protection of their progeny, and all nest builders face a similar range of environmental and biological constraints, including those imposed by climate, shelter and concealment, reproductive mode, cavity availability, predation, and parasitism (Davenport, 2018). In general, bony fishes provide little or no parental care beyond nest defence; amphibians usually congregate their young in water-filled sites and offer a variety of physiologically based protection methods; birds characteristically commit themselves to the intensive feeding of their young; and mammals offer both extended personal care and the nurturing of offspring in close contact by means of lactation (D. Carvajal-Castro et al., 2021).

Physiology & Genetics of Nesting

The process of nesting is an important adaptive behaviour in many animal species, occurring in all five vertebrate classes and in numerous invertebrate groups such as insects (Jeffrey Mass, 1980). Although nesting predominantly serves to facilitate an offspring's survival, the detailed forms and functions of these structures vary widely, with some providing only shelter for eggs and hatchlings, whereas others also accommodate transient or permanent shelter for adults. As such, studies of animal nests extend beyond the parent–offspring relationship and can provide valuable insights into basic principles and processes of behavioural biology, but the majority of the accumulated knowledge is confined to the more commonly observed examples apparent in birds, fish, mammals, reptiles and insects.

Many patterns, processes and themes common to all groups are displayed by the successive chapters, along with the characteristic diversity within and between each class discussed. A comparative approach provides a convenient and flexible framework for organising the material and emphasises the fundamental unity of nesting behaviour within the animal kingdom, Despite the singular variation, the subject remains much underexplored and further elucidation is likely to emerge from experimental and theoretical advances in areas such as evolution and behavioural development, the application of different theoretical perspectives and the increasing use of molecular techniques.

Human Impacts

Human activity influences nesting animals globally (L. Allbrook & L. Quinn, 2020). Land-use change, in particular, threatens nesting behaviour by reducing nest sites and suitable habitat, creating barriers to social information and movement, increasing predator abundance, and altering predator-prey interactions (Kubelka et al., 2018). Climate change also influences weather, plant growth, water availability, predator distribution, and population dynamics, potentially disrupting the timing of nest initiation, availability of resources, and timing of offspring needs (Benvenuti et al., 2018). Human disturbance additionally affects reproductive success and saps energy needed for foraging and defence. When animals nest near humans, the resulting changes in behaviour and physiology often mediate further indirect effects on fitness.

Nest sites are critical for the reproductive success of numerous animals and a subject of concern for conservation biologists. The selection of nesting sites is affected by a range of human-induced environmental changes including urbanization, tourism, and land-use change. Many birds occupy sites with characteristics similar to those of older nests, yet innovation in nesting behaviour does occur and may facilitate colonization of new habitats. Worldwide, the annual rate of habitat loss is increasing and anticipated to reach a level that may cause widespread extinctions in multiple taxa during the twenty-first century (Vaugoyeau et al., 2016). A better understanding of the consequences of land-use change on reproductive behaviour and nesting requirements is important if the adverse effects of habitat loss are to be attenuated (Dias et al., 2017). Moreover, land-use change can also result in the fragmentation of agricultural, forest or rangeland habitats. Because such habitats contain a diverse range of resources, fragmentation usually leads to significant losses in biodiversity and changes in species composition. Loss of breeding habitat, the simultaneous increase in proximity to human infrastructure and changes in the landscape around occupied sites might therefore all be considered important factors that influence nesting behaviour and the mechanisms that underpin the establishment of new breeding sites (Kubelka et al., 2018).

Climate change influences key stages in the nesting cycle, including migration timing, nest-site selection, and food availability, thereby affecting survival and reproductive rates. Variation in snow cover can alter hibernation phenology, body condition, and physiology, impacting survival and recruitment (J Sheriff et al., 2017). Long-term monitoring of daily nest survival shows that warming disrupts the global pattern of nest predation in shorebirds, with trophic interactions modulated by mean temperature (Kubelka et al., 2018).

Anthropogenic pollution affects the nesting behaviour of some taxa, such as fish and birds, and in particular the choices they make in mate acquisition (Candolin & Bern Ming Wong, 2019). For instance, in fish, where parental care is commonly expressed via protection and maintenance of the offspring, the impact of pollution on mate choice consequently compromises provisioning to the next generation. Whereas other species such as crab spiders rely on the extended parental investment of nestbuilding spiders, the immediate consequence of pollution on reproductive output is much less clear. The review by shows numerous experimental and field studies on the potential impacts of pollution on mate choice, and hence nest construction, and their consequent effects on populations and communities. Owing to the range of effects pollution has on nestbuilding behaviour, it constitutes a serious conservation concern.

Conclusion

This review has provided an extensive overview of the literature on the diverse constructions produced by animals and their motivations for constructing such structures. Animals across taxa employ construction, but only some animals build specifically to aid juveniles. Evidence suggests that even among nest-building animals, eggs/juveniles are not always a primary motivational driver. Nesting behaviour serves multiple adaptive roles across avian, reptilian, mammalian, piscine and invertebrate species, representing varied solutions to a common selective pressure. Taxonomic comparative analysis highlights how diverse animals converge on a similar behavioural suite (nest building) in response to this pressure. Animal-built structures take a variety of forms but are typically designed to regulate the offspring's environment, with architecture and site choice reflecting the environmental hazards to which the occupants will be exposed. After the eggs/juveniles hatch, nesting structures direct continued parental care both in terms of the type and amount of care provided, although evidence implies these structures rarely play a role in the care provided by males (C Mainwaring et al., 2014). Parental care and nesting effort can interact with other behavioural traits, such as mating system, while nests may aid parents in assessing whether to attempt a re-nest if a clutch is lost. Nests, as well as adults and juveniles themselves, are often vulnerable to predation—a major influence upon the evolution of nesting behaviour. The physiological and genetic basis that control breeding and nesting behaviour are known in some species, linking the observed ecological and evolutionary patterns with our understanding of mechanism and thereby providing greater insight into the behaviour's function.

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