

Chapter 2

Genetics and Other Mechanisms Affecting Behavior

2.1 Introduction

Innate behavior, e.g., behavior that is genetically programmed, enables certain organisms, such as spiders to spin a web (some species in the order Araneae). Use of highly inbred white mice, which are actually are inbred strains of the wild house mice (*Mus musculus*), by comparative psychologists is important as models of human disease or to demonstrate the effects of genetic versus the environment on behavior. However, even if a specific gene or set of genes for a given behavior is present in an organism, that behavior may not necessarily be shown. For instance, male birds usually do not sing outside the breeding season, because certain genes may not be turned on by hormones or nerve activity (Gill 1990).

2.2 Diversity in Behavior Diversity

Patterns of diversity in behavior are often similar among genetically similar species (Brown 1973). For example, many ducks and geese (family Anatidae) feed and forage the same way. Pigeons (*Columba livia*) drink water by sucking it into their throats with beaks in water (like mammals); in contrast, other bird species pick up their heads to let water go into throat via gravity. Some new species have been discovered using behavior. Prairie dogs (genus *Cynomys*) and fireflies (family Lampyridae) have been segregated into different species on the differential behavior (vocalizations and patterns of flashing, respectively). Fighting versus retriever ability has been selected in dogs (e.g., pit bull versus Labrador retriever). Dinosaur teeth, based on fossil records, have been used to distinguish predatory versus prey ways-of-life.

2.3 Sociobiology and Behavioral Ecology

Perhaps the most important concept in the study of animal behavior has been the idea proposed by Charles Darwin that evolution through natural selection has provided the necessary framework for the development of traits (Goodenough et al. 2001). Sociobiology and behavioral ecology are the application of evolutionary biology and ecology to social behavior, which were developed in the 1960s onward (Wilson 1975; Barash 1977; Goodenough et al. 2001). According to these two disciplines, ecological factors better correlate to behavior than phylogenetic or genetic factors. In my view, sociobiology is not segregated from behavioral ecology; both are the focus of what many behaviorists study in natural populations.

Most behaviorists concur that natural selection acts on individuals, families or kinship groups (ants, bees), or spatially defined populations (demes) (Brown 1973). Natural selection acting on the latter group, however, is questionable. Another concurrence among most behaviorists is that fitness is mediated by natural selection and is expressed by differential natality and mortality.

2.4 Social Organization or Social System

The totality of interactions within and among species can be viewed as the social organization or social system of a species (Crook et al. 1976). Each aspect of this organization can be affected by selection, either natural or human-induced factors in the landscape. Seven aspects of social organization may be recognized: social units (composition and dispersion patterns), food-acquisition behavior (foraging behavior), predator-defense behavior, mate-acquisition behavior (sexual behavior), parental-care behavior, spacing patterns (e.g., territoriality), and communication systems. Communication of various means mediates all of the previous aspects of the social organization or social system of a species.

2.5 Social Units

Animals are distributed in the available or preferred habitat. The spatial distribution or dispersion pattern is determined mainly by behavior towards others of the same species (conspecifics) or other species (prey, predators), or by resources in the environment [e.g., spring seeps or streams in water-dependent salamanders, as the northern spring salamander (*Gyrinophilus porphyriticus*)] (Shaffer 1995). Typically, a given dispersion pattern is characteristic of a species; for instance, some species live in colonies, such as the yellow-bellied marmot (*Marmota flaviventris*) of the western states (Armitage 1998), whereas others, such as the woodchuck or groundhog (*Marmota monax*) of the eastern states, are solitary (Davis 1967) (Fig. 2.1).

Fig. 2.1 The woodchuck, or groundhog, is the only marmot in eastern North America. Unlike its western counterparts, the woodchuck is solitary; western marmots tend to be colonial



Spatial distribution or dispersion pattern can be of three basic types: random, clumped, or regular (sometimes termed uniform) (social behavior from fish to man text). A random pattern is rare in nature; it may occur in a few species, maybe in a few species, such as the Poli's stellate barnacle (*Chthamalus stellatus*) on shoreline rocks, which may be a random resource for attachment. A clumped pattern is common in many social animals, such as a colony of ants (Formicidae) or herd of wildebeest (*Connochaetes* spp.). A regular or uniform distribution is found in species that defend a space via aggression (e.g., of territorial), as found in the songbird called the common yellowthroat (*Geothlypis trichas*).

Compared to an aggregation, a social unit has (1) a complex system of communication, (2) a division of labor based on specialization, (3) cohesion or tendency for members to stay together, (4) degree of permanency of group members, (5) and tendency to be impermeable to nongroup members [e.g., members of a gray wolf (*Canis lupus*) pack may kill a lone wolf] (Eisenberg 1966).

An example of an aggregation may be several brown bears in close proximity while foraging in a stream full of salmon (family Salmonidae) in western states. Group feeding, as with brown bears at a salmon run or with a flock of wintering birds, may increase the efficiency at which food is gathered (Morse 1970). For instance, wintering flocks of birds often contain several species, which later presumably pair and mate in the breeding season (Brown 1973; Rollfinke and Yahner 1991). In central Pennsylvania, over 50% of 123 wintering bird flocks contained four species, including downy woodpeckers (*Picoides pubescens*), black-capped chickadees (*Parus atricapillus*), white-breasted nuthatches (*Sitta carolinensis*), and golden-crowned kinglets (*Regulus satrapa*) (Rollfinke and Yahner 1991). Of these flocks, there was a mean of 8.2 individuals and 3.8 species. Chickadees are often the most abundant flock members, perhaps because they have a distinct alarm system; as a result, other species may flock with them (Brown 1973). Hence, in harsh northern

winters, flock formation may enhance (1) the ability to find food, and (2) decrease predation risk (more eyes) (Brown 1973; Bertram 1978). Some species may even form postbreeding flocks prior to migration to wintering areas (Hobson and Van Wilgenburg 2006). Some bird species in northern boreal forests, such as Tennessee (*Vermivora peregrina*) and yellow-rumped warblers (*Dendroica coronata*), form flocks of about 20 individuals as early as late June, and the flock size continues to increase to over 60 prior to southerly migration. Probably, the earliest birds to become members of a postbreeding flock were nonbreeders or “floaters” in the population.

Similarly, why do turkey (*Cathartes aura*) and black vultures (*Coragyps atratus*) form aggregations by roosting communally during winter in Pennsylvania and Maryland (Thompson et al. 1990). Winter roosts have 13–200 black vultures and 43–429 turkey vultures. Vultures selected winter roost with coniferous trees to provide favorable microclimate. Because black vultures cannot smell well, if at all, and turkey vultures have a keen sense of smell, the information-center hypothesis has been given for the use of the same roost by both species of vultures (Wright et al. 1986). Turkey vultures find carrion and other food items in the morning, and this food information then is transferred to the more aggressive black vulture who capitalizes on the food.

Bald eagles (*Haliaeetus leucocephalus*) roost communally in winter in Oregon and California (Keister et al. 1987). I probably would characterize this roost as an aggregation rather than a social unit. Bald eagles commonly exhibit winter roosts throughout their range. Sometimes as many as 500 eagles may roost overnight within 0.25–24 km of major daytime major concentrations of food, such as fish and waterfowl. In these roosts, subadults tend to roost closer to food resources, suggesting that, compared to adult birds, subadults were less efficient at foraging than adults.

In contrast to vultures or eagles, semipalmated sandpipers (*Calidris pusilla*), which are found in subarctic and Arctic regions of North America form nesting colonies of 2–4 pairs/ha (Jehl 2006). The semipalmated sandpiper is the only one of three sandpipers ($n=31$ species) that is known to form nesting colonies. This species is monogamous and highly territorial, which facilitates early nesting and identification of individuals, thereby making these pairs a network of social units rather than an aggregation.

A given social unit (or aggregation) and its dispersion pattern can be determined by censuses, aerial photos, quadrant sampling, etc. For example, by plotting burrow systems used by marked eastern chipmunks (*Tamias striatus*) in 12 0.3-ha quadrants located in optimal habitat was used to determine a regular distribution of solitary animals in the habitat (Yahner 1978a). Mean variance of distances between neighboring burrow systems was compared statistically to a value of 1.0.

Social units and dispersion patterns can change temporally. For instance, in white-tailed deer (*Odocoileus virginianus*), nonwintering units in the Welder Refuge of Texas typically consist of a matriarch group of a female and her young from 1 to 2 generations (Hirth 1977); range mean size of social units (matriarch group) exceeded four animals, perhaps because animal in the social unit (more eyes) could detect danger in the landscape. On the other hand, the matriarch group at the George Reserve in Michigan was typically less than three individuals and did not include

the young of the oldest generation. The Reserve had small open areas (less than 25 ha) within the landscape, with a total amount of open areas = 22%. In winter, on the other hand, deer may form huge amorphous herds (probably more appropriately termed, aggregations) of both sexes and many age groups as occurred once at Gettysburg National Military Park (R.H. Yahner, personal observation).

2.6 Matriarchal Social Units

What is the significance of a matriarchal social unit to animals? Much needs to be learned about this phenomenon, particularly because wild populations often have been managed by culling or hunting older, larger individuals, with the assumption that older animals play little role in the success of a social unit (Fox 2003). In African elephants (*Loxodonta africana*), overall reproductive success of a social unit has been found to increase with older females as matriarchs for three reasons: these matriarchs have improved knowledge of social calls for protection (e.g., bunching calls) of food source locations and possess better parenting skills than younger females in the social unit.

2.7 Plasticity in Social Unit Size

Some species presumably have plasticity or flexibility in size of a social unit. For example, the coyote (*Canis latrans*) has a basic social unit of a mated pair [such as the red fox (*Vulpes vulpes*)], but the size of the social unit in coyotes can vary with habitat. In forest areas of the eastern deciduous forest, only about 33% of coyotes are pack forming (3–5 individuals), 33% are pairs, and 33% are solitary (Todd et al. 1981). In the eastern forest, major prey of coyotes is rodents (order Rodentia) and rabbits (order Lagomorpha). But in open areas, as in the plains of Oklahoma, coyotes often form packs of greater than five individuals (Stout 1982). Major prey item of coyote packs in the open plains are often large (such as adult white-tailed deer). Hence, prey size may dictate the size of social unit.

Large mammalian predators have two strategies to be an effective predator on large prey. Large cats, such as the mountain lion (*Puma concolor*), are large in body size and hunts solitarily on large prey. Members of the dog family hunt large prey by increasing the number of members in the hunting party (social unit). Red fox always form a pair; as a consequence, red fox feed on small food items. Larger pack size of gray wolves allows cooperative hunting. In Alaska, pack size in gray wolves is usually 5–8 animals (Thurber and Peterson 1991; JM 74:881). In addition to increased pack size in coyotes to enable hunting of larger prey, two other factors for increased size of social units in the open plains may be (1) cooperative defense of carrion (presumably against other coyote packs) and (2) delayed dispersal of young (winter in coyotes versus fall in fox) (Stout 1982).

Why then do the African lion (*Panthera leo*) form social units (prides) rather than hunting solitarily like other large cats? Unlike large dogs, e.g., gray wolf, prey capture seemingly is not related to prey size in the African lion. A solitary lion is as efficient in prey capture as pride of 5–6 females, if prey is abundant. Larger prey size in African lions is apparently related instead to defense of cubs against infanticidal males (Bertram 1978). In addition, larger pride size in African lions also aids in defense of territories against other prides of lions or clans of spotted hyenas (*Crocuta crocuta*).

2.8 What Do Animals Learn in a Social Unit?

What do animals learn in a social unit (Goodenough et al. 2001)? Obviously, animals need to learn a number of things to maximize their fitness—what foods to eat, how to find these food, what habitats to use or choose (if given a choice), territorial boundaries, the identity of neighbors versus intruders, with whom to mate, familial or social unit relationships (most of whom are probably kin), or how to be or interpret aggression. Can animals learn how to choose these things? This becomes an important question when trying to determine the impacts of land-management practices on wildlife (McDonough and Loughry 2005).

For example, at Tall Timbers Research Station in Florida, the impacts of prescribed burning and timber removal on the nine-banded armadillo (*Dasypus novemcinctus*), which is the only armadillo species in the USA, did not affect individual movements away from the burned area (McDonough and Loughry 2005). Instead, burning reduced body weights and the number of females lactating, thereby affecting reproductive fitness in this population of armadillos.

2.9 Cultural Transmission of Learning

Is protecting cultural diversity in wildlife as important as protecting genetic or species diversity (Fox 2003)? Like humans, wildlife can pass on cultural traits from one generation to the next.

Cultural transmission of behavior occurs when an animal learns the behavior from others by a process known as social learning (Goodenough et al. 2001). Probably one of the best-known examples has occurred in the great tit (*Parus major*) of Britain (Fisher and Hinde 1949). This bird learned to open milk bottles and drink cream from them; this behavior then spread among great tits throughout the British Isles. In order for there to be cultural transmission of behavior, an animal probably must be preadapted to this behavior; the origin of opening milk bottles may have been bark tearing on birch (*Betula* sp.) trees for use of birch bark in nests; bark tearing may have been a preadaptation for opening milk bottles. Another example of cultural evolution can be found in cetaceans, such as sperm whales (*Physeter macrocephalus*),

that live in matriarch units of up to a dozen females, whereas males of the species tend to be solitary (Vaughan et al. 2000).

Sperm whales can dive as deep as 1,000 m for up to 70 min in search of food. The matriarch unit of sperm whales uses a form of auditory communication, termed echolocation, to capture prey, to stay together as a social unit, and to avoid predators (e.g., humans). The population of sperm whales of the South Pacific can be subdivided into five clans, each with their own songs (dialects), movement patterns, and habitat use. A dialect can be defined as differences in vocalizations in one population to the next (Brown 1973). The adaptive value of cultural transmission of dialects in the sperm whale is that adult females conceivably imprint on dialects of their neighbors to serve as a reproductive isolating mechanism (Fox 2003). Hence, when conserving the sperm whale, what works as a conservation measure for a segment of the population may not work for another—one clan may use vocalizations or behavior in different ways to avoid whaling activities by humans. For instance, one clan of sperm whales may feed close to shore, whereas another may feed away from shores. If a given weather phenomenon, e.g., El Niño, affects food patterns, one clan may be more susceptible to whaling than another. Because culture is vital to ways to making a living and survival in humans, we are beginning to appreciate that culture diversity, and associated behavior in wildlife need to be considered in conservation.

Tool use in common chimpanzees (*Pan troglodytes*) has been seen most often in populations found in west Africa than those from east Africa. With dexterous hands and use of tools to acquire foods and for social displays in this species, the common chimpanzee is predisposed to this behavior via cultural transmission.

Scavengers often use cultural transmission of behavior to find food (Goodenough et al. 2001). As mentioned earlier, black vultures capitalize on the foraging efficiency by turkey vultures, which have a good sense of smell at communal winter roosts. This is a theory known as the information-center hypothesis, whereby animals learn about the location of food by interacting with others. This type of information transfer differs from individual learning because what an animal learns via individual learning stops when that animal dies. Observational learning, or cultural transmission of behavior, may increase the rate at which food is found (Morse 1970); for instance, sandwich terns (*Sterna sandvicensis*) take food from adults until midwinter, at which time they no longer take food from adults (Fig. 2.2).

By observing the foraging behavior of adults, young sandwich terns learn how to forage efficiently. As observers of this behavior, we can surmise that young are less dependent on parents.

2.10 Ultimate Versus Proximate Factors in Wildlife Behavior

When referring to ultimate factors, typically are asking how does evolution via natural selection shape behavior. Proximate factors are not evolutionary in nature. For instance, red plumage in house finches (*Carpodacus mexicanus*) are the result



Fig.2.2 The sandwich tern is a seabird, in which males plunge for fish and offer the fish caught to females as part of the courtship. Young sandwich terns learn food items from both parents via observational learning

of carotenoid color pigments that are consumed in food (e.g., hinged to diet) (Hill 1993), but not clear what foods provide these pigments. Female house finches are not reddish; thus, differences in color between the sexes seem to be caused by differences in dietary intakes of carotenoid pigments. Females do not benefit by being colorful, so they focus on maximizing caloric intake per unit time; therefore, for both males and females, food is the proximate factor. Brightly colored males were significantly more likely to get a mate than lightly colored males, so being very red is the ultimate factor for male house finches. Because there is a positive correlation between male coloration and his parental care, whereby redder males are better mates by feeding females and chicks at a higher rate than less red males, survival of a chick and fitness of males are enhanced.

2.11 Hormones and Proximate Factors

The endocrine system consists of ductless glands that secrete hormones, which are molecular messengers secreted directly into the bloodstream (Goodenough et al. 2001). Hormones can affect behavior, as in adult male mammals where hormones initiate and maintain sex characteristics (as in the antlers of white-tailed deer).

Hormones in males are especially at high levels in the blood before male–male encounters. Testosterone, which is a male hormone, acts as a proximate factor affecting fighting ability and “play fighting” in younger animals. Proximate factors address questions such as “How is it that...” “What is it that...” e.g., How does a bird learn this? Ultimate factors get at the whys—e.g., “Why is it adaptive for a bird to learn this, e.g., a male red-winged blackbird to learn breeding habitat?”

2.12 The Nervous System, Biochemistry, and Behavior

The nervous system provides an electrical impulse via nerve cells, which consist of dendrites at its ends and an axon (long body) (Goodenough et al. 2001). Nerve cells provide mechanisms for instantaneous responses in wildlife. These instantaneous responses are necessary for all behaviors from flight in migration to feeding on a preferred food item.

In the vertebrate brain, a structure, called the hippocampus is found just inside the temporal lobes of the brain (Goodenough et al. 2001). The hippocampus (derived from Greek) has a curved shape resembling a seahorse. Phylogenetically, the hippocampus is one of the oldest parts of the brain; in humans suspected of having Alzheimer’s disease, the hippocampus is one of the first regions to suffer damage, causing memory loss and disorientation. In vertebrates, memory and navigation is based on the hippocampus.

In corvids, the hippocampus of the brain is important (Krebs et al. 1989), by enabling these birds the ability to retrieve food. The large hippocampal volume in the brain helps these birds find 6,000–11,000 seeds stored after a period of 9 months. In gray squirrels (*Sciurus carolinensis*), the hippocampus is vital in finding the spatial location of acorns stored in the forest floor during autumn.

In invertebrates, the hippocampus does not exist. Rather, insects, such as honeybees (*Apis mellifera*) have a cluster of small neuron cells called mushroom bodies (corpora pedunculata) (Withers et al. 1993). The bodies enable a honeybee to learn foraging locations. Foraging bees have mushroom bodies that are about 15% larger than nonforagers.

A good example of how a biochemical factor affects behavior is with the ability of some species of animals, including fish, amphibians, reptiles, birds, and mammals to see ultraviolet (UV) light (Goodenough et al. 2001). For instance, in zebra finches (*Taeniopygia guttata*), a single change in an amino acid (C84S) can cause change in UV perception; the loss of this amino acid resulted in violet perception only!



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