CHAPTER 4

Developmental Environments

LIVESTOCK-GUARDING DOGS

An ocean of grass extends westwards from Manchuria to the Hungarian Plain. Over its undulating horizons, mounted nomads moved their flocks on a restless search for food. In winter they sheltered under the lee of mountains from the *buran* or white wind of winter; in the spring they relaxed when the flowers lacquered the ground . . . Their migration was their seasonal ritual, their music the howling of mastiffs, clanging of bells, and pattering of feet. [Bruce Chatwin, *What Am I Doing Here.* New York: Penguin Books, 1990, p. 197.]

Dogs . . . are of the greatest importance to us who feed the woolly flock, for the dog is the guardian of such cattle as lack the means to defend themselves, chiefly sheep and goats. For the wolf is wont to lie in wait for them and we oppose our dogs to him as defenders. [from *Roman Farm Management: The Treatises of Cato and Varro* (circa 150 B.C.) *Done into English, with Notes of Modern Instances, by a Virginia Farmer* (Harrison Fairfax) New York: Macmillan, 1913, p. 247.]

IN THE NEST: SHAPING THE BEHAVIOR

There are several types of sheepdogs. There are the herding dogs, which conduct livestock from one place to another. And there are the livestock-guarding dogs, which cannot herd sheep, are not expected to herd sheep, but are expected to protect sheep from predators such as wolves, coyotes, bears, jackals, baboons, leopards, or any other depredator that

pastoralists might encounter. (Note that I use "sheep"—as Varro used "cattle"—as a synonym for all livestock.)

The herding dogs and the livestock-guarding dogs are an animal behaviorist's dream team of study animals. Two types (breeds) of dogs are raised in the same environment—pastures; they are both selected to respond to the same environmental stimulus—sheep; but they respond in two very different ways. One herds the sheep, the other guards them. Since the two breeds behave differently in the same environment, then we can assume the differences between them are genetic.

Livestock-guarding dogs are probably among the oldest of the working dogs. Obviously, they cannot be older than domestic sheep and goats, which are the first livestock, dating from about eight thousand years ago. In Varro's time (2,050 years ago), livestock-guarding dogs were common and economically important. They show up frequently in ancient writings and pictorial art.

They are probably also the most numerous of all the working dogs. There are millions of them throughout the world. We in the West think of them as rare breeds, such as komondors, kuvasz, or Great Pyrenees. When I started studying livestock-guarding dogs in the 1970s, I found practically nothing written about them in the United States. What there was often turned out to be wrong. Breed books claimed that these big sheepdogs were both guardians and herders. English-speaking peoples tend to think of sheepdogs as collies or herding dogs. Perhaps this confusion was because the English-speaking world had either rid itself of significant predators many centuries ago and had no need for livestock-guarding dogs, or, more likely, the breed-book authors had not really observed closely the behavior of the dogs with the flocks.

In fact, when twenty-four-year-old English biologist Charles Darwin encountered livestock-guarding dogs on his visit to Uruguay in 1833, he was "amused" with what he saw. It was as if he had made an original discovery unique to South America. He didn't seem to realize that the raising and training procedures he reported on were standard the world over (except in the British Isles). He didn't seem to realize that there are, and were in 1833, millions of these dogs, with four or five of them each working for just about every shepherd from Portugal to China, from Russia to South Africa.

But Darwin is such a keen observer and wonderful writer, I will

present his discovery in his own words. He manages to capture all the elements of the livestock guardians in just a few sentences.

> While staying at this estancia, I was amused with what I saw and heard of the shepherd-dogs of the country. When riding, it is a common thing to meet a large flock of sheep guarded by one or two dogs, at the distance of some miles from any house or man. I often wondered how so firm a friendship had been established. The method of education consists in separating the puppy, while very young, from the bitch, and in accustoming it to its future companions. An ewe is held three or four times a day for the little thing to suck, and a nest of wool is made for it in the sheep-pen; at no time is it allowed to associate with the other dogs, or with the children of the family. The puppy is, moreover, generally castrated; so that, when grown up, it can scarcely have any feelings in common with the rest of its kind. From this education it has no wish to leave the flock, and just as another dog will defend its master, man, so will these the sheep. [Charles Darwin, *The Voyage of the Beagle,* New York: P. F. Collier and Son, 1909, p. 163.]

Note that he says nothing about their breed, special breeding, selection, or anything to do with genetics. Breed is not an issue. In fact, from Darwin's description one has no idea what the dogs look like or how big they are. My guess is they are not much more than useful village dogs, adapted to the flock. Darwin was such a good reporter, surely he would have said something if these dogs were really big or beautiful or strikingly special in some way.

The message inherent in Darwin's description is, Take any local puppy and raise it properly and you have a decent livestock-guarding dog. Uruguayan shepherds, or any shepherds, for that matter, knew how to achieve good guardians. One hundred and fifty years after Darwin's observations, when biologists Hal Black and Jeffrey Green were trying to teach modern-day ranchers in the western United States how to raise and train livestock-guarding dogs, they reproduced the recipe used by Navajos to develop their flock guardians. They acquired this recipe by observing Navajo sheepdogs. The Navajos were originally taught by Spanish missionaries that the proper way to care for sheep is to raise sheep-guarding dogs with them. The system sounds very much like Darwin's formula.

> Raise or place mixed-breed pups in corrals with sheep, lambs, goats, and kids at 4-5 weeks of age. Feed the pups dog food and table scraps. Provide no particular shelters such as dugouts or doghouses (the pups will sleep among the sheep and will dig their own dirt beds). Minimize handling and petting. Show no overt affection. Return pups that stray to the corral (chase them, scold them, toss objects at them). Allow pups to accompany the herds onto the rangeland as age permits. Punish bad behavior such as biting or chasing the sheep or goats, and pulling wool by scolding and spanking. Dispose of dogs that persist in chasing, biting, or killing sheep. [Black and Green, 1985]

In both descriptions the critical factor for achieving the appropriate adult behavior is to start with very young pups and raise them with the target species, without other dogs around. Darwin says, "I often wondered how so firm a friendship had been established." How can a carnivore become a protector of a prey species? Then Darwin answers his own question by describing the essential developmental environment. Instead of the dog being raised in the house, where it becomes trustworthy, attentive to, and protective of its master, it is raised in the barn, where it grows up trustworthy, attentive to, and protective of sheep.

If Darwin had had a modern vocabulary, he might have written: the interspecific social bonding between sheep and dogs depends upon *imprinting* puppies during the *critical period* of socialization, which for dogs is roughly between four and sixteen weeks of age. By paying strict attention to the puppy's developmental environment, one shapes and conditions the dog's adult behavior in such a way that it displays normally intraspecific social behaviors (innate dog-dog behaviors) interspecifically (nurtured dog-sheep interactions). As a result of this rearing environment and imprinting, the dogs cannot display predatory routines toward sheep. We have seen this phenomenon already with village dogs in Pemba, which, being raised with chickens, don't kill them.

Most shepherds don't even realize they are manipulating the dog's behavior, just as most of us have little knowledge of how we change a dog's behaviors by raising it from puppyhood in our home. We buy an eight-week-old puppy, take it home, where it is isolated from other pups, and it grows up with us. People, then, become the dog's social attachment. Livestock-guarding dog pups are born in sheep barns, form

their attachments during their first few months of age, and grow up socialized to sheep.

The only difference between the commensal village dogs, which were difficult to lay a hand on, and our pet dogs, or livestock-guarding dogs, is the social environment they were raised in.

Will any breed of dog do? Can you take any dog and start at four weeks and make it into a livestock-guarding dog? No, not really. We raised a retriever according to the recipe, but she never developed the protective attitude that the guardians do, and she never forgot how to retrieve. None of the specialized breeds I discuss in Chapter 6 will make good livestock-guarding dogs. And I will explain why.

Marcus Terentius Varro might have been among the first to recognize this distinction, and his advice to farmers over 2,000 years ago is still irrefutably valid today.

> Be careful not to buy a sheep dog from a professional hunter or a butcher, because the one is apt to be lazy about following the flock, while the other is more likely to make after a hare or a deer which it might see, than to tend the sheep. It is better either to buy, from a shepherd, dogs which are accustomed to follow the sheep, or dogs which are without any training at all. While a dog does readily whatever he had been trained to do, his affection is apt to be stronger for the shepherds than for the flock. [p. 249]

Livestock producers who rely on their guarding dogs come to the same conclusion. Breed, shape, and genetics are not as important as the developmental environment. I will modify that statement ever so slightly as I show how the breeds of livestock-guarding dogs evolved. But for the most part, while the dog is in its first few weeks of life, and growing its brain, it is making the cell connections and rearranging them in a specific way, according to the signals that are coming from outside. This development predetermines its adult behavior. In other words, imprinting changes the dog forever.

Austrian ethologist Konrad Lorenz was maybe the first to recognize the importance of this period of primary socialization, which he was able to articulate suitably and which he tested in his now-famous experiments with birds—observations that won him a Nobel Prize. Working with graylag geese, he demonstrated that socialization with another

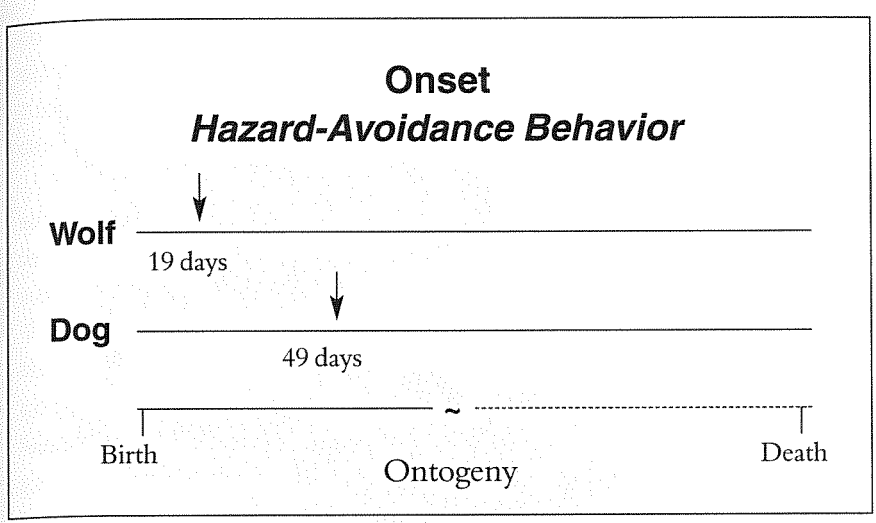
species (namely, with Lorenz himself) during a time-sensitive period of development resulted in the birds' being "imprinted" on him. Geese are a precocious species, walking and swimming within an hour of hatching. In some cases social bonding takes place within *minutes* of birth. In contrast, with Lorenz's jackdaws, an altricial (hatched in a helpless and naked state) species, the bonding was more gradual and occurred later in development. But if the bonding was done correctly, both species would prefer the company of their "foster parent."

Dogs have altricial young more like the jackdaws than the geese. Dogs are born without eye and ear function. Their survival, like that of the jackdaws, is dependent on parental care. They can't make it on their own. The concept of critical period resulted from the differences Lorenz recorded between the goslings, which can make it on their own and which form their social attachments immediately upon being born, and the jackdaws (and dogs), which need several weeks to form theirs.

Wolves, coyotes, jackals, and dogs all begin to form their social allegiances after their eyes open at thirteen days. With the onset of sensory functions, they have the capacity to form social relationships. By the time dogs are sixteen weeks old the window of social opportunity is greatly diminished or even closed. If they haven't seen sheep or people during that period, they will be forever shy of them. Wolves are different from dogs in that although they begin their social development at thirteen days, it is greatly accelerated and is closing rapidly by nineteen days. One of the reasons dogs can be so much tamer than wolves is a consequence of the much longer period during which dogs can form new attachments.

The period roughly between two and sixteen weeks, called the "critical period for social development," was originally described for dogs in a 1950 paper by John Paul Scott and Mary Vesta Marston, resulting from the notable studies at Bar Harbor, Maine. Critical period simply means that during this time, the pup is predisposed to and has the greatest capacity to learn particular social skills. It is in this period when dominance hierarchies are formed and dogs learn and practice their submissive behaviors. They learn to beg for food, whom to beg from, and how to turn begging into social greetings. They learn what species they belong to.

At sixteen weeks the social learning window closes. After that the dog has very poor abilities to develop or change its social skills. Essen-

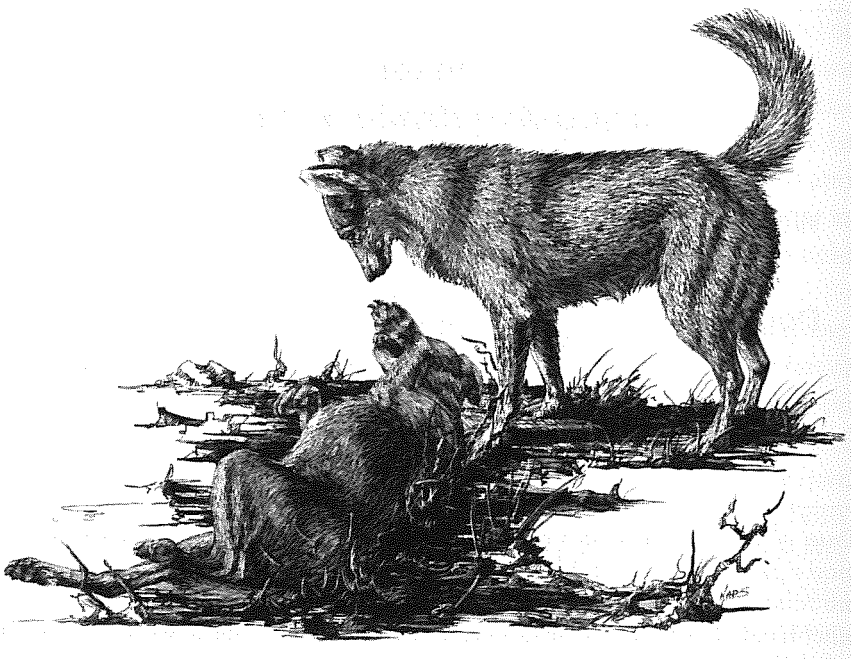


Onset of fear (hazard-avoidance) motor patterns in wolf and dog. The onset of fear motor patterns occurs at about nineteen days in wolves. If wolves haven't been introduced to people by then, it is doubtful they can ever be tamed. Dogs, on the other hand, don't have the onset of fear until the sixth to eighth week. It is much easier to make a pet out of a dog.

tially, at sixteen weeks, the dog's social personality is set for life. If a dog is shy of people at sixteen weeks then it will be shy the rest of its life. Can it learn not to be shy with intense training? It certainly could make some progress but it will always have a social "accent."

Is there any variation in the closing of the social window? Of course. Individuals will differ within a breed, and the average for each breed will differ. In fact, at Wolf Park the puppy socializers remove the puppies from the den before their eyes open. Because wolves' social abilities mature so rapidly, the human puppy parents have to spend twenty-four-hour days with them from their thirteenth to nineteenth days. And that includes feeding, cleaning, and playing with them. You can see why Mesolithic puppy snatchers would have had such a hard time taming and training wolf pups. Removing pups from mom and taking care of them during that neonatal period are extremely difficult and time-consuming. Just bottle-feeding them is a chore.

When a future livestock-guarding dog is raised among sheep for its first sixteen weeks, then for the rest of its life it treats sheep as its primary social companions—it is imprinted on them in a way similar to



Dominant and submissive motor patterns emerge during the critical period of social development. (K. Doktor-Sargent)

Dog submissive behavior displayed to sheep. When a pup begins to show dog social motor patterns toward sheep, one can conclude it has successfully bonded with them. This Anatolian shepherd dog, displaying a classic dog submissive posture to these sheep, is developing into a fine guarding dog. (Photo by Jay Lorenz)

the imprinting of Lorenz's geese. The adult guardian dog follows sheep, greets them, and responds to their signals by showing dominance and submissive behaviors interspecifically. Sometimes these dogs even get sexually involved with sheep.

Some people say that the dog thinks it is a sheep, but that is probably wrong. It "knows" it is a dog. The behaviors it directs toward the sheep are dog social behaviors, not sheep social behaviors. If it thought it was a sheep it would display sheep social behaviors, which are very different. When dogs threaten they show their teeth and growl, while a sheep threatening a dog stamps its front foot. Growling as a social response is genetic, a dog characteristic. Dogs do not normally growl at their prey. Growling is directed at animals they need to communicate with. Thus, growling at sheep is a good sign that the dog has developed a social relationship with sheep during the critical period. Who they socialize with is learned, but dogs can learn this lesson only during the critical period, which is genetically timed.

When I talk to my dog I'm communicating by means of human social behaviors. I don't think I'm a dog. But there is a part of me that thinks my dog is human. I even think my dog knows what I'm talking about. I watched a Portuguese shepherd yelling in perfect Portuguese at his goat, which was browsing his neighbor's garden. The goat must have understood Portuguese because it hastily got out. It seems that livestock-guarding dogs, in the same way, think sheep are doglike and understand dog language. When I feed my dog, the sheep try to steal as much dog food as they can, and the dog growls at them, as if they could understand what it meant.

Typically, Old World shepherd dogs spend their first sixteen weeks with one or two littermates, a few adult dogs, including their mother, three hundred or so sheep, and a shepherd. The Italians have a word for this social triangle. It is called a *morra.* After the sixteen weeks are over, the dog has been physically shaped and behaviorally molded in such a way that it "needs" to spend the rest of its life with the morra. One would never think to purchase such a dog and take it back to a city apartment as a pet. It probably would be very uncomfortable and could never make a total adjustment to the nonsheep environment. Taking a wolf pup from the den at four to six weeks would produce a similar unsatisfactory result.

The practical aspects of critical period contribute much to our relationships with dogs. In fact, the first and most important aspect of cre-

ating a mutual relationship with dogs is not genetic at all, but rather the development of puppies in the environment they are expected to perform in as adults. Unfortunately, the critical period is often poorly understood, even by trainers whose job it is to shape a dog's behavior for a specific use as an adult. For example, a pervasive view describes the social behavior within a pack of wolves as genetic. Because of this, the reasoning of dog trainers goes: dogs are descended from wolves and wolves form packs, and therefore dogs understand wolf-pack behavior and should respond to the trainer as "alpha," or dominant, in its life.

But *is* wolf-pack behavior genetic? Not really. Pack behaviors, like all behavior, are epigenetic—above the genes. They are a result of behaviors learned during the critical period. Pack behavior is just one of many social options available to wolves. If dogs don't develop pack social behavior during their critical period, there is no sense in trying to simulate pack leadership after that social window closes. Pack behaviors are much more complicated than just hierarchies of social status. They are learned through social play and care-soliciting behaviors during the juvenile period. A trainer who pretends to be the alpha leader of a wolf pack—say, by turning a dog over onto its back and getting down and growling at its throat—is intimidating the dog, no doubt. But to a dog, the message is not what the trainer thinks it is. Teaching and learning are seldom facilitated by intimidation. A dog doesn't learn how to sit from a trainer who intimidates it, simply because the coercion diverts the dog's attention away from the task and toward its social status. An alpha wolf is not trying to teach a pack member anything, especially to sit. The fact that so many believe the wolf-pack homology, and use it in training a dog, is really a testament to how little is understood about canine behavioral development.

Critical period for social behavior sounds like magic. Something permanent is actually happening in the dog's brain that causes it to become essentially unalterable after the period is over. For some reason, what is learned, and when it can be learned, is limited to that time period. Once "learned," the behavior cannot, easily or completely, be unlearned. Given how much we do know about teaching and learning, it would seem that we could teach the dog to behave differently. But the dog doesn't appear able to learn it. Proverbially, people do know this: you can't teach an old dog new tricks. But do they know why?

Some permanent change must be taking place during the critical

period. It really does look like a dog that is socialized with sheep is wired differently than that same set of genes growing up in a village without sheep. Could it be that the ability to learn is a genetic response to the environment? Could learning be genetic?

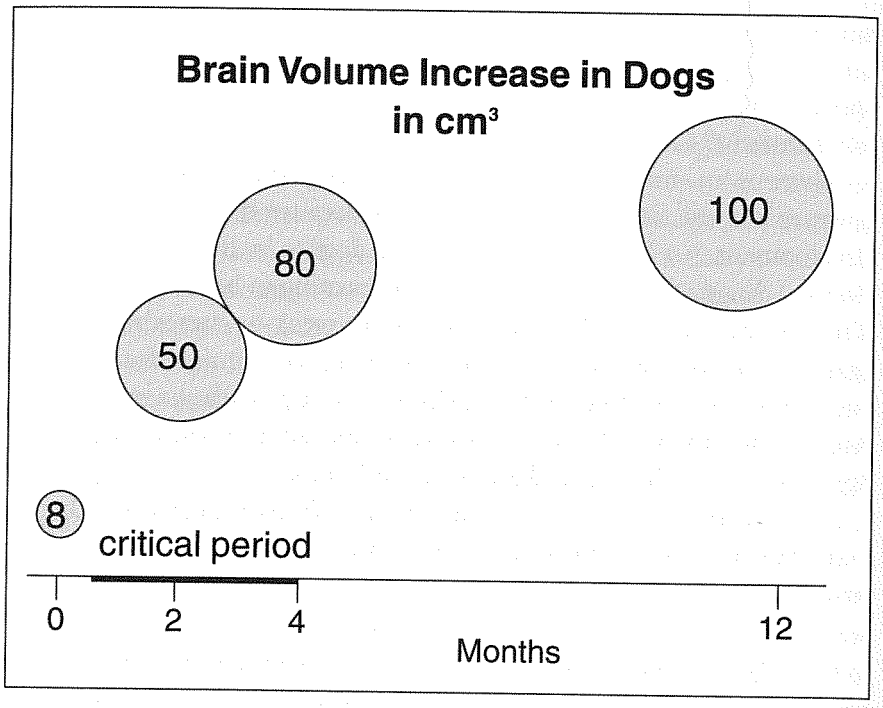
There is an important essential here. Early experience is vital not because it is the first learning, but rather because it affects the brain's development. A while back, I was training dogs to be livestock-guarding dogs—I *thought.* I thought the dogs were learning to be flock guardians. The critical period closed on the sixteenth week or thereabouts, so, I reasoned, if we got our dogs out with sheep any time before sixteen weeks we would be fine. But by keeping our pups with sheep, we were not teaching them to be flock guardians. Instead, the young dogs were "growing" their flock-guardian-behavior brains.

Brains grow, just like legs or any other body part. Legs not only *can* walk but they *must* walk in order to grow properly. Legs that do not walk while they are growing (critical period) wither and become useless. The same is true of brains. Brains grow in two ways: they get bigger, and they change shape. How much they grow and which way they change shape depends on the kinds of environmental stimulation they receive during their first sixteen weeks.

The period of the most rapid brain growth is also coincidental with the critical period for social development. A day-old livestock-guarding puppy has a brain volume of about ten cubic centimeters. That is about the size of the very end of my little finger. By the time the pup is weaned at eight weeks, it is sixty cubic centimeters. By the time it is sixteen weeks, its brain is eighty cubic centimeters and rapidly approaching full size at a little over one hundred centimeters. Tom, one of our original and favorite Italian sheepdogs, grew to a hundred pounds with a brain volume of a hundred and six cubic centimeters.

At birth a puppy has essentially all the brain cells it is ever going to have during its whole life.

If the puppy brain has essentially the same number of cells as the adult brain, how can it grow ten times bigger? The answer is that brain growth is almost entirely in the connections between the cells. Of all the brain cells present at birth, a huge number are not connected or wired together. What takes place during puppy development is the wiring pattern of the nerve cells. Some nerves make their connections spontaneously, driven by internal signals. Some nerves actually "look" for a



Brain growth chart. Most of the growth in a dog's brain is during the critical period of social development. After growth stops, it is difficult to change the wiring.

muscle to attach to. Other connections are motivated by external signals. External to the brain, that is. For example, the eye tells the brain how many cells it needs to have in order to run the eyeball. Big eyes need more cells than small eyes, and thus animals with big eyes tell their brain to connect up a greater number of cells for eye function.

It is not only the size of the eye to which the brain must accommodate, but also the activity of the eye. The brain accommodates to the eye by growing the appropriate connections for both its size and its activity. The brain of a puppy raised in the dark doesn't make as many connections. A puppy raised in the dark has a smaller brain than one raised normally. A puppy that is raised in an impoverished environment has a smaller brain. It has the same number of cells, but not as many get wired together. Experiments with kittens showed that animals raised with horizontally striped glasses during development of the eyes cannot, as

adults, see in the vertical plane. They walk into table legs as if they can't see them.

The onset of other sensory functions, too, happens in the critical period. Animal behaviorist Ed Bailey notes the importance of olfactory imprinting for establishing a bond with a young pup. He advises prospective owners to visit the litter from five weeks of age on, handling the chosen pup and allowing it to imprint on specific smells. Darwin in Uruguay noted that the guarding-dog pups were given "a nest of wool . . . in the sheep pen." From birth, they lived amid the feel, sight, sound, smell, and taste of sheep. Among gun-dog breeders, it is known that young pups can easily be accustomed to the sound of a gun firing nearby, if they are exposed to this and other loud noises before the onset of fear.

At this point, it should be clear that the sight, smells, and sounds of sheep influence the growth of a brain in a manner distinct from the influences on the brain of a puppy that grows up in a city apartment. If the puppy doesn't see sheep until it is eight weeks old, it has a differently shaped brain than one that sees sheep from four weeks old. At sixteen weeks old, almost all the connections have been made, and the brain is about to stop its major growing. A puppy that sees sheep for the first time at sixteen weeks can make some tiny growth adjustment to those environmental signals, but not as many.

It is complicated and would take massive computers to figure out all the possible variations. But at the same time it is conceptually relatively easy to visualize what is happening. Why is it that no two animals truly look alike or think alike? Simply because no two animals can grow up in identical environments. No two animals can occupy the same space at the same time, which means they cannot receive identical environmental signals, and therefore they do not get wired up identically. As a result, they do not have the same capacity to think and behave. Even if the impoverished pup gets taken to an enriched environment as an adult, it cannot learn to cope with that environment because it does not have the necessary cell connections. Once the dog gets to sixteen weeks it has made (or has not made) just about all the social connections it is ever going to make.

Understanding brain growth should dispel the nature/nurture controversy once and for all. It is never, ever either nature *or* nurture, but always both at the same time. But liver cells make more liver cells

because that is the environment they respond to. Behavior is always epigenetic—above the genes—an interaction between the genes and the developmental environment. It is a synergism of gene products and the climate, producing a unique organism. No two look or behave alike.

Development of the growing brain is a cascade of billions of events that are internally (nature) and externally (nurture) motivated. To say, however, that the cascade of growth events is genetic is to miss the point.

In 1976, when I started studying livestock-guarding dogs, I assumed that since the behavior of guardian dogs was so dissimilar to that of border collies, then guardian dogs must be preprogrammed to be livestock guardians. I thought livestock-guarding-dog behavior was genetic. That was what everybody was telling me. These breeds, everyone said, had been selected to guard sheep. We were also constantly asked, "Which breed is best?" The implication was, which breed has the best genes?

At the same time, during our research program with the guardians, we received many telephone calls from producers with the following complaint. The caller had purchased an older pup—say, a four-month-old Pyrenean from a breeder who told him it was a traditional livestock guardian—and he couldn't get the dog to stay with the sheep even though the dog was from "good" breeding stock. Our first question to him: Was the dog in with sheep for its first four months? No? Then it had the wrong brain shape. You can't satisfactorily teach a dog a new social trick.

Raising puppies, and especially raising them for special jobs as adults, requires attention to detail. When people raise pups as pets, they often get them at about eight weeks old, take them home, feed and cuddle them, housebreak them, take them for walks, and play with them. What they are doing (and they're usually not aware of it) is providing specialized brain-growing conditions that shape the dog's future behavior. If I were buying a puppy for a pet, I would check its early environment and make sure it wasn't raised in a kennel or in the laundry with only its mother and littermates for immediate company during that first eight weeks. I'd be very suspicious of a department-store dog that was twelve weeks old, wondering if the dog had time left to grow the brain I was looking for. I'd also suspect that if I locked the pup up in the house alone each day while I went to work, I'd get a small-brained dog without enough connections to be a good social companion.

Critical period needs to be explored even further. It implies so much more than simply animal-to-animal socialization. For example, one reason Konrad Lorenz's geese stopped imprinting shortly after birth was because they experienced the onset of a fear response. Fear is a threshold response, meaning that a stimulus has to exceed a certain level before it provokes a response. Take any signal. The animal could respond to the signal by approaching it curiously, or the animal could try to escape or avoid whatever produced the signal. Take a sound. The same sound could be loud or it could be barely perceptible, depending on the ear's development. As the sense organ begins to function, what might be a loud sound to an adult is a soft sound to an immature ear. Animals avoid loud sounds and could ignore or investigate soft sounds. They could habituate to sounds that were continuous. Fear is in great part an avoidance of novelty.

Before the onset of fear responses, animals do not show fear to novel shapes and sounds. For a newborn puppy, everything is novel. But after the onset of fear, new novel shapes and sounds cause avoidance behaviors—call them hazard-avoidance behaviors. Gun-dog trainers expose their pups to gunshots before the puppies grow the "fear" portions of their brains. Shooting guns around puppies for their first six weeks grows a brain that expects those sounds from the environment. Gunshots become normal. But if the gunshots are not introduced until after the onset of fear (which in this case might simply be the threshhold where the sound is perceived as loud), the dog will perceive them as hazards to be avoided. A gun-shy dog is not much use on the hunt. And as always, once you have a gun-shy dog, there is not much that can be done about it. (That is not to deny that some dogs are more sensitive than others, regardless of the environment.)

Fear turns on at different times in different breeds, and even among individuals within a breed, due to individual development rates. Six to eight weeks is an average age for one breed to display fear responses, while the next might not display them until eight to ten weeks.

Each behavioral system—fear, submission, investigation, play—has its own rate of development, and varies among breeds. Each is dependent on glandular development and hormone secretions, as well as motor coordination and sensory perception. And each feeds back on the puppy to change not only the shape of the brain but the shape of all the other developing organs. And after that each new signal works on

that new shape, changing it in a novel way. And so on. The bones of active puppies are a different shape than those of inactive pups. One can change the growth rate of glands by exercising them, and thus change the threshold timing of specific behaviors.

During the critical period of socialization, border collies and some bird dogs show the onset of predatory behaviors. Ten-week-old border collies begin to eye and stalk objects in their environment. They then incorporate eye-stalk-chase games into their play routines with other border collies. Thus, part of their social play has predator-versus-prey components. Sheep are very sensitive to predator-versus-prey behaviors and avoid animals that display eye-stalk games.

If livestock-guarding dogs ever display predatory behaviors, they generally do not appear until the dog is five or six months old. By then, their window of social development is closed. Therefore they cannot integrate those predatory behaviors into their social play. That in itself makes their breed personality very different from collies.

The basic predatory behaviors (called predatory motor patterns) of a dog are:

orient/eye/stalk/chase/grab-bite/kill-bite/dissect.

Not all breeds of dogs have a complete set of predatory motor patterns. In fact, one of the clues about the status of the village scavenger on Pemba is that this dog didn't display any, at least not to village livestock or chickens.

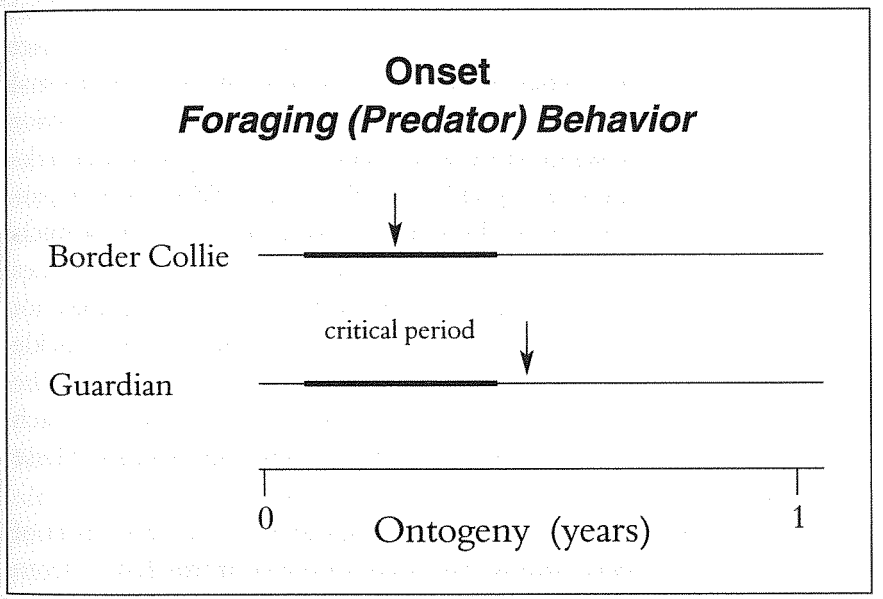
Dogs and carnivores in general don't show kill behaviors to animals they grow up with, or individual animals they know. Ethologist Paul Leyhausen, in his book *Motivations of Human and Animal Behavior,* described an example of this phenomenon. He had a wild golden cat (*Profelis temmincki*), to which he fed rats. One rat avoided being caught and hid under the cat's bed. That rat became "friends" with the cat. The cat ate each new rat but not its friend—until at four months the rat was removed, to be put back, much larger, three months later. The friendship was over.

We had five chickens that our Alaskan husky Sitka "knew." She never touched them. They got old and I added two more. Sitka killed and ate both new ones and still didn't touch the old ones. Breeders of working foxhounds know how this works, and place their puppies out to be raised by farmers known as puppy walkers. Since these hounds don't

develop their hunting instincts until after the time during which they have been socialized with farm animals, the adult foxhounds, thus raised, can chase a fox through the farmyard and never look at a chicken, even one they don't know. The knowledge and use of critical period by foxhound breeders greatly improves hunter-farmer relationships.

The very best livestock-guarding dogs never develop any predatory motor patterns. The less than the best (which is practically all of them) display one or two predatory motor patterns (most likely chase and grab-bite), but very weakly.

What that means is that many an imperfect dog makes a very good sheep guardian if the owner has paid strict attention to the development of the animal during the critical period. But with other animals the good guardian may not be so circumspect. Some will chase and sometimes kill wildlife. In Texas, one of our Maremmano-Abruzzeses, named Dolly, was a wonderful guarding dog—trustworthy, attentive, and pro-



Onset of predatory motor patterns: border collies and livestock-guarding dogs. Border collies have an early onset of predatory motor patterns that they incorporate into their social play. Predatory behaviors of livestock guardians onset after the social window has closed. Their play behavior is not as rich in behavioral elements as that of border collies.

tective with mohair goats. But she would catch and kill a rabbit, and then carry it around for days until it wore out. Then she would get another. She had the chase and kill motor patterns, but not dissect. Therefore she could kill animals she hadn't been socialized with, but she couldn't eat them because she was missing one of the essential elements of predatory behavior. The rancher's interpretation was that Dolly just needed a soft pillow, for he often observed her resting her head on the rabbit carcass.

Just as the social motor patterns have a critical period, so do the predatory ones. Each of the patterns of eye, stalk, chase, grab-bite, kill-bite, and dissect emerge independently from one another during their own critical subperiod. One day you observe the kitten eyeing the ball of yarn. Days later it does the chase and the pounce. Eventually it ceases displaying the behavior to yarn and turns its attention to mice. It appears that the animal is learning to kill, or practicing to be an adult, by playing the eye-stalk games with the yarn. Actually, something much more elaborate and serious is going on.

Motor patterns need to be reinforced the first time they appear. Not all of them, but many, if they are not reinforced during the onset period, drop out of the repertoire, never to appear again. If the animal performs the new pattern then it will persist. Presumably the behavior is "growing," and if it is not stimulated it does not grow properly. Suckling in newborn puppies is a good example. The suckling motor patterns, sometimes called the suckling reflex, turn on in most mammals slightly before birth. If the puppy doesn't suckle within a few minutes after birth, the behavior extinguishes, presumably because it does not grow the proper nerve connections. The puppy that does not suckle within a few minutes after being born loses the ability to perform the sequence. It cannot be taught to do it later. Not only can you not teach an animal to suckle, you cannot teach one to chew and swallow. These are innate motor patterns that develop or onset later.

I've seen cases of livestock-guarding dogs that showed the onset of the chase motor pattern, but if they were removed immediately from the sheep pasture, the behavior dropped out of the repertoire, never to appear again. I've also seen cases of livestock-guarding dogs, with the onset of chase, running at the sheep. My sheep, which had a long history of being socialized with dogs, didn't run in response to the chase. If the sheep don't run, the dog can't chase them. Even though the dog

has the potential to chase, it needs the environmental signal in order to display the behavior.

The layering and interacting of developmental events that produce an adult working dog are precisely unfathomable. The complexity of the developing dog's behavior should remind the reader how passé is the nature-versus-nurture controversy. Although it was once a compelling question for behaviorists, scientists now understand why nature cannot ever be separated from nurture. When we look at the critical period for social development, we realize that the genetic nature of the dog is being shaped by the environment in which it is growing up. If there is no environmental stimulation, there is no epigenetic response.

Most good working-dog people make their own dogs. I might buy myself a border collie pup, but that is when my work begins. I have to shape the behavior of that pup from an early age in order for it to be the herding dog I want.

With livestock-guarding dogs, the shaping often comes naturally. The dog is born in a sheep culture. The rest is natural. To the people who call me and ask,"What breed of dog is best?" I reply, "None of them will work at all if they are not raised with sheep during the critical period. The only thing you are looking for is a breed of dog that has a weak tendency to show the predatory motor patterns, a breed where the predatory motor patterns drop out if not reinforced, and dogs four or five weeks old that can be socialized properly. A village scavenger can have all those qualities. Go capture a village pup and raise it with sheep."

THE TRANSHUMANCE: DISTRIBUTING AND MIXING GENES

The behavior of a good working sheepdog is the interaction of a number of environmental, genetic, and epigenetic events, occurring during development. The behavior of the original livestock guardians is not predicated on any genetic evolution of these sheepdogs. And yet we now think of them as breeds—breeds selected to be large, white, and protective. Often, when livestock-guarding dogs are discussed, the topic hinges on which breed is best. Our research at Hampshire College focused on breeds, and we compared the success rates among several hundred each of Italian Maremmano-Abruzzeses, Anatolian shepherds,

and Yugoslavian Šarplaninacs. We also observed a smaller number of Tibetan mastiffs, Portuguese Castro Laboreiros, Pyrenean mountain dogs, komondors, kuvasz, pulis, and two Transcaucasian ovčarkas, to assess how they worked on American farms and ranches.

Why, if their adult behavior is shaped by their developmental environment, do these livestock dogs have distinctive shapes also supposedly adapted to guarding livestock? We must explore how the ancient dogs metamorphosed from village dogs growing up among shepherds and their flocks to the special shapes of today's great breeds.

The Roman writer Marcus Terentius Varro describes in discerning detail the appearance of flock guardians as follows.

> . . . handsome, of good size, with black or tawny eyes: a symmetrical nose: lips blackish or ruddy, neither drawn back above nor hanging underneath: a short muzzle, showing two teeth on either side, those of the lower jaw projecting a little, those above rather straight and not so apparent, and the other teeth, which are covered by the lips, very sharp: a large head, ears large and turned over: a thick crest and neck: long joints: straight legs, rather bowed than knock-kneed: feet large and well developed, so that in walking they may spread out: toes slightly splayed: claws hard and curved: the pad of the foot neither horny nor hard, but as it were puffed and soft: short-coupled: a back bone neither projecting nor roached: a heavy tail: a deep bark, and wide, gaping chops.

I suppose this might have been the first breed standard ever written. Its overall message is that the dog should be well built. It doesn't say big or fierce but rather that the dog should be nicely shaped with good pigment. This description implies that shepherds, by ancient Roman times, were paying attention to the conformation of their flock dogs—the conformation present in the best working dogs. Varro added one more trait: "The colour to be preferred is white because it gives the dog a lion like aspect in the dark."

To state that the preferred color is white implies that there are good working dogs that are not white.

I suppose it could be interpreted from Varro's description that the ancient Romans were breeding livestock-guarding dogs. Unless one reads carefully, one might think the Roman ranchers were practicing arti-

ficial selection in the Darwinian fashion of sorting among their best dogs and selecting traits such as the white coat color and breeding together those dogs with the desired characteristics. We might assume that since the Italian Maremmano-Abruzzese is white, people have been breeding these dogs since ancient times, preserving ancient traits generation after generation. We might be tempted to think the Maremmano-Abruzzese is an ancient breed.

I don't think that is so. I don't think that is the way breeds of livestock-guarding dogs evolved. And I don't think any breed is ancient in the sense that it has been sexually isolated since Varro's time and is directly descended from ancient ancestors. I have no doubt that some Romans had dogs that were uniform in traits and looked like breeds, and maybe they even looked like modern breeds. I'm sure there were distinctive livestock-guarding dogs and distinctive hunting dogs. And I don't doubt that there were a few Roman aristocrats who kept kennels, and kennel personnel who arranged matings between individual dogs. Just as now there are Walker coonhounds, there must have been Caesarian spaniels.

But it is a long way from some rich Roman kennel to the millions of shepherds and their multimillions of working sheepdogs in remote mountain pastures. Survival as shepherd dogs depends on the phenomenon of the "transhumance." Every spring and every fall, shepherds move their sheep to where the grass is fresh and plentiful. They wander vast rangeland pastures and along mountain trails. While traveling, they don't have the facilities to isolate their female dogs in estrus. A female in heat is receptive to males for about two weeks. Think of walking around one of these huge grasslands every day, camping each night in a different location, and trying to prevent a female from getting bred by every male within olfactory range. Modern shepherds in these same sheep-producing nations still don't have any system for protecting a female in heat. It is hard to imagine that in Varro's time or in the early Neolithic period, shepherds could have had control over their dogs' reproductive urges. When I think of the problems I have, kennels and all, and the mistakes I've made arranging matings, it is just impossible for me to believe that any of these "breeds" are the result of sexual isolation over centuries.

Dogs in heat inevitably get bred, first by the dogs they socialize with daily, then by the other dogs of the *morra.* Then by dogs from the neighboring morras, and perhaps by all the males from the shepherd's village.

It is a volunteer program. Sometimes a male, or a group of males from the shepherd's flock, will defend the female from other males. Thus the female is most likely to get bred by members of her own morra. But "most likely" is the pivotal term.

All the eligible dogs of the flock and the surrounding flocks and all the dogs of the village can volunteer. The resulting litter could conceivably have as many fathers as it has pups. The dogs closest to the female are most likely sheepdogs, and so even if there are many fathers, they are most likely all neighboring sheepdogs. Thus, all the pups are most likely pure sheepdogs, in that all the volunteers are being tolerated by humans on the sheep range.

By the way, this is the healthiest breeding system possible. Any male carrying deleterious genes does not threaten the whole litter. Random matings among a population of animals that is well adapted to the habitat is a better way to maintain the appropriate gene frequency. And a litter with many fathers should at the same time maximize the variation within the litter upon which natural selection can operate.

Since the livestock-guarding dogs breed themselves, why don't they end up looking like village dogs? In fact, in most of the sheep pastures of the world they are still scavengers and have those village-dog traits of size, shape, color, and behavior. But what has to be realized is that the selective forces that determine the size of the Pemba dogs are not the same selective forces operating on dogs in mountain pastures in Nepal. Even though they are still scavengers, and largely responsible for their own reproduction, livestock-guarding dogs are commonly up to three times bigger than Pemba dogs.

The sheepdogs of the Damara people in Angola and Namibia are not three times bigger, but rather indistinguishable in size from the local village dogs. The sheepdogs of Eurasia tend to be larger than sheepdogs of Africa. Biologists have long known there is a tendency for members of a species to get larger as they move away from the tropics toward the poles. They also get larger as they go higher in altitude. The shepherd dogs of Eurasia live farther north and in higher pastures than the ones in Africa. One might think it was just natural for Tibetan mastiffs to be considerably larger than Pemban dogs—because the latter would freeze to death in the alpine environment.

Thus we must consider that regional variation might be the product of natural selection and not necessarily the result of purposeful selec-

tion by people. It is often assumed, when one finds a population of dogs with a high frequency of some attribute such as size or color, that it is because people are selecting for those attributes. But we need to keep in mind that regionally, a population of dogs can be the product of founder effects (Chapter 3), that is, they descended from only a few ancestors. And, further increasing their local uniformity of appearance, they are a product of exposure to local selective forces.

The simplest way to refine a natural breed is by postzygotic selection. This simply means the shepherds cull what they don't like and care for and support what they do like. If a dog chases sheep, they kill it. If a dog doesn't stay with the sheep, it gets lost. If it gets lost, it doesn't have a good chance of breeding with the shepherds' other dogs. If it gets lost, it can't collect the shepherds' and the sheep's wastes.

If a Neolithic shepherd notes that a likable dog is perhaps performing some service such as protecting the sheep from wolves, then the shepherd might share a meal or direct some of the surplus or waste to the preferred dog. All this gives the good dog a better chance of survival and leaving genes to the next generation.

But, take note, it was not bred on purpose to be a good working dog. Nor was it trained to be a good working dog. In fact, the real reason it is a good dog is that it grew up during its critical period with the sheep and shepherd. Its working behavior is partly an accident of the environment into which it was born.

The processes of the natural forces operating to shape the physical attributes of livestock-guarding dogs in the direction of "breeds" are fascinating. Like all natural selection, survival depends on feed, reproduction, and hazard avoidance. Long, long after Varro, I saw my first working livestock guardians in Macedonia, just west of Skopje. Sheep and dogs were on their annual spring migration to the Šarplanina Mountains. I followed a flock of more than half a million sheep walking from lowland winter pastures in Greece up to summer pastures along the Albanian-Macedonian border. I sat at one road crossing for fifteen days with a young Macedonian I'd met through the American consulate there, and watched thousands of sheep, shepherds, and dogs wend their way north. At first the dogs were hard to spot, because they were sheep sized, sheep shaped, sheep colored, and had long, woolly tails very like those of the sheep. The dogs also behaved like the sheep, plodding along with their heads down, mile after mile.

Eventually I followed flocks and their dogs in much of Mediterranean Europe. From west to east, every country has one or more regional variations (or, nowadays, they are called breeds) of guardian dogs. Portugal has at least three—the Estrela mountain dog, the Castro Laboreiro, and the rafeiro do Alentejo. Spain has the mastino español and claims some portion of the Pyrenean mountain dog, which is normally thought of as a French breed.

The Italians have one breed, the Maremmano-Abruzzese, although every so often some group wants to divide it into regional varieties such as the Maremmano and the Abruzzese mastiff. Dog reference books a few years ago designated two Italian sheep-guarding dogs—the Maremmano, with a shorter coat, and the Abruzzese, with a longer body. Then someone noticed that the Maremmano appeared only during the cold months, when the sheep were herded to winter pasture in coastal Tuscany (*mare-mma,* the "pasture by the sea"), and the Abruzzese appeared only during the summer, in the mountain pastures of the Abruzzi Mountains along the central Apennines.

The Yugoslavian Šarplaninac dog is named for the Šarplanina Mountains in what is now southwestern Macedonia and eastern Albania. In the winter, when they are in pasture in Thessalía, they are called Greek shepherd dogs. What starts to be apparent is that each population of dogs has several names, based on where it is located when it is seen.

Most of the sheepdogs in Slavic countries are named ovčarka, or "sheepdog," stemming from the Slavic word for sheep, *ovtsa.* Thus, the mid-Asiatic ovčarka, the (north) Caucasian ovčarka, the south Russian ovčarka, the Transcaucasian ovčarka, the Polish ovčarka, or Tatra mountain dog, for a start. The Hungarians have komondors and kuvasz. Turkish guardians, too, have many varieties, including the Sivas, the Kangal, and the Kars, or, generally, the Anatolian shepherd dog (of the Anatolian Plateau). When political boundaries change, the name of the variety changes, at least in the outside world. The Transcaucasian ovčarkas we bought a few years ago are now called Turkish Kars shepherd dogs. Although I haven't studied them all, I've seen pictures of similar sheepdogs working in Romania, Bulgaria, Georgia, Iran, Iraq, Lebanon, and across into Afghanistan, Tibet, Nepal, and in the Gobi portion of China. Just about every traditional sheep culture employs a "breed" of livestock-guarding dog. A recent compilation for KORA, a Swiss carnivore conservation and management program, named twenty-six countries

across Europe and all the way to Tibet with at least forty-eight types of guardians. Their ("breed") names are usually variations on "sheepdog of the (nearby) mountains (or region)."

The modern trend is to ascribe breed status to the dogs of different ethnic groups or national areas. With the current interest in sheepdog breeds and ethnicity, there are more breeds of dogs identified than there are sheep cultures to develop them. It seems that with present-day hobbyists there is virtue in discovering the "names" of ancient "breeds." Within new national boundaries or regions, hobbyists develop rationales (and controversies) about which are the real, the pure, the original breeds. For example, in Turkey recently, some agencies and some non-Turkish hobbyists have initiated efforts to recognize their "breeds" by color variation. The ubiquitous Anatolian shepherd dog, known also as the karabash, which means "black head," has a white variation. Within the past few years this variation of the karabash has gained value abroad, and is becoming one of those newly discovered "breeds"—the akbash, meaning "white head."

Many mountain shepherd dogs are being adopted by breeders, and subsequently registered with national and international kennel clubs. Travelers, diplomats, military people, and expatriates will import a few dogs and start a breed club. Usually they will bring back a pair and find someone else who has also brought back a dog. They form a club, write a newsletter, keep records for several generations, and then apply to a national kennel club, like the American Kennel Club, for the dogs' recognition as a registered pure breed. The membership often disagree on the particulars of what the breed should look like and who has the "real" ones. Then they split into two groups and even change the breed name of the dog.

But how should a breed be identified? Years ago, I asked a shepherd in Portugal, "Is this an Estrela mountain dog?" and he replied, "Are these the Estrela Mountains?" And, voilà, a new breed is discovered! Now when I visit these mountains, even the shepherds are convinced that there is something unique about Estrela mountain dogs.

Once these working dogs acquire identification as a breed, they become the focus of national pride and gain value for their potential in the kennel-club market. Fanciers assert that their breed is best. It is, to me, a kind of master-race mentality of asserting genetic superiority of a regional variety. I have a good friend who claims that the Maremmano-

Abruzzese has to be the best breed of livestock-guarding dog because the Renaissance started in Italy.

It is, or should be, all in fun. But pure breeds are artificial constructs of breed clubs, and the bottom line is money and pride. The dogs living on a mountainside are not a true, pure, kennel-club-defined breed until someone takes a number of them and sexually isolates them from all other dogs. Since shepherds did and do not have the ability to isolate their females in heat, they could not have fashioned a breed, in the AKC sense of the word. However, because of environmental stresses, founder effects, and preferential postzygotic selection, their dogs might have taken on regional characteristics.

A breed standard is a description of a genetic variant, produced artificially by people who have isolated a smaller population from the rest of the species. International club recognition of a breed does not really pivot on biological rules for forming a breed or race of dogs. The terms *breed, race,* and *subspecies* all have similar biological definitions. They all assume that differences in gene (allele) frequency are not randomly distributed over the earth's surface, and that this nonrandomness is dependent on some selection process. *Subspecies* implies that geographic adaptation has taken place which gives a species regional, subspecific characteristics. Finding differences in the coat color of a species on different continents, for example, leads biologists to assume that the color is an adaptation to local conditions. When such variation is found in people, the term *race* is used, rather than *subspecies.* In animals, *race* assumes racial characteristics that grade from one region to the next and have no clear boundaries. *Breed* is a term used mostly for domestic animals. It implies the capture and penning of animals, breeding programs, and arranged matings. It connotes sexual isolation that is achieved not by regional separation or natural selection, but by separation by people and subsequent artificial selection for a preferred trait. To choose white because it is somehow pure, or a corded coat because it is unusual, is capricious. To preserve the regional livestock-dog characters in the captive environment of the breeder is capricious, in that the adaptations to the mountains are not necessarily adaptations to a civilized environment.

As I watched that huge transhumant migration from Greece to Macedonia in the early spring of 1977, I was witnessing a very important mechanism in dog evolution. Transhumance is the seasonal migration of

pastoralists or nomads from their winter pastures at low altitudes to summer grazing higher up, or between lower and upper latitudes. I was tracking a form of livestock management that has been going on for many centuries, surely even before the time of Varro, over two thousand years ago. Stonehenge and other such monuments, built four thousand years ago, may have been calendars designed to tell shepherds when it was time to start for summer grazing. The Bible is in part a history of tribes of shepherds migrating to and from faraway places with their flocks. The Ice Man discovered melting out of his four-thousand-year-old grave in the Italian-Austrian Alps in 1991 might well have been a shepherd caught in a late-spring storm.

The Macedonian migration in 1977 consisted of half a million sheep walking three hundred miles from the lowland Greek wintering grounds to the summer pastures in the Šarplanina Mountains. And then they walked back to Greece in the fall. That is like walking from New York to Washington, D.C., and back every year. For most of us the thought of walking from New York to Washington even once in a lifetime is a little awesome. But thousands of Eurasian shepherds have walked those distances twice a year ever since they were boys.

Understanding the transhumance is critical to understanding "breeds" of livestock-guarding dogs. The transhumance has always had a direct effect on the development of good working guardian dogs, complete with their regional variations. Every dog lives in two places: on wintering grounds in the warmer lowlands, and in cooler, mountain summer pastures. Lowland grasses dry up in the hot Mediterranean summer. The flocks *must* migrate to the fresh mountain meadows emerging from under winter snows. In the fall they *must* get out of there before being trapped by winter snows. If you don't move in time in the spring or in the fall, all the sheep die.

During the winter, Greek shepherd dogs rest on the plains at Thessalía, protecting their sheep from Greek wolves and jackals. Then, those very same dogs walk the three hundred miles through Macedonia to the Albanian-Kosovo border. Many of the shepherds are Muslims, and many speak Albanian and not a word of Greek, Macedonian, or Serbian.

I sit in conferences and listen to discussions about what color Greek shepherd dogs are supposed to be, or Turkish shepherd dogs, or Yugoslavian, or whichever. But I have seen wintertime Greek shepherd dogs transform into summertime Yugoslavian shepherd dogs, also

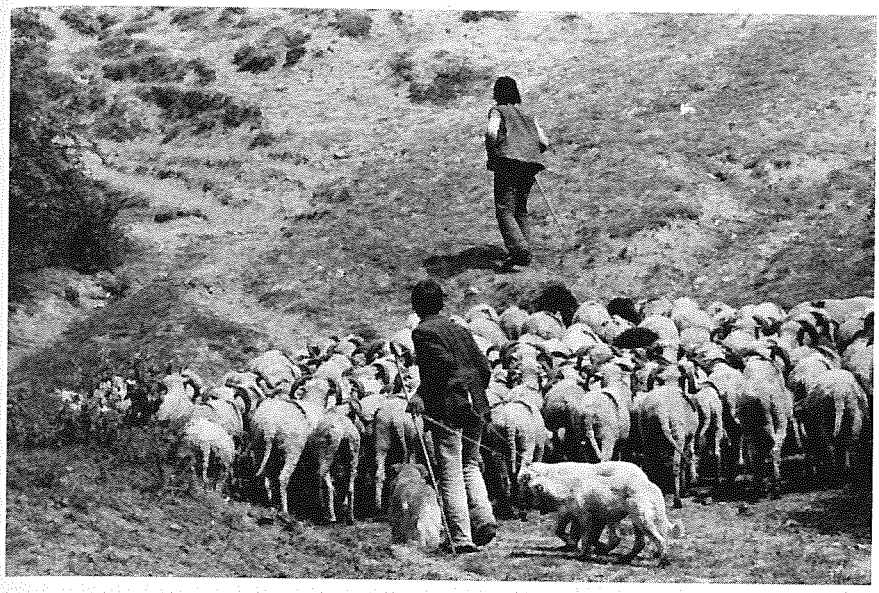
known as beautiful Šarplanina mountain dogs, or beautiful Albanian mountain dogs. Today, with reemerging ancient countries with nationalistic spirits, the summer dog's heritage includes direct descent from the dogs of Alexander the Great's own flocks. During each season, the exact-same dog can mutate linguistically into three or four breeds, all in the same year.

The large livestock-guarding-dog "breeds" typically belong to these nomadic (transhumant) peoples. On every trip their dogs are capable of breeding with local dogs along the way. When they get to the high country they breed with shepherd dogs from other regions and other countries. Pups born on high pastures are sold and given to friends from other faraway places. A single dog's genes thus can be spread along the trail and then, through the puppies, be transported to regions the parent dogs have never visited. And all this can happen in a matter of months. In a single year, a single dog's genes can move thousands of miles. The Foundation for Transhumance and Nature in Switzerland estimates that there are over 77,000 miles of sheep trails worldwide, in width as much as 250 feet. Each migration averages from 370 to 620 miles, one way. Although some of the flocks are now transported by trucks—for example, in Spain, where the last big migrations took place in the 1950s—the animals are still moving great distances, twice a year, and spending long months in the new environment. And in the Middle East and Asia, sheep, and shepherds, often on horseback, still transport themselves.

The impact of the transhumance on dog genetics becomes crystal clear when you understand how many dogs are migrating over these long trails. On the Greece-Macedonia migration I watched, there were better than half a million sheep divided into morras of about three hundred and fifty sheep, a shepherd or two, and two to five dogs. Sometimes we would see two large, placid dogs walking near a shepherd, and behind them, a teenager towing two subadult dogs on strings. And sometimes we could hear baby pups protesting from inside a gunnysack dangling from a saddle.

Half a million sheep, then, would consist of fourteen hundred morras: at least fourteen hundred shepherds and as many as seven thousand adult guardian dogs.

The Macedonian transhumance may be average or small, compared with those farther east. If the proportion of shepherds, dogs, and sheep were the same as in Macedonia, then 414,000 shepherds and about



A little help from my friends. A shepherd boy on transhumance migration helps his dogs to complete the journey. Mutualism between people and dogs requires humans to help dogs to survive and reproduce and dogs to contribute their skills. Breeds of dogs originate when human help is directed nonrandomly at the surrounding dogs. Here the shepherd is aiding white dogs. Why he picked the white ones doesn't matter. In the next generation there will be a higher frequency of white dogs.

1,600,000 dogs accompanied the transhumance on their biannual migrations. Even farther east, China is the third-largest sheep producer in the world, with huge migrating herds around the Gobi Desert.

My guess is that well over a million adult sheepdogs are moving back and forth over three continents in a thousand-mile-wide band from the western Mediterranean to somewhere east of the Himalayas. Each year there is mixing and remixing of endless populations of dogs. Over the centuries, sheep cultures have repeatedly invaded new lands: Arabs into Albania; Sumerians into Hungary, perhaps all the way to Finland; Asiatics into Turkey. Each population gathers genes and brings them home to share with winter companions who have collected genes on their own in other locations. And they have done this twice a year for, what—four thousand years? They have been doing it for so long, the sheep have worn deep trails in the rock, as if glaciers had carved the passes.

For a population geneticist, the mental imagery of a million dogs migrating semiannually across Eurasia and Africa is simply mind-boggling. Every time someone starts talking about breed, my brain wobbles with the thought of the transhumant migrations.

THE TRANSHUMANCE: EVOLVING THE SIZE AND SHAPE

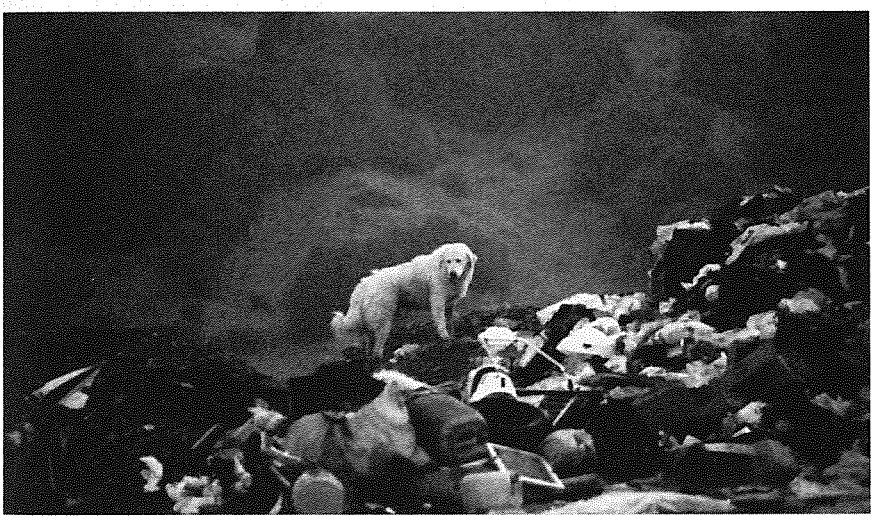
Yes, I believe the ancestors of our modern livestock-guardian dogs arrived in each area with ancient nomads. I believe that the Macedonian dogs came with their Turkish Muslim shepherds years ago from Anatolia, and before that from Iraq and Iran and Afghanistan and China. And I believe that they came to places where there had been previous migrations, and also that they are migrating back to those places. Many of these migrations are not strictly discrete events; some may simply be disruptions of traditional journeys. Many of these shepherd cultures are much older than the nations they cross. Many of these shepherds speak languages different from those in the areas in which they travel or graze. In fact, many of these shepherds seem immune from international restrictions, and cross boundaries without passports as they have done for centuries. When a Masai warrior was asked where his passport was for crossing into Kenya, he said, "My earrings are my passport!"

Because these shepherd cultures are old traditions does not mean that their dogs have remained pure (i.e., sexually isolated) since the original migration. Actually, it means just the opposite. The importance of these long migrations is that the million dogs currently attached to the flocks are a homogenization of populations. The first mitochondrial DNA study I ever did showed that my border collies had identical haplotype patterns to the Šarplaninac I'd brought from Yugoslavia. In another study, an Italian Maremmano-Abruzzese I bought on the Gran Sasso had an identical haplotype to wolves from Romania and southern Russia. Having the same haplotype means that somewhere in the not-too-distant past, my border collies and the Šarplaninac had the same grandmother. In my Maremmano-Abruzzese, protecting my sheep in Massachusetts, was the identical haplotype of some great-great-grandmother whose haplotype also appeared in a wolf from Russia, probably descended from a wolf she met while on the transhumance.

The fact that these migrations are arduous means that the stresses of migration are factors in terms of natural selection. Like all other organisms, mountain dogs are selected by survival of the fittest, in the classic Darwinian sense. Any dog that doesn't or can't keep up with the migration is lost to the livestock-guarding-dog gene pool. In Italy, dumps along the way often have two or three dropout Maremmano-Abruzzeses skulking about. I still wonder why I spent good money for Maremmano-Abruzzeses in Italy when the dumps along migration paths are full of really fine-looking dogs that got left behind.

Dogs on migration have high mortality rates. On the Macedonian migration I saw many dead dogs along the way, mostly hit by cars. And the transhumant dogs come into contact with and spread diseases over great areas. Exploring Turkey for healthy dogs made me realize the extent of those puppy diseases throughout the dog world.

The dogs of the transhumance, therefore, have tremendous selective pressures put on them—by their activity, their feed, their breeding, and their mortality. One of the effects is on their size. They are typically bigger than the average village dog. Watching them, I can see why. First, bigger dogs have bigger strides. Bigger dogs cover more ground with each



Dog in the dump. This dog has dropped out of the transhumance, which, today, means that shepherds couldn't get it onto the truck. It is now lost and has little chance to reproduce in a sheep culture.

step. How many steps does it take to walk six hundred miles? It depends on how big the dog is. Each step contributes to wear and tear on the dog. Each step takes energy. To cover the distance with half the steps means a longer-lasting dog, a dog that has a better chance of making the round-trip. Such a dog is better adapted to keep up with the flock.

Second, their size enables them to endure a deficit of food; big dogs don't react to starvation as adversely as small dogs. Big dogs can carry more fat reserves and store more heat because they have lower surface-to-volume ratios. This is important, biologically. The bigger you are, the longer you can go without food. Animals that endure long, food-scarce Arctic winters (for example, the woolly mammoths and Irish elk of the glacial period) are gigantic species even within their taxonomic families. For mountain dogs, migration is like a winter. Human-waste resources become less stable. Each day the dump is left behind. On migration, people, dogs and sheep all have less food and less time to eat. It is better to start out with lots of reserve, and not take too many steps.

Third, big animals are more likely to survive than little ones the ravages of diseases, adverse weather, and accidents. Puppies, like children, don't have the body mass to survive rapid dehydration, and so they succumb more quickly to the effects of diarrhea. Big dogs are also better at tolerating low temperatures in those mountain pastures. Sudden storms with freezing rain can kill little animals fast. And it may be that big animals are less accident-prone. They cross streams and scale slopes at less risk, in part because bigger bones don't break as easily as little ones.

That is not to say big dogs don't have their own unique set of problems. Not the least of these is that big animals require more food. But in comparison with the wastes on Pemba, sheep cultures provide better-quality waste food. The by-products of sheep—milk, whey, dead sheep, sheep manure, and afterbirths—are rich in protein and fats, which support large animals better. And, like our Chake Chake curs, the dogs would be more protective of this high-quality food, sticking closely to this moving dump, and threatening approaching predators.

Really big dogs (one hundred pounds or more) have terrible problems getting rid of excess heat. Dogs like Saint Bernards and Newfoundlands commonly suffer from heatstroke on a long walk. These two big breeds evolved in cold climates, where heat load is not such a problem. It is doubtful that such big dogs could survive a Mediterranean migration. On the first hot day, the hundred-plus-pounders

would be popping blood vessels in their brains. Most of the dogs we saw on migration were in the fifty-to-eighty-pound range. Farther east, in semidesert countries, the flock dogs get smaller and sometimes have greyhoundlike shapes—which probably adapt them to getting rid of heat. Higher up, in mountainous countries such as Afghanistan and Nepal and into Mongolia, the medium-sized dogs have blockier shapes for conserving heat.

Again, it is natural selection in action, and each regional size and shape is a compromise between at least three factors: the length of stride that is most efficient, the amount of heat generated and stored, and the amount, quality, and distribution of the food source. The size and shape of flock-guarding dogs have to be adaptations to the particular transhumant niche they occupy.

It might seem intuitively obvious that bigger dogs are necessary to defend sheep against wolves, bears, or big cats. But that is only marginally true. Many shepherds around the world have small (thirty-pound) guardian dogs that appear to be just as effective. The twenty-five-pound Masai cattle dogs warn against lions, and the similar-sized Navajo dogs in Arizona are effective against coyotes and pumas. The dogs of the Damara in southern Angola and Namibia are indistinguishable from the local village dogs and protect against leopards, cheetahs, baboons, and a host of other big predators.

Very large dogs are not needed to protect against predators. The mythology about how the guardians defend livestock includes images of dogs out there fighting packs of wolves and being courageous heroes. I have no doubt that occasionally happens. But most of the time nothing happens, because predators don't like to go into a flock of sheep with five dogs watching the scene. Most of the time, guardians protect by being defensive, disruptive, and noisy.

It is rare that a predator will engage a dog in a fight. Actual physical engagement, with teeth, is not to a predator's advantage. Fighting is energetically very expensive. Neither predator nor dog has a lot of surplus energy to expend on dangerous activities. All animals have to assess the "cost" of fighting. The stakes have to be really high to risk it. Most cats—pumas, cheetahs, or leopards—will often retreat from even the smallest dogs. A wild predator injured in a fight—even one it wins—risks infection and an inability to hunt effectively, making it harder or maybe impossible to acquire its next meal.

Most predators are not behaviorally programmed to fight for uncaught prey. They will defend a carcass, but that is very different from fighting for the right to attack a prey.

Guardians warn stock and shepherd about the presence of a predator. The most important part of the equation is (and I can't say this loudly enough) that the predator is being warned. The predator is warned that it has been *discovered.* Someone is watching, someone is focused on this predatory behavior. As I pointed out in Part I, many species, including wolves, are shy about feeding if someone is watching. That one single fact in itself is enough to stop the hunting-stalking behavior of many predators. Animals like cheetahs will often break off eye-stalk behavior if the potential prey discovers them sneaking up.

Stalking a prey, that is, sneaking up on it, while something is barking at you just doesn't make sense. In most cases, approaching and barking at a predator are enough to divert its attention away from the hunt. Most carnivores can't continue hunting if some dog is yapping at them. Further, a predator trying to focus on a fat lamb while the dog is trying to engage in tail-sniffing, territorial, or dominance displays cannot maintain the attack.

Shepherds, whether they have large or small dogs, will keep more than one dog, perhaps as many as five, for every 350 or so sheep. Wolves trying to penetrate the flock are faced with a cacophony of sounds coming from all directions. Many shepherds bell their sheep, which adds to the confusion. Bells are novel sounds for predators and can produce fear-avoidance reactions. The agitated sound of bells on the necks of sheep being stalked or chased also alerts the dogs and shepherds to a broken normal rhythm.

In the Old World, shepherds often tell me that guardians must earn their spiked collar by killing their first wolf. I asked a shepherd in Portugal about his seventy-pound dog sporting an ugly-looking iron collar, "Is he any good?" The shepherd replied, "He has killed many wolves." When I said, "But he doesn't have a single scar on his whole body," the shepherd responded proudly, "That just proves how good he is!"

It's a recurring theme in my life. I sit through lectures where testimonials are given about how effective some dog of the national breed has been, taking on an entire wolf pack and singlehandedly saving the sheep. I sit, remembering my hours measuring the skulls of hundreds of wolves and livestock-guarding dogs and thinking how cute the latter's

teeth are, and how small their heads are, and how weak their bites. Are dog brains so small that they can't see they are outclassed in a fight against a wolf? I don't think so. Every time I've seen a confrontation between a wolf and a dog, the dog looked scared.

I know dogs can fight with wolves. Blizzard, a Šarplaninac-Maremmano hybrid, fought a defensive battle against four wolves one night in Minnesota. The next day, I tracked the combatants for two miles with my heart in my mouth for fear they might have killed Blizzard. I found patches of dog hair and then wolf hair, giving evidence that sometimes Blizzard took a wolf down and sometimes they pinned him to the ground. And somehow he fought his way back to his feet. Blizzard finally got his back to a wall, a corner of a concrete abutment, and made a stand. And that is where I finally found him. The wolves had long since left.

He was fine. There was not a mark on him. Like many canine fights, the altercation had been mostly ritual. Dogs and wolves display their prowess to each other, but nobody wants to get hurt. I don't know what those four wolves were. Three of them might have been big pups that were not much of a match for Blizzard, the old veteran. They may have been with their old dad, who was feeling his arthritis that day. The image of the wild wolf on the prowl rarely includes its individual variations. In this fight, Blizzard figured out that he was outclassed, took up a defensive position, and he stayed right there. Even after the wolves took off, he stayed right there. He was in general a grumpy dog, but he wasn't a fool. He'd figured out that if these guys got serious he could become a pile of meat and fur. And each wolf had figured out that even though the four of them could take Blizzard, he might bite somebody seriously. Each wolf had to assess its own chances of survival, and the pups might not have had enough experience to be very sure of themselves yet.

The fight between Blizzard and the wolves was exciting. But that is not what I want to happen. Essentially, I don't want my dogs fighting. I certainly don't want them killing wolves or coyotes. The whole idea behind our project was to find a nonlethal method of predator control. The idea is not to kill or even displace wildlife. What's important is to keep the wildlife from killing sheep. My favorite guardians are the little yapping dogs of the Damara and the Navajo.

On my farm I have a little (fifty-pound) Maremmeno-Šarplaninac

hybrid named Ellen who is the sweetest dog around. She wouldn't bite anybody, wouldn't fight anybody, and stays with our sheep. We have no losses or liabilities, even though there are coyotes in our forest and visitors in the barnyard. She is everything I want in a livestock-guarding dog. If I could walk to Washington, she could too. I tell people Ellen is a livestock guardian, and in my mind that means she has the perfect behavior and shape to do the job. This is because she grew up in my pasture with my sheep. She and I have a mutualesque relationship—I feed her, take care of her health, and give her breeding opportunities. And I think the reason I don't lose any sheep to predators is because she is there. Ellen is unregisterable by any breed club, but she is, to me, the result of thousands of years of natural selection, and the absolute best "breed" for the job.

BREED GENESIS: SELECTING FOR COLOR

Regionally, dogs often have distinct colors. The high frequency of a particular color can also be in part the product of culling. In an earlier chapter, I pointed out that color means nothing to dogs. Their reproductive games are played with their noses and behavior. What color the individual is plays little role in whether it breeds or not. There is an exception to this, which Varro points out. Good dogs should be well pigmented. Eyes, lips, and footpads should be of "good" color. In my experience, the blacker the better. Pink eyelids get sunburned, and pink footpads are softer and wear out more easily. When people insist on breeding white dogs to white dogs, they eventually create—at the very least—pigment problems. I always liked the Italian Maremmano-Abruzzese in my project except for that white coat. One of the best working Maremmano-Abruzzeses I ever had was named Anna, but because of her pink eyelids, she was constantly crippled with sunburn.

Some of the regional breeds (now) are predominantly white: Maremmano-Abruzzeses, komondors, kuvasz, Polish ovčarkas, Pyrenean mountain dogs. In most regions, white dogs exist, but at low frequencies.Varro preferred white. I suspect this is because white puppies are, for whatever reason, cuter in the minds of people than are darker ones. They are also rarer. In a heterozygous litter, on average, two pups out of eight will be white. I was looking at an Italian Maremmano-

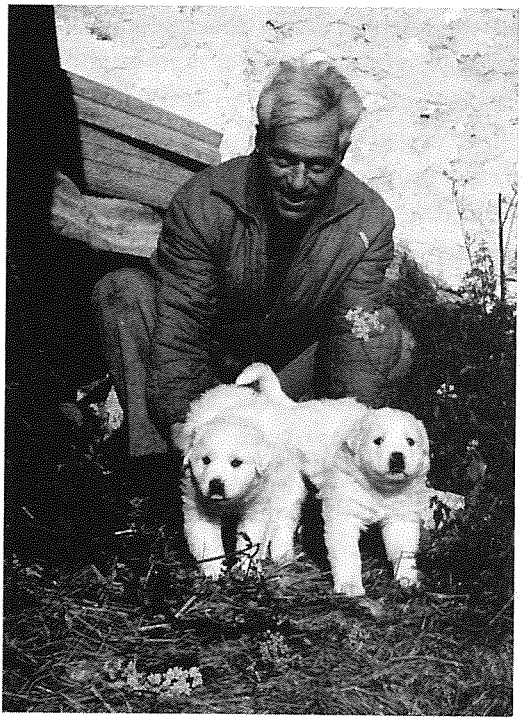
Abruzzese litter one time and the shepherd said that the two white pups were the "pure" ones. He destroyed the rest.

It is fairly common for shepherds to cull litters to two pups. Livestock-guarding dogs tend to have big litters, which are difficult for a nomadic scavenger mother to care for. And it is difficult for a shepherd who is following the grass to attend to a favorite dog if she has a big litter. Culling also means that those two pups are more easily focused during the critical period on their mother and on the sheep rather than on their playful littermates. Hence those two pups will make better guardian dogs.

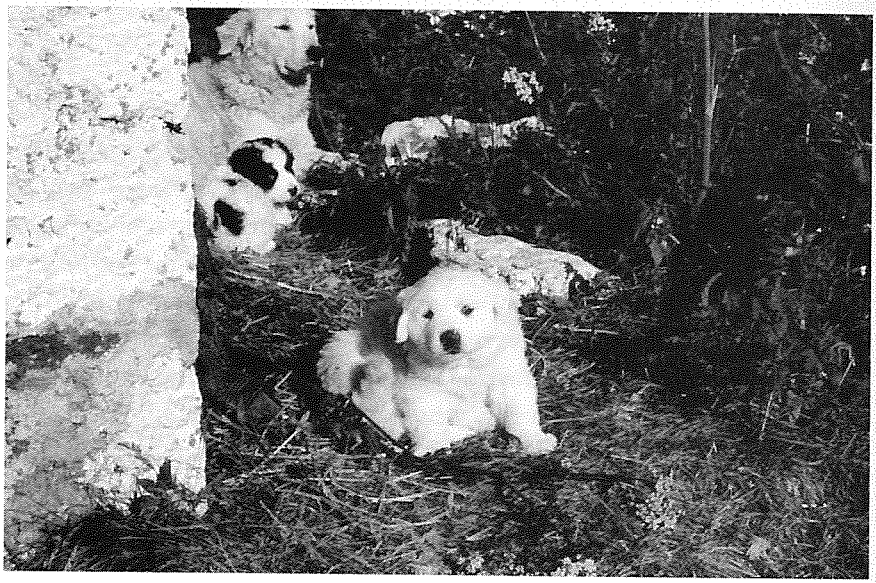
Culling of litters down to two is where the regionally distinctive breed colors are born. Shepherds have their favorite colors. Shepherds identify a sheepdog by its color. If I wanted to sell a dog or even advertise that I had good dogs, I would stick to the regionally favored color. Just as the Italian shepherd thought the two white pups were the pure ones, the Portuguese shepherd thinks the harlequin pups are pure, and the Turkish shepherd thinks the fawn with the black mask is pure. In each case the pups that survive the initial culling have the regional color pattern. If there were no pups in the litter with the regionally preferred color, then none of the pups might survive, or two pups of some other color would survive. It really depends on whether shepherds need replacement dogs or not. Often, shepherds will keep only the male pups. Males make better guardians simply and only because they don't have litters.

The outcome of culling litters down to two pups of the preferred color is that in a few generations, a high frequency of dogs will have coats of that color. Thus when a dog breeds with its neighbor, the neighbor probably has the same color coat.

When I was in Portugal in 1980, the Estrela mountain dog and the Castro Laboreiro were not very uniform in coat color, although jet black was common in the Castro. I couldn't find the other traditional breed, the Alentejo. Now, twenty years later, in response to political/ethnic events, the populations of the three breeds have grown and each has become distinct and easily identifiable by coat color. In the town of Castro Laboreiro in mountainous northern Portugal, most dogs now have a brindle pattern on a dark coat. But—the uniformity of the dog's conformation has not kept up with the uniformity of its color. The reason is simple: shepherds can identify the dog's adult coat color shortly after



Pure Maremmano-Abruzzese. These are the pure Maremmano-Abruzzeses, I am told. It must be true because pure Maremmano-Abruzzeses are white, and the rest of the litter will be culled because they are not pure. The shepherd's definition of pure is not wrong, it is simply different than mine.



Pure Maremmano-Abruzzese. Around the corner is the rest of the litter, the not-so-pure Maremmano-Abruzzeses.

birth, but the size and conformation are impossible to predict in the neonate.

Recently, with the interest in preserving rare "breeds," the breed-identifying characters have become valuable for off-the-mountain sales. As the shepherds' dogs become valuable for other than their working ability, the shepherds pay more attention to what are perceived as breed characteristics and cull those puppies that don't have those traits.

In each region the high frequency of some color is accompanied by the development of a story about why that color is important. Like Varro reasoning about white, northern Portuguese shepherds believe the harlequin coat of the Castro Laboreiro makes the dogs invisible to the wolf because it blends in with the local rocks. The reasons for preferring white are many. Varro's lions aren't much of a factor in Italy these days, but white dogs, they say, blend in with the sheep, so the marauding wolves have to be careful. White dogs are preferred also because the shepherd can tell the dog from the wolf in the dark, and not club his dog hero by mistake. And some will insist that the original flock guardians were white, and white is pure and therefore a sign of antiquity. White signifies to many a state of noncorruption: white dogs aren't mongrels, is the intuition.

Well, the explanations make nice traditions. But closer inspection of the reality belies most of them. Nice white sheep are rare. Rather, their fleece tends to be dirty gray, picking up the color of the substrate. I can usually pick out a white dog among sheep from miles away. I have never met a shepherd who has accidentally clubbed his dog to death, or has even clubbed wolves to death in the dark. I have never met a wolf who has met a lion. I have never met a guarding dog with enough scars to attest to any necessity it may have had for fighting off wolves. Nor have I ever met a dog I thought could or would want to try to beat up a wolf (its small head, teeth, and brain must be intimidated by the idea of attacking big head, teeth, and brain). My best and smartest livestock guardians always showed modest, conservative behaviors around wolves and bears. Wolves and bears usually show reserved behaviors around a group of dogs. Who wants to get hurt so he can't forage tomorrow?

Most of the regional varieties are not white, of course. In the mountains, even the white Maremmano-Abruzzeses often have large yellowish or sometimes grayish spots on their ears or back. In most of the pastoral paintings I've seen in European art museums, a pure-white dog

is rare. Color serves as a marker that the dogs that produced the puppies were shepherds' dogs. In some few areas the white pups survive the culling process. They also attract tourists, who purchase pups for very good money. Other regional color variations attract puppy buyers. Color is their best sign that the pup is an authentic member of the local shepherding livelihood. In some places, pups' ears are cut back, which is supposed to signify a true shepherd's dog. People with working dogs, however, know well that "a good dog can't be a bad color." The best Anatolian shepherd I ever bought was named Bernie. I bought him from a shepherd who knew dogs better than anybody else I'd met in Turkey. Although most of the shepherd dogs in that region were tan with dark muzzles, Bernie was colored like a Saint Bernard, which is a common color among village dogs.

WALKING HOUNDS

> But of dogs there are two kinds, hunting dogs, which are used against wild beasts and game, and herd dogs, which are used by the shepherd.
>
> —Marcus Terentius Varro, 2050 B.P.

> Hippolyta: I never heard so musical a discord, such sweet thunder.
>
> Theseus: My hounds are bred out of the Spartan kind,
> So flewed[1], so sanded[2]; and their heads are hung
> With ears that sweep away the morning dew;
> Crook-kneed, and dewlapped[3] like Thessalian bulls;
> Slow in pursuit, but matched in mouth like bells . . .
>
> —*A Midsummer Night's Dream,* Act IV, Scene 1

Besides the livestock-guarding dogs, Varro also wrote about hunting dogs 2,050 years ago. I call them the walking hounds. Beagles are a good modern example of a dog that accompanies a person into the field. In the

1. With hanging cheeks.
2. Sandy colored.
3. Flap of loose skin hanging from the throat.

course of the walk both person and dog end up chasing a rabbit or other quarry. Other walking hounds are the otter hound, mink hound, wolfhound, coonhound, and so on. Since there are over two hundred recognized breeds of hound, they may well constitute the largest number of distinct types of dogs. On Pemba I am a member of two genet-hound hunt clubs and have participated in a monkey-hound hunt club. (Genets are in the mongoose family, but superficially they look like big weasels.)

Walking hounds are essentially distinct from gun dogs (see Chapter 6), which are the pointers, setters, and retrievers. If you have a subscription to *Gun Dog* magazine, you won't see any mention of the walking hounds. Gun dogs have special arrangements of innate motor patterns. The walking hounds are more of a generic dog. Breed differences in behavior are primarily the result of the puppies' developmental environments. I think of them as generic dogs in the same way I think of livestock-guarding dogs as generic dogs raised in a sheep culture. Granted, the distinction between walking hounds and gun dogs is not always clear-cut. But the point is that regardless of selective pressures, a shepherd's dog or a walking hunter's hound will not express breed-specific behaviors unless strict attention has been paid to its developmental environment.

The walking hounds have identical evolutionary histories to the livestock-guarding dogs. They start as village dogs somewhere in the distant, or even in the not-too-distant past. As village dogs, they grow up in a hunter's environment. Those that "learn" to hunt well are favored by people. As favored individuals, they get better feed and better health care, which in turn may result in better reproductive opportunities. Those reproductive opportunities may frequently be with other local dogs that also are favored for their hunting behavior. In addition, hunters cull, or withdraw support from, dogs they don't like. Natural selection, human support, and culling produce regionally distinct dogs even though no one is actually breeding dogs.

The walking hounds are nestled here in this book between livestock-guarding dogs and sled dogs. They are here because their evolution is intermediate between the self-trained, self-selected livestock-guarding dogs and the sled dog, where every detail of the dog's morphology and behavior is scrutinized by the driver. The difference between the walking hound and the livestock dog is that the hunter consciously manipu-

lates the puppies' environment so that the adult dogs not only learn how to hunt, but what to hunt.

Walking hounds might be the earliest example of useful dogs. By useful, I am implying the symbiotic sense of mutualism. These dogs could be the oldest in the sense that any village dog could be developed into a walking hound. Since the generic village dogs could have evolved several thousand years before sheep, the opportunity for dogs to be walking hounds preceded the opportunities to be livestock dogs. People could have raised (imprinted) and paid attention to the well-being of the dogs, and trained the generic dogs soon after the village dogs evolved. Since it is so easy to produce a walking hound from the generic village dog, Mesolithic peoples could have produced animals that were predisposed to hunt with them.

It is possible, but I doubt it happened until much later in the Neolithic age. I will come back to this question in a minute. But because people used village scavengers to hunt with is not evidence that they bred dogs for this purpose, or that there were breeds of such dogs in any sense sexually isolated from other dogs. Indeed, the great number of modern "breeds" suggests that it is a very easy leap from scavenger to hunter, and every region of the world and every era of history has repeated the process over and over.

In Chapter 2, I described village dogs that live in a commensal relationship with people. I used an anthropological technique in which I compared the life of modern Pembans with that of the hunter-gatherers of the Mesolithic age. I said that Pemban dogs were not strictly comparable to the original dogs, but I thought the selective processes and forces might have been illustrative of how it all happened. Although I said in that chapter that Pembans tend not to like dogs and avoid them, I was focusing on the hunter-gatherer portion of their population and ignoring (for the moment) a segment of the agriculturalist population that does like dogs (kind of), and uses them regularly for hunting. Pembans have walking hounds, and they use them to hunt vermin.

I was studying the feeding behavior of village dogs on Pemba when quite by accident I came across a monkey hunter with six dogs. They looked just like any other village dogs except they were following him, which is rare and unusual behavior for dogs on Pemba.

This man hunted green monkeys because they are considered a crop pest. The mango farmers had recently hired him to kill the monkeys

depredating their groves. It was a job and it paid well. I had run into monkey-hunting dogs years ago on St. Kitts, in the West Indies. There the green monkeys ate sugarcane, and the hunters were paid a bounty for every one they killed. But on St. Kitts the carcasses were valuable as human food: "Monkey meat is sweet," I was told. When I asked the Pemban hunter about this, he just screwed up his face, as if I'd suggested eating rats.

Did he have good dogs? He told me that he had very good dogs and had caught many monkeys. He took his bare foot and rolled a dog upside down to show the scars on its lower jaw and neck. (He didn't really like touching dogs, and this footwork was an interesting compromise for displaying his pride in his dog's prowess as a monkey hound.)

I asked if this demonstration of scars proved this was a good dog. "No," he said, "I know I have good dogs because I always win the hunt club prize for the best dog." Well, you could have knocked me over with a feather. The hunt club prize?! I was amazed, because supposedly, as I described in Chapter 2, these people don't like dogs. And they don't. But at the same time, there are the dog-oriented hunters.

A good monkey hound. This is a good walking hound, not because he is scarred from many battles with monkeys, but rather because he is a frequent winner at the local hunt club. The owner has just rolled the dog over with his foot. He likes dogs, but he doesn't really want to touch one.

Hunters on Pemba hunt varmints and crop pests with dogs. Green monkeys are destructive to mangoes and vegetable crops. Indeed, monkeys can eat anything people can, and compete with people for food. The other major pest is the beautiful genet. It lives around the villages and steals chickens and ducks.

The important point here is that the dogs and the people are not hunting for food. Pembans are Muslim and have strict rules against eating monkeys or genets. In England, foxes and minks are the pests, and they aren't eaten. In America, we don't eat coyotes or rats but both are hunted by people with dogs. Hardly anybody eats raccoons. This is not unusual behavior for hunters.

In many parts of the world, farmers and ranchers hire hunters to rid their property of pests. In Portugal, wolf hunters parade their victims from town to town, and the shepherds tip them for killing such a terrible varmint. In America, ranchers will pay for hunters to come with their dogs, find coyotes, and kill them. In past decades the hunters not only got bounty payments from the ranchers, they could sell the furs. Terrier hunt clubs in the United Kingdom will go to people's farms and spend the day killing rats. In the old days, farmers would also pay for hunters to kill badgers, minks, and foxes. I interviewed a farmer in England who invited a lurcherman to get rid of the rabbits. Seven rabbits, he told me, eat as much grass as one sheep. The hunter got 450 rabbits, and the farmer claimed he had barely affected the population. Rabbits in this case are not considered game or food but simply a pest species. My favorite pest-species story involves the trout and salmon clubs that paid otter hunters to rid their streams of salmonid-eating "pests." Isaac Walton, the "compleat" angler, thought otters were the most terrible of vermin.

A lurcher, by the way, is a crossbreed between a greyhound and some other breed. The other breed is often a border collie, but can be almost anything—saluki, Bedlington, American pit bull terrier, Airedale. All are popular, and all have a special trait that blends well with the greyhound to accomplish a specific task. The reason I mention this is to reinforce the point that any dog will do if it has the ability to perform in a particular environment. The other point is that there is a long tradition among walking-hound hunters to create their own dog for specific purposes.

When people invite hunters to bring their dogs and rid an area of vermin, they do so believing that the hunters will be successful in alle-

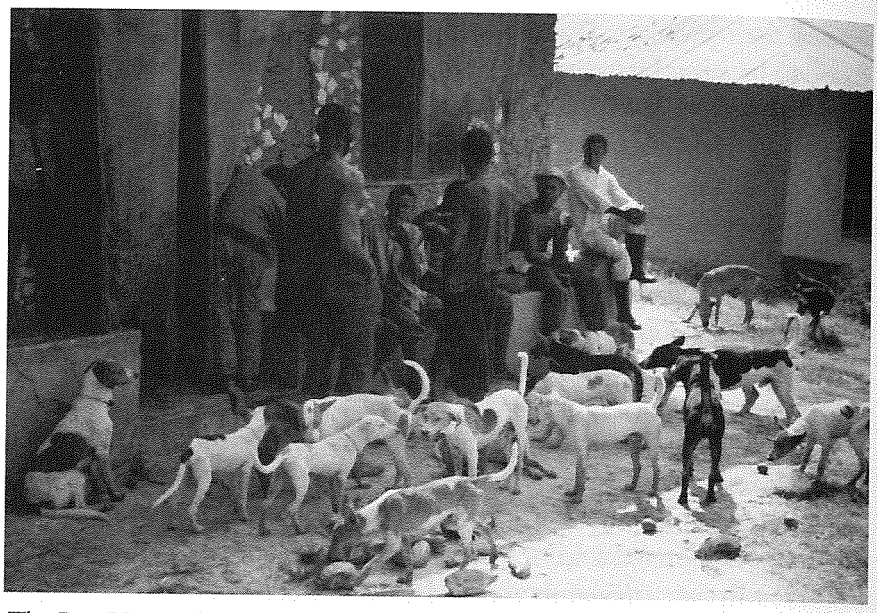
viating their problem. But here is where our story takes a telling turn. In every location I have ever visited, every hunt is performed by people whose passion is not for the hunt or the kill, but for watching the dogs. The hunt is, or has become, sport. Like my monkey hunter who gets paid for hunting on a particular farm, the payment is just a bonus for what he would be doing anyway.

I joined two of the genet hunt clubs on Pemba, and not because I wanted to kill genets. I just love to watch the dogs work. I bought myself a really good dog, and I left her right there on Pemba. She is a top dog in a top club, and I'm proud of "my" dog. I send the huntmaster money to take care of my dog, and I hope she has puppies and I'll support them. I was such a good patron that they named one club after me (at least while I was there).

I love the hunt clubs on Pemba. I'll show up somewhat erratically and say, "Let's have a hunt." Everybody, including the village dogs, brightens up, arrangements are made, and a meet is on.

We collect at an appointed place. There will be twenty club members, a gallery of spectators, and fifty dogs, each following its own hunter. After some rallying ceremonies where tales of previous successful hunts are retold, off we go to where someone has spotted a genet. Then there is a lot of yelling and beating of bushes with sticks. Sooner or later a genet is awakened (they are nocturnal) and begins to move. A dog marks the event with a yipping cry, and the people and dogs are off on the chase. The excitement rises. There is a lot of shouting of instructions—head it off at the pass! Then we lose the genet. And all goes quiet. Then we find it again and dogs cry and people shout more directions. Sooner or later the genet is caught, maybe by a person who manages to hit it with a stick, or maybe the dogs bite it. A dog will pick up the genet and parade around with its colleagues tugging and pulling at it. Everybody rests (especially me) at the kill site and the huntsmen gather around and talk and laugh happily about the hunt, recounting moments of near misses, successes, and glory: "Did you see my dog when . . ." or, "I think such-and-such dog has lost it."

The genet is then impaled on a stick and triumphantly carried out of the forest. At some point the party stops again, a ritual fire is built, the genet is roasted and cut up, and each dog gets a tiny piece. (That is usually the signal for my annual contribution.) It is truly exciting, with good comradeship and wonderful dogs. That is why I am there. And it turns



The Ray Hunt. These are the best dogs in the world, not because they have caught the most genets but because ours is the best club. The best club always has the best dogs (if that makes any sense).

The Mink Hunt. Note the similarity of the English mink hunt to the African genet hunt.

out that is why everybody else is there—to watch the dogs and swap stories with your buddies.

Besides having a good time, is it useful work? Is it a symbiosis between people and dogs? Are the dogs chasing and killing genets performing symbiotically with humans for their mutual good, their mutual economy? Is the motive of the hunters to get rid of pests so there will be more chickens for starving children? Do I support the club dogs because they save chickens for this protein-poor country?

I don't think so. I've asked the question many times, "Why do you hunt genets [or monkeys]?" The first response is always "It is fun to watch the dogs work." I push and push for a better, more socially responsible answer. And I never get it. Then I rephrase the question: "Aren't genets a terrible pest?" And the light dawns as to what I'm looking for and they tell me what a terrible pest genets are and why they need to hunt them. Substitute "monkey" for "genet" on St. Kitts, and "mink" in Great Britain, and "coyote" in America, and it's the same story.

Fox hunters have a slightly different take on the scene. They will tell you that fox hunting is now tradition. They actually have to raise and release the varmint. One avid rabbit hunter in England is also the leader of the rabbit conservation movement. He doesn't want this terrible grassland pest to be eliminated, because there will be nothing left to hunt.

It seems to me that there are several lessons from our Pemba study of the walking hounds. First of all, the walking hounds are associated with the agricultural culture and not the hunters and gatherers. Could we interpret that to mean that the original use of walking hounds was a product of the Neolithic and not the hunting-gathering Mesolithic age? Could we contend that hunting dogs were from the beginning varmint and sporting dogs, and not used for hunting food?

Using dogs to capture food for humans is not unheard of. But I have always wondered whether, in the great scheme of things, meat-hunting dogs were ever very important. Although one popular hypothesis is that people originally selected dogs as hunting assistants, it never made much sense to me. Some claim that cooperation between wolves and humans, combining the power of the human brain with the senses and agility of the wolf, could increase the take-home pay for each—if they cooperated and shared the results. But I'm unaware that any of these concepts carry the calorie counts from start to finish, or even try to demonstrate an advantageous calorie intake per unit of effort for either species.

Mostly, people assume that since wolves are social hunters and people are social hunters, linking together would benefit both. They assume that tame, trained wolves would share a vital resource with humans.

From a biological viewpoint, when I calculate the energy costs to humans and dogs cooperating in food-gathering behaviors, I don't find a significant advantage for either. A formal study needs to be done that would measure how much energy a dog puts into a hunt, and add how much energy the human puts into it, and then divide that figure into the number of calories returned by the captured-prey species. The formula might be: # of calories in a rabbit ÷ # of calories expended by humans and dogs to capture rabbit.

If the answer is greater than one, then the hunting mutualism would be confirmed. In my own dog-hunting experiences, five beagles and me chasing after a rabbit need caloric subsidies to sustain this activity.

With this in mind, when I contemplate the evolution of highly specialized retrievers from some wolf ancestor, I discard the wolf-into-hunting-dog model. I assume that in the late Mesolithic period, both people and wolves didn't have the sumptuous food-reserve budgets that my retrievers and I have. For the ancients, the energy in–energy out formula did not include the luxury of heading for the grocery store if the game got away. Besides, where did they get the energy to invest in this taming-of-the-wolf experiment? Wolves of the late Mesolithic, like any top-level predators, were on a very tight energy budget. After all, twelve thousand years ago there was a noticeable decrease in the size of wolves, suggesting that the environment had become less bountiful. If most wolves are or were starving to death (which is the basis of the Darwinian assumption), then sharing food with another species is not going to be a top priority. I expect that Mesolithic hunter-gatherer populations had to pay tribute to the Malthusian theorem, that increase in human numbers outstrips food production or availability. The average size of humans also decreased twelve thousand years ago, further suggesting a decline in the amount or quality of food. The human population must have been limited by food competition. My guess is that hunter-gatherers behaved in energy-conservative ways, just like other animal species. Some fellow experimenting with a caveful of hardly socialized pet wolves doesn't sound energy conservative to me.

The history of hunting with dogs, especially hunting large animals like deer, where the energetic payback might be better, shows this activ-

ity to be the privilege of the sporting wealthy. It is the activity of people who have access to surplus resources. It takes a lot of work and time to train a dog, and it takes knowledge to breed a dog that can do the job. And it doesn't always work that the dog turns out to be a successful dog. I just don't believe that dogs were ever significant as mutual symbionts in food gathering, but I shall remain open-minded.

But let's ask the question whether the original hunting dogs could have been varmint dogs. The more I observe the walking hounds, the more I convince myself that the original walking hounds were varmint dogs. If that is true, then it places mutualism with these dogs firmly in the Neolithic period (less than ten thousand years ago) rather than the Mesolithic. Varmints are animals that steal our domesticated crops. Once domestic crops were planted and became a significant portion of the human diet, varmint hunting made sense. Pests are ever-present around a village. They are a nuisance and they compete cunningly for human food.

Does varmint hunting satisfy the energetic requirements of the participants? Does it pay village people to keep a pack of varmint dogs around? In other words, is the answer to the formula—pounds of food saved by killing varmints ÷ energy required by humans and dogs to find and kill varmints—greater than one?

Maybe—but again, I doubt it. I realize that one of the main chores (energy expensive) of any farmer is protecting the crop. Western ranchers invest heavily in killing coyotes and protecting sheep from a variety of predators. One of my friends spends better than 50 percent of his ranching time protecting sheep from varmints. But, figuring that on Pemba the energy expended by the fifty dogs and the thirty men running around excitedly trying to catch a four-pound genet is in some way equal to the amount of energy contained in all the chickens that genet would have eaten in a year, is a tricky calculation. I suppose it is possible, though—after all, these Pemban dogs are still little dogs and still primarily living from village wastes. If, however, the English mink hunters are buying dog food and transporting dogs by trucks over hundreds of miles, then there is no way to balance the equation. The honest answer is that hunting with dogs is simply good sport.

The first lesson from the modern Pemban hunter-gatherer societies is that it is not their hunter-gatherer culture that supports these hunting-dog activities. It is their agricultural activities that initiate the evolving

mutual symbiosis. These hunting dogs are not supplementing the food-gathering activities of humans. The mutualistic relationship between people and dogs is centered around crop protection. One could argue that since dogs are the beneficiaries of the wastes from the crops, participating with humans is an example of true mutualism.

The second lesson I learned from participating in the Pemba hunt is that hunting is initiated by people. For the most part, dogs show little natural interest in hunting. In order to be a hunting dog, wee puppies have to be removed from their natural environment and raised during the critical period in a special environment that predisposes them to hunt as adults.

Even then dogs rarely go, wolflike, searching for game. They lie around the village eating waste products (some of which their human hunters save for them). The hunt commences with the humans rallying at some predetermined location with their dogs and then proceeding to the hunting area. The dogs are following the people. It is the people hunting excitedly that motivates the dogs to hunt. It is *social facilitation.* The dogs are hunting because the people and other dogs are hunting. They are hunting genets because people and other dogs are hunting genets. They are killing genets because people and other dogs are killing genets. If my Pemba hunt friends walked to a potential genet territory and yelled and screamed and startled a genet, but then turned and headed for home before the genet was caught, the dogs would follow the people home. Some of the modern walking-hound breeds will hunt on their own. In these cases, the motivation to hunt is internal rather than external. They become more like the gun dogs in Chapter 6.

Walking hounds are not—repeat, not—hunting to eat. Dogs don't participate because they might get fed at the end. And, indeed, when they catch and kill the genet, they don't eat it. There is no feeding frenzy. They don't seem to have the dissect motor patterns. If the people cut open the genet, the dogs will eat it. Again, they seem very like livestock-guarding dogs in this respect. And for the sled dogs in the next chapter, the immediate reward for the dogs is playing with other dogs and people—playing in the sense that there is no biological reward in terms of food or reproduction from participating in this energy-expensive behavior. It is sport for the dogs as well as the people. They hunt to fulfill social needs.

Are these Pemba dogs different from our modern, carefully bred

Western hounds? I don't think so. I think they are just as sophisticated. With a television film crew, I participated in a British mink hunt and a Pemba genet hunt. The British let the dogs out of the van, walked to the stream, blew horns, and made strange noises. The dogs got excited and followed the people. There were only two differences of any note between the two hunts. First, the Pembans didn't dress up in red and yellow jackets, and second, the Pemba dogs caught their mongoose.

The third lesson from studying Pemban hunter-gatherer-agriculturalists was the revelation of how one develops a species-specific genet hound. How can you get a dog to chase only genets, or foxes, or minks? Here again, I doubt there is any difference between the ancient and modern systems. Start with any village dog growing up among chickens and cows. Start with tiny puppies. Tie them up and feed them. Tease them with a dead-genet skin. As they grow up, take them on the hunt with other dogs. Encourage them to hunt. They will learn how to hunt and what to hunt from other dogs. From then on, each time the dog goes out, the hunt will reinforce the focus on the specific quarry. This script sounds a lot like the Navajo recipe for raising a livestock-guarding dog.

When I went on the hunt in Pemba with the fifty dogs, not all of them were hunting and it seems to me that at the end some of the dogs had already gone home. When I interviewed the mink hunters in England I got the same story. Mink hunting in England has recently become popular. Minks were introduced to England only a few years ago. At the same time, otter hunting has been discontinued because otter populations are dangerously low. The newly formed mink-hunting clubs have drafted dogs from the other clubs, dogs such as foxhounds, otter hounds, and rabbit hounds, and have "taught" them to hunt mink. "We don't have a mink hound yet," says one expert. "It sometimes takes a dog years before he gets the mink message," says another.

To call them a mink hound or genet hound suggests breed: "We don't have a mink hound [breed?] yet." But maybe the respondent did not mean breed in the AKC sense. The fact that some hunts are composed of dogs with uniform conformation, color, and behavior does not mean they are a sexually isolated population of dogs especially adapted to hunting mink. In a really fine hunt, all the dogs will be the same size, have the same cry, be of the same color pattern. This is important in the best hunts because if all the dogs are the same size and shape, they will run at the same pace and with the same motions. That

increases the likelihood that they will run together. That in itself increases the mob effect and the self-stimulation to carry on. If some dog gets too far ahead or behind because it is a faster or slower runner, it loses interest and goes home. If all the dogs in the pack are homogeneous, with like behavior, then the excitement is maximized.

The first step in hunting-breed formation is to develop a hunt. Within the framework, some hounds will be better than others. Some dogs will follow the huntmaster, or find the mink, or—of great value—mark the mink better than others. Some will do this because they work together with other dogs. The dogs that stand out will get better care, better training, and ultimately more opportunities to reproduce. Those which stay in the village or don't mark the mink might be culled, or at least not be included in the breeding program. Like the transhumant livestock-guarding dogs, some of these hounds will simply get lost or abandoned.

Each new generation of hunting dog is better, and also looks more and more alike. It is very much the same process of breed development as for the sheepdog. But note, these carefully selected dogs are not a breed. Individual dogs do not have intrinsic (genetic) capabilities beyond their own hunt. If I took a really good dog and put it into a different hunt with dogs of different size, it might be a complete flop, simply because it can't work uniformly with these other dogs.

Getting a dog to focus on a single quarry species is the result of two separate processes. First, the pups grow up in the village or on a farm and they are imprinted on the farm animals. Modern foxhounds, for example, are raised by "puppy walkers." This is often a local farmer who takes care of the pups right on the farm, through their critical period of social development. Thus the dogs cannot and will not show predatory behaviors to farm animals, just as livestock-guarding dogs don't hunt sheep. The resulting adult foxhounds can chase the fox right through a farmyard without swerving toward the fleeing domestic stock.

Second, the dogs learn to hunt the target species. From an early age they are taught by various methods, including the dragging of a carcass lure. They learn what the fuss is about and which species is to be tracked. Primarily, however, they learn through social facilitation with other dogs. It is easy to train a sled dog if you have a team. It is easy to train a mink dog if you have a mink hunt. Once the British develop a good mink hunt, specialized mink-hunting hounds will quickly follow.

The hunt takes on a conformation of its own. The local hunt becomes a tradition that involves the entire community. It is a cultural habit. Repetition and anticipation generate excitement in dogs. In the next chapter, I'll describe a similar social facilitation existing within sled dogs, which run without chasing anything. These evolving mutual relationships with people of walking hounds and sled dogs are not based on modified wolf-pack behavior, but simply on self-stimulating social relationships between the dogs and the people. Food is not the goal; the activity itself is intrinsically rewarding. It is good sport.

In many hunt clubs one person cares for and develops the dogs, while others (like me) buy in. The pride is in keeping the dogs in a very good pack, one with uniformity and identifiable features. A unique color becomes the symbol of a particular hunt club, a particular expert, or a particular region. One can find wonderful examples of these color markers among the foxhounds, and even in the American coonhounds.

The idea that the marker color pattern is indicative of an intrinsic quality of a dog is a major misconception. It isn't an American foxhound that is being marked, it is a hunt club, and the dog is only as good as his club. Many modern breeders select dogs, in prezygotic matings, as if the coat color were symbolic of a good dog. The only good thing about the dog is that it is sixteen inches tall, like all the other dogs in the hunt. My friends who hunt with dogs for mink and genets are never breeding for color, but rather choosing good dogs that have that color.

It was the same with the mountain shepherds who did not cull the puppies from good females that had the preferred color. Similarly, Pemban huntsmen not only give good dogs more care, but they give the puppies of good dogs more care. These puppies have value. Whether hounds or shepherd dogs, puppies from notable dogs can be easily sold. In many of these rural, agricultural societies, the descent over the generations is matrilineal. Usually, nobody knows who the father(s) are. In African hunt societies, there is recognition of good mothers or even a good pack. A well-bred puppy can be from a good pack with no recognition of who its parents are. After all, if hunting is learned, then better hunting is learned from better dogs.

Selecting puppies from good mothers is a form of breeding. It isn't exactly prezygotic selection, but it is getting there. By having mostly hunting dogs in the area, the best female is most likely to get bred by the best hunting dogs. Again, the parallel with shepherd-dog hus-

bandry is striking. Going back to Varro's advice to his shepherds on how to buy a good flock guardian, we read, Don't buy one from a hunter. And, if you are a hunter, you shouldn't buy from a shepherd. Once the pup is imprinted, you can't get it to behave another way.

What if we calculated the mutual value to each species (hounds and humans), and determined that there was no ecological benefit to hunting varmints? It turns out to be just plain sport. The vast number of dog people since the beginning of dogs just like to see the dogs run. The benefit to the dogs, then, is that they get better care and become valuable. The benefit for people is psychological—and not just for the hunter but for the community. The farmer feels cared for since the hunters and dogs are trying to rid the area of pests. The hunters are local boys showing their prowess as hunters and dog people. They take pride in their hunt and everybody else likes to watch. During the filming of the mink hunt in England, a hundred hunt-related people spent the day running around in the rain.

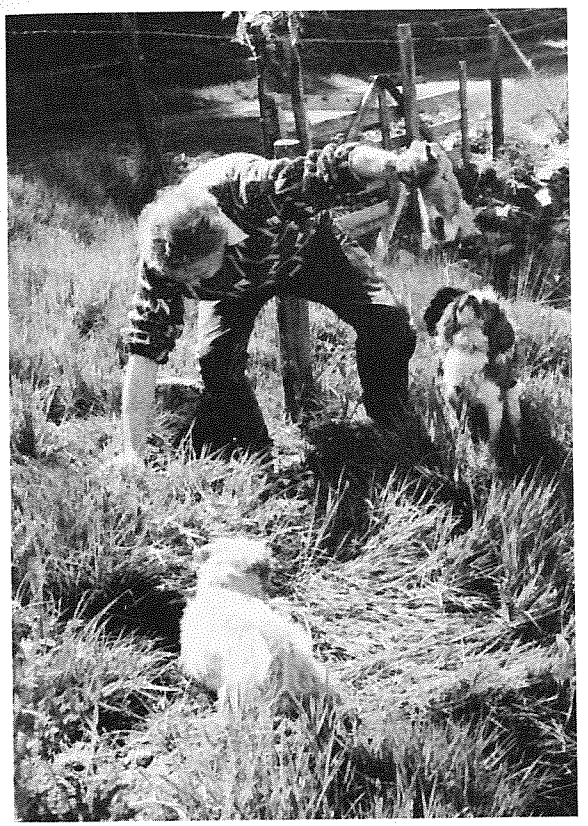
If I were going to contend (which I do) that pet and companion dogs bestow psychological benefits on their human companions, wouldn't I have to extend that consideration to all the people who take pride in the local hunt? I have a good dog and I feel better about myself even though she is in Africa. I have a good dog and other people want me to belong to their club. I like to watch dogs run, which connects me to communities of people that also like dogs. Certainly the zeal hunters show for the activity suggests it is very important to the participants.

What is the benefit for the walking hounds to be a part of this symbiosis? Is it true mutualism for the dog? I think that because the walking hounds are supported and cared for and valued, they probably have a better quality of life. To be born of a good mother probably increases the chances of survival, and perhaps longevity. This would be especially true on an island like Pemba, where the commensal scavenger isn't liked. Although dogs are spread out across a village fairly thinly, a hunter's yard may be full of dogs. In other words, the dogs are nonrandomly distributed across Pemba. The hunting dogs exist in higher concentrations than could be supported by only village garbage. Hunting dogs benefit from their talents.

The important message in this chapter is that any dog will do for any job if raised and trained properly. Brian Plummer in Scotland has a pod of King Charles spaniels that tears across the countryside searching for

bunnies and killing them. Here is a hunt that is seriously uniform, to say the least. These spaniels have been a lapdog for centuries. They have not been selected to be hunting dogs. But Brian, who prides himself on being a good dog trainer, uses them to illustrate his point: if you think about it and work at it, and you know your dogs, you can teach any breed to do any task.

I made the case to Brian that any dog can do anything *only* if it is socialized correctly when a tiny puppy. I was sure Brian would see this as an exception to the rule that you can train any dog to do any task. He didn't seem to. Then I asked Brian if one could train King Charles spaniels to hunt lions. Or could King Charles spaniels join a transhumant migration, and guard sheep against wolves, even if they were socialized properly? Well, Brian's a good dog man; he knows dogs. He just gave me a big grin and asked, "What do you think?"



Brian Plummer and King Charles spaniels. Much of a dog's behavior is shaped during early development. These rabbit-killing spaniels are Brian Plummer's testament that you can train any dog to do anything.