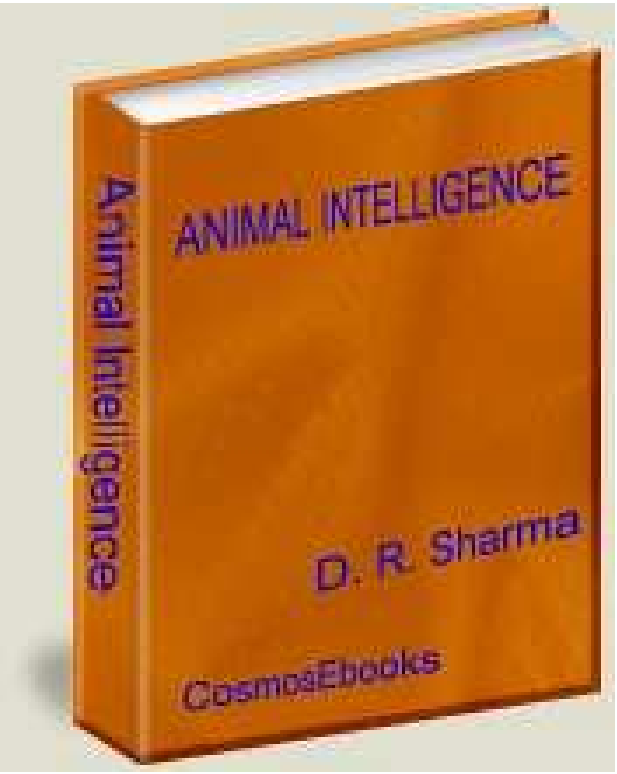
INTELLIGENCE IN ANIMALS



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Introduction

Consciousness is the very basis of existence. On the face of it this statement may seem to apply to sentient beings only but as we shall see later, it is true for the entire universe – everything in it. At the most elementary level matter is simply an aggregate of electrons, quarks and other particles, which in turn are aggregates of packets of vibrational energy. There is no reason why consciousness would reside only in some combinations of the elementary substance and not in others. A rock out there – does it have consciousness? The ocean water that changes into ice, vapor, and back into water – does it have consciousness? These are not frivolous questions and we will try to answer them in this book.

We often associate consciousness with feelings. While feelings arise due to consciousness, they do not say anything about it. In particular the Western thought has been very much influenced by Descartes' dictum "I think, therefore I am" (*cogito ergo sum*), who confused thinking with consciousness. Thinking is a function of the mind and mind owes its existence to consciousness. It is an attribute of consciousness and is as nonphysical. It is the existence of mind and not consciousness that makes the difference between animate and inanimate objects. Does every living organism have a mind? People have been struggling to find the answer for quite sometime but so far there are only speculations. We know that humans as well as animals have mind. But what about plants? Intelligence is an attribute of the mind and even in humans its variation is quite large. So we expect the same distribution in animals. It appears though that within the same species the distribution is nearly uniform.

A problem in understanding consciousness, mind, and intelligence is the tendency to anthropomorphize and view it only from a human perspective. Man being at the highest stage of evolution is automatically assumed to have intelligence superior to other creatures. But there is no rational basis for this assumption. There is ample evidence to suggest that other living beings – animals and insects - may have equal if not superior intelligence. The intelligence in some animals seems astounding given the fact that unlike man they do not have the vast repertoire of science and technology at their disposal.

The question whether animals have intelligence is moot now. After decades of discussion and research it is generally believed that animals do possess intelligence. Since intelligence and mind are coupled with consciousness, the discussion now centers on whether animals do have consciousness. Here again the question is rooted more in philosophy because consciousness is almost impossible to define and study. For those who believe that the entire creation comes out of consciousness this question

is also moot. Animals do have mind and intelligence. The questions that are usually raised in this regard pertain to how they use them. Are they capable of applying insight to solving problems? Do they have abstract concepts and reflect on the past and worry about the future? Do they have an awareness of the self and their own mortality? To answer these questions we discuss in detail the life patterns of four different species – ants, spiders, honeybees, and a small bird native of Southeast Asia.

Ants – Nature's Civil Engineers

Ants are one of the oldest inhabitants of this planet having lived here for more than one hundred million years. They can be found everywhere except in regions with extremely low temperatures. The number of species of ants is around twenty thousand, larger than that of any other insect or animal in existence. They are so numerous that the weight of all the ants in the world is estimated to equal the weight of all human beings in terms of order of magnitude.

It is also remarkable that the patterns of the life and behavior of ants are in many ways much similar to those of human beings. They are social animals that live in large colonies. They build underground habitats that are almost like complete cities with sections earmarked for specific functions. They have their own system of communications and carry out group activities with cooperative effort. There is a division of labor in the community based on age, learning, and also on hereditary traits*.

Ants are small creatures the body length ranging from one-sixth of an inch to almost an inch. The egg-producing female has the largest body. The ant's body is very strong for its size. It consists of three main parts – the head, the trunk, and the rear. It has six legs all attached to the trunk. At the end of each leg is a sharp claw that helps it to climb and to hang on to surfaces. The head contains the jaws, eyes, and the antennas. The jaws are like two strong pinchers for carrying food and to dig. The eyes are compound, i.e. they consist of several lenses that help it to see movements exceedingly well. The antennas are the sensing organs that combine the functions of smell, touch, taste, and hearing.

The ant has two stomachs, one for its own food and the other for storing food that can be transferred to other ants or developing pupae. In many species the rear contains also a poison sack and a stinger at the end. Like all other insects it has its skeleton on the outside. It can carry up to five times and drag up to twenty times its own weight. Its relative brain (the ratio of the brain to body size) is the largest of all living beings.

Ants build different kinds of nest depending on the species and also on the size of the colony. But the most common is the underground nest identified by a mound at the surface. While excavating for the nest they bring the grainy dirt up and deposit it outside. The nest can go as deep as fifteen feet with chambers designated for different purposes and interconnected by tunnels. Chambers at different depths allow for regulating the temperature required for safe nursing of the larvae and pupae, which has to be around twentyeight degrees centigrade. The queen has its separate chamber. There are nursery, food storage, and garbage dumping sections. Ants also provide

against rainwater getting in and flooding the nest. In cold weather regions they also close the entrance during winter when outside activity is suspended.

A typical colony may contain forty to fifty thousand ants. There are three distinct types in a given colony – the queen, the workers, and the males. It has been customary to call this a caste system. In actuality though this is a class system based on division of labor and function. The queen has the largest body, the males and workers are much smaller in size. The only function of the queen is to lay eggs and the only function of the male is to mate with a future queen, after which it dies. Its life is very short. The life span of the worker is about two to three months. The queen may live up to seven years.

The sex of the ant is determined by whether the egg is fertilized or not. All workers are sterile females. The difference between egg-producing queen and the workers is caused by the kind of diet fed at the larva and pupa stages. Initially the egg-producing female and the male have wings. At appropriate time the winged males and females from different colonies fly out and mate in flight. The queen comes down and selects a place for building the nest. She shades her wings and start laying eggs. For the first batch it takes care of the larvae and pupae herself. Once the young ants come out of the pupae they take over the job of tending to the next batch and the queen herself. With increasing age they proceed sequentially to other jobs of food storage, garbage dumping, digging, and finally foraging for food.

Ant sucking honey from aphids.

Ants mainly feed on seeds and insects. They have strong attraction for sweet material. They suck honey from tree saps and flowers, and also ‘milk’ aphids for honey. Some even maintain a ‘herd’ of aphids in the nest for regular ‘milking’. They may bring as much as two thousand insects or seeds to the colony each day and have enough food to last over winter. The husks of the seeds and exoskeletons of the insects are regularly removed to the garbage dump.

Ants have a very effective way of communication through their antennas. These are long and thin and fairly mobile. Since they come in pairs they provide information about direction as well as intensity of the signal. In close proximity they mainly communicate by touch. Watching ants closely one can see that ants going in opposite directions often stop and join their heads as if talking to each other. They also use a chemical called pheromone for communicating the path to newly found food sources. They use remembered landmarks and the position of the sun to leave a trail. This chemical is also used for identifying members of own colony and intruders. It is unique to the colony and is provided by the queen.

Another peculiar behavior noticed in ants is related to their survival instinct. If the nest is in danger of being swept away in water, they group themselves in a spherical bundle flowing in water and wait to encounter some obstruction to catch on to. While in water they probably keep turning the ball in order to keep alternate portions above water.

It is interesting to note that the division of ants of a colony into different classes (or castes, i.e. queen, male, and workers) is identical to that of honeybees and so is the biology. In both cases the workers are the dominant class and do almost all the work. But they are sterile. Then how are the traits of the workers genetically transferred to the next generation of workers? They exist for the colony and not for themselves, and thus epitomize unselfishness. This was a puzzle that Darwin struggled with in studying ants while developing his theory of evolution. He circumvented this difficulty by considering the colony itself as an organism and an extension of the queen. Thus the evolution referred to the colony and not to ants individually.

Here again we have some parallels with humans. Instead of single colony humans have family, society, culture, nation, and so on. There are always individuals in the group who sacrifice self-interest for the group as a whole. In the long run the survival of a group depends largely on such people.

Spiders – Cunning Designers

Spiders are one of the earliest inhabitants of this planet. They have been around for three hundred million years. They are found everywhere except in polar and high-altitude mountain regions. There are over a thousand species of spiders, their sizes ranging from a tiny fraction of an inch to several inches. Many species live in close proximity to humans in and around houses.

Small spider

All spiders have eight legs and two body segments joined by a thin waist. The first contains the head and thorax, the second is the abdomen. The mouth contains a pair of jaws each having a hollow fang that is used for injecting venom. They have six to eight eyes arranged in various configurations. Apart from the normal function the abdomen has at its tip a number of small finger-like spinnerets for producing silk. Spiders feed on living prey. They, like many other insects, ingest only liquid food. So they first inject a fluid into the prey to turn the edible part into liquid and then suck it.

The life of a spider begins with an egg. The female lays eggs within a silken sac usually round, which may contain several hundred eggs. The sac is hidden in the web or carried by the female on its body. After hatching the young ones remain there for a few weeks before venturing out. Spiders grow by shedding their exoskeletons several times until reaching maturity. The female is much larger than the male and lives much longer. Many spiders live for several years but most of them live for a year or less.

When a male attains maturity, it leaves its web or hiding place and goes out in search for a female of its own species. The search may be guided by the silk of the web or by chemicals put out by the female. Once the female has been located the male needs to identify itself as a mate so as not to be mistaken as a prey and end up as a meal. This is done through some courtship rituals that may include sending vibration through the

web. Some females may include in their web a special silk line for this purpose. After mating the male wanders off but in a few cases both may live in the same web. However, some females eat the male. The widow spider may have acquired the name for this reason.

Most spiders make webs for capturing prey and protecting eggs. The most intricate is the orb web and it shows the ingenuity of this insect. This web has mainly one purpose – tapping of preys. The silk used for making the web is unique and the web is an architectural marvel in nature. Spiders produce seven different types of silk used for different purposes. One is used for the sac for eggs. The rest are used in making the web. The strongest of these is used for making the dragline and the frame. Its tensile strength is five times greater than that of steel of comparable thickness. The one used for trapping flying insects is highly elastic and can be stretched to thirty to forty percent in length without breaking. There are other characteristics (exposure to high humidity and extremely low temperatures) that make the spider silk unique.

The material of the silk is a protein. It is secreted as liquid and hardens into solid as soon as it comes in contact with air. An interesting aspect of this silk production is recycling. A spider may construct the web in the evening and eat it in the morning to recycle the protein. Even in the process of spinning the web towards the end the spider removes some strands the same way.

Making of the Web. In making the web the spider follows a well laid out pattern that must involve considerable thinking and planning. It is hard to believe that this could be done without rational intelligence. There are so many aspects of the web construction that could not be accounted for by pure instinct.

First the spider lays down a dragline of silk between two fixed points going back and forth to ensure that it is strong enough to support the web. Then it makes a Y pattern between the two end of the dragline and a third point of support down below. This pattern provides the initial three radials with the hub at the center. Next it constructs the frame attached to several other points of support along a circle. Several other radials are laid making sure that the distance between adjacent radials is short enough to be within the reach of its legs. With the radials in place it lays a spiral starting from the hub and going out to the periphery. This is all done with non-sticky silk. Finally it lays much denser spiral using sticky silk going from the periphery to the hub. It leaves blobs of the sticky silk along the spiral to make capture more effective. In the process it removes the

earlier spiral by eating. At the center it clears a space large enough for sitting in wait for the prey using just the radials for the legs to rest on.

Orb web. Courtesy Dave Neu: archlich@purdue.edu

When a flying insect gets caught in the web it struggles and sets up vibrations that travel along the radials. The spider senses these vibrations through tiny hairs at the end of its legs. It is able to sense the difference in the amplitudes of the vibrations in the radials and thus determines the direction of the prey. If a part of the web is damaged by the prey or otherwise, the spider can promptly repair it.

Some species put thicker strands of the silk in the web. Usually this is a linear pattern across the web (Fig.) but a few make this in a spiral pattern. It is believed that its purpose may be to attract insects or to provide camouflage for protection from predators

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Cross sublimeta. Courtesy A. K. Chalasani: akc@donschool.com

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predators. The purpose of the spiral pattern may be to tune the web for specific prey size. This pattern results in a higher tension in the radial threads. Thus they transmit higher frequency vibrations, produced by smaller preys, more
efficiently. The spider can then choose between small and large preys. But as yet these are all speculations. It is also believed that orb webs produce patterns that mimic those reflected by flowers in ultraviolet light to lure insects.

The unique properties of the spider silk have stimulated large amount of scientific research for producing the silk synthetically. But so far there has been no real progress. However, the spider silk has long been used for different purposes. Fishermen in remote islands use it for fishing line. It is also used as cross hair in measuring instruments and telescopic gun sights.

Honeybees – Quantum Physicists?

Honeybees are probably the only insects that are almost essential for human existence. Without them there would be no fruits, no vegetables, and perhaps no grains. They have been around for at least one hundred million years, long before the appearance of human species. What is amazing is that there has been no evolution change in them for more than forty million years. Apparently nature considers them perfect.

Anatomy. Like most other insects honeybees have three main parts in the body – head, thorax, and abdomen. The head contains the antennas, the eyes, the mandibles (jaws), and the brain. The thorax contains the three pairs of legs and two pairs of wings. The abdomen has several segments for different functions.

Honeebee collecting nectar. Courtesy:P. O. Gustafsson: beeman@algonet.se.

The two antennas are located close together in the front and are the main sense organs responding to touch and smell, and perhaps sound. They are segmented and can move freely. Honeybees have two compound eyes located in the front and three simple eyes at the pop of the head. The compound eyes consist of thousands of tiny lenses each

contributing a small part of the vision. The brain combines the contributions from all these lenses to make up the complete vision. The range of colors perceived by the bees is broad in range but they cannot see red; instead they can see ultraviolet. The simple eyes do not contribute to vision; they are sensitive to light but are apparently good only for determining the up direction. The pair of jaws are used for grasping and cutting during constructing or repairing the hive. There is a long thin tongue for bringing the liquid food like nectar, honey, and water into the mouth, as well as the fine particles of pollen. It cannot handle larger particles. When not in use it is drawn up in the head.

The brain of the honeybee must be rather highly developed to process the input from the compound eyes and to have a stable memory to store and later communicate the information to other bees through the symbolic language of the dance routine. We discuss the dance language in a later section.

Resting with pollen baskets full. Courtesy P. O. Gustafsson: beeman@algonet.se

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The thorax is the middle part that supports the three pairs of legs and two pairs of wings. The hind legs contain pollen baskets between the two segments of the hind legs. The other legs have structures to comb and collect pollen sticking over the body. Before transferring pollen to the baskets it is compressed into pellets. The wings are in the form of flat thin membranes. The front wings are larger.

The abdomen contains a storage unit for the nectar besides having the usual parts for the body function. It also has at its end the stinger. It is a modified form of the egg laying mechanism in females that ejects venom instead of eggs. So only females with the exception of the queen have the stinger. The bee also has four pairs of wax glands that secrete wax used for making the honeycombs. These glands are part of the body wall.

The Colony. A typical bee colony may consist of twenty thousand bees of three different categories. There is just one queen, a hundred or so males called drones, and the rest are workers. The queen is the focal

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Honeycomb. Courtesy P. O. Gustafsson: beeman@algonet.se

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point of the colony; in fact the colony may be considered simply an extension of the queen. It goes out of the colony only once to mate with drones in flight. After that it shades its wings and its only job is to lay eggs. The drones have only one purpose to mate with a virgin queen. If they do, they die immediately after. If not, they are tolerated for sometime and ultimately driven out of the colony to die. The workers are all sterile females. The workers do all different types of chores in the colony and the division of work is based on their age. The newly hatched ones tend to eggs and larvae, feed and attend to the queen. As they grow they take over making the honeycombs, cleaning the combs, making and storing honey. At the final stage of their life they graduate to foraging and gathering nectar, pollen, and resin. After a large number of foraging flights their wings wear out. At this stage they usually leave the colony and go out to die.

The life of a honeybee starts with an egg. It goes through larva and pupa stages before emerging as a bee. The queen determines the sex of the bee. It uses the sperms stored in a compartment in her abdomen to selectively fertilize the eggs. The unfertilized eggs produce females, the fertilized ones produce males. Some of the female eggs are ‘chosen’ to be queen and are given much richer food. That makes them fertile. Several queens may be reared but only one reigns by killing other contestants. The average life of a worker is four to five weeks. The drone’s life is much shorter. The queen may live up to two years.

Honeycomb. The nest of the honeybee colony is an engineering marvel. It consists of a large number of hexagonal cells made out of the wax secreted by the workers of a certain age. The other workers take the wax and make these cells with walls less than one tenth of a millimeter thick. These cells are geometrically

Bee hatching out from pupa. Courtesy P. O. Gustafsson: beeman@algonet.se

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precise and can support twentyfive times their own weight. (This property of the hexagonal shape is used in making strong cardboard boxes.) The structure is supposed to provide optimum utilization of space and wax.

This aspect of the honeycomb has been also of academic interest for a long time. It has been almost regarded as fact that a hexagonal pattern divides a surface into parts of equal area with minimum length of the total perimeter. But this had not been proved mathematically until recently. In two dimensions a hexagon can be constructed by joining the centers of five circles, one at the center and other four placed around touching it. Extending it to three dimensions it gives the optimum way of packing spheres. The hexagonal cell arrangement improves on it by using also the space between the spheres.

Honeybees have other remarkable skills as well. They can evaporate water from honey to a precise content by fanning with their wings. They bring water and sprinkle around the combs to cool the nest. They know the exact proportions to mix pollen and honey to make appropriate meals for would-be workers, drones, and queens.

Communication. The ability of honeybees to communicate information about newly discovered sources of nectar and pollen is the most intriguing aspect. When a bee returns to the hive after collecting nectar and pollen it tells the other bees about the location of the source (distance and direction) and its capacity (the quality and quantity) through a symbolic language by performing a number of dances. These are intricate movements of making some geometrical patterns and waggling the abdomen. For sources at short distances it performs round dances in circle cutting across it in a straight line to indicate the direction, which is always in reference to the position of the sun. For distant sources it performs the waggle dance making more complicated patterns and waggling its abdomen. The dance has been interpreted as a symbolic language of the bees.

A detailed discussion of these dance patterns is beyond the scope of this book. It has attracted considerable academic interest in its own right. Some of the suggested explanations are farfetched. For example, the geometry of the dance pattern is said to be similar to that of the behavior of quarks in abstract multidimensional space, implying that honeybees know a thing or two about quantum physics. In recent years though doubts have been expressed about the interpretation of the dance as a symbolic language. It is possible that odor plays an important role in the communication. Also the bees may be using very low-frequency sound emissions during the dance to communicate the information.

Whatever be the explanation of the dance it certainly appears that honeybees have an excellent mind and brain capability to do all the things they do. Some may be instinct based but others cannot be explained by assuming that all skills are genetically transferred. The suggestion that the honeybees know quantum physics may be farfetched but the idea that elementary particles have a role in creating consciousness and intelligence of different types in different species may not be.

Baya – Shrewd Architect

Baya is a small sparrow-size bird found commonly in Southeast Asia. It belongs to *ploceus philippinos* species but is popularly known as the weaverbird. This name derives from the fact that it weaves its nest ingenuously from thin grass blades and strips torn from leaves. These birds inhabit plain cultivated fields and grass lands making their nests on small trees. The nest is unique in design and almost an architectural masterpiece.

Another distinctive feature of bayas is the marked change that the male's plumage goes through during the mating season. Normally the plumage of both male and female is plain brown with streaks on the upper parts. Their mating season coincides with the monsoon period that usually lasts from the end of May through September. Towards the end of April the plumage of the male starts changing. Its head and breast acquire a golden color. After the mating season it loses this coloring and reverts to the original streaked brown. The female does not go through any change of the plumage.

The nest building involves shrewd planning. The nest hangs from the branches or twigs of a tree and is subject to being blown and swayed by the wind. The bird always builds the nest on the leeside of the prevailing wind during the monsoons

Male in mating season. Courtesy Nikhil Devasar: devasar@delhibird.net

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Right: Female courtesy Alka Vaidya: chitralka@yahoo.co.in

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in order to minimize the swaying caused by the winds and to avoid the danger of eggs or the young ones falling out. Birds can certainly determine the wind

direction but finding the prevailing winds for the entire season does require thinking and intelligence.

Another aspect of the planning involves security considerations. In order to thwart predators, especially snakes, the nest is suspended from a small branch of a tree with the entrance through an elongated tube at the bottom. The opening is just large enough for their own size so that even other birds with evil intentions cannot get in.

The nest building is an exclusive privilege of the male. At the start of the mating season the male starts building the nest. It is made entirely from grass blades or thin strips torn from

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Baya nests. Courtesy Neeraj Mishra: mishran@samacharnet.in

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larger leaves. First it makes a short plaited rope tied to an outer branch of the tree; the main part of the nest begins at the end of this rope. The main part is a conical structure which contains the main chamber at the bottom that houses the eggs and, later the young ones. The floor of this chamber is shaped like the bottom of a bowl below the level of the entrance. Once this part is finished it builds the tubular entrance on one side extending down to about eight inches or a foot. The bird industrially weaves this entire structure bringing one grass or leaf strip at a time, which it may break into smaller pieces. It has a strong and sharp conical beak to perform this delicate task of weaving and knotting the grass blades and strips. It may make several hundred trips to fetch the material for a nest.

Once the nest is near completion the male tries to attract the females; sitting on the unfinished nest it makes shrill wheezing calls. A female arrives and examines his handiwork. If it meets her approval, she consents to be his mate and

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Male weaving the entrance tube. Courtesy Alka Vaidya: chitralka@yahoo.co.in

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helps in finishing the interior, while he gives finishing touches to the exterior. The mating

occurs and the job of the male is practically over. Unlike many other birds these are not monogamous. The male is rather promiscuous and starts building another nest to attract another female. It is the female's responsibility to tend the eggs and take care of the brood.

Bayas prefer to live in colonies. It is not unusual to see several nests on a single small tree usually near fresh water and open ground. The nests are abandoned at the end of the breeding season and seldom reused. They also prefer to be in flock formation found sitting on wires and poles. They fly in flock performing intricate maneuvers especially outside the breeding season.

Several species of birds are known for their intelligence. But baya's ingenuity in building the nest is unique both in planning and execution. Considering the fact that the male hardly spends any time with the young ones, it is improbable that there is any teaching or learning involved as far as the nest building is concerned. The males must be inheriting the trait through the genes.

Baya colony. Courtesy Neeraj Mishra: mishran@samacharnet.in

Conclusion

We started with certain questions raised in connection with consciousness in animals. We review them in the context of the examples discussed above.

Capability to Apply Insight to Solve Problems. Ants know that the eggs, larva and pupae need to be at some optimum temperature in order to survive. The fate of the colony depends on successful regeneration cycle. So they move the nursery activity around. They also know when and how to organize a group activity in order to accomplish a task. Honeybees do the same in a different way. They regulate the temperature in the hive by fanning and spreading water or by huddling together. They seal the combs when there is a possibility of leakage. In general animals foresee problems and take action to avert or solve them.

Reflecting over Past and Worrying about Future. There is reason to believe that animals think about the past and future although it is difficult to ascertain how far back their memories go. Both honeybees and ants remember the locations of the food sources they have visited. They obviously remember every detail of their nests. As to the future they think at least months ahead because they do provide for food supply for the winter period. The fact that they take meticulous care of the young ones from the egg stage on tells that they also care about the long-term health of the colony. The memory span and the look into the future must be very different for different animals.

Being Aware of Self and Own Mortality. The idea of self and of belonging to a particular group is quite common in animals. All think of themselves as separate entities distinct from others of the species. Most animals recognize their own instinctively; others may use additional means for identification such as chemicals. Every animal has the survival instinct and that itself implies an awareness of mortality and the fear of death. In all probability though they are not concerned about life after death. They are not encumbered by religion.

Feelings and Emotions. Any pet owner will testify to the fact that dogs and cats have feelings and emotions, which is true for all animals. Happiness, sadness, and fear are all universal emotions. Animals express these feelings in their own ways and it is not difficult for humans to recognize their expression. Perhaps their fellow animals recognize more easily. The expression of anger is easy to recognize. Animals also feel bereavement, which may mean that they have memories of the past to brood over. They also have feelings of compassion. We hear about animals saving and caring for

human babies. About a year ago (June 2005) there was a newspaper account of how in a remote corner of Ethiopia three lions rescued a twelve-year old kidnapped girl by chasing off the kidnappers. They guarded her until the police tracked her down and then left.

It has been argued that the intelligence in animals is instinctive and transferred genetically. It is also believed that nature has been very conservative with the process of evolution building sequentially on success. If man has the most developed brain and mind, why is the instinctive intelligence not genetically transferred in humans?
In animals a female can recognize her offspring in a crowd of similar young ones without any difficulty. A woman will have hard time finding her new born in a nursery without the identification tag.