Not to Harm a Fly: Our Ethical Obligations to Insects

Jeffrey A. Lockwood
University of Wyoming

Sentience is the most empirically sound basis for the study of animal rights. Perhaps that is why this attribute most often provides the foundation for philosophical investigations of the ethical treatment of animals. A number of psychological parameters have been used to define sentience, and many philosophers find these attributes intuitively and rationally satisfying criteria with which to define the limits of moral consideration. Mental experiences which provide answerable questions for biological experimentation and theory and a defensible basis for moral consideration include pain and consciousness. Given the early argument of Jeremy Bentham, that upon introspection pain is the one intrinsic evil that we can all agree upon, and the contemporary philosophical arguments regarding the moral relevance of pain in animals (Singer 1975, 1977, Fox 1977, Regan 1983), it would seem that Clark (1977) is on safe ground in arguing that the sparing of unnecessary pain is a minimum principle of ethical behavior. Conscious thought is fundamental to beings who have interests or lives that can be made better or worse, and the inclusion of a being within the scope of moral concern is often predicated on the life of the being mattering to it (Rollin 1981, Rachels 1983). It follows that painless death of an organism without the capacity to think of itself as a distinct entity is at worst a replaceable loss of pleasure (Singer 1975, 1977). Thus extensive and generally convincing arguments ground animal rights and human obligations in sentience.

Although a great deal of biological research relevant to sentience has been incorporated into discussions of the ethical treatment of animals, insects have not been addressed with more than a passing acknowledgment, if that. This exclusion represents a significant oversight, in that insects are by far the most diverse (75% of all animal species are insects) and abundant (there are about 10^{18} insects alive at any moment or 200 million for each human being) of any class of animals (Eisner and Wilson 1977). Insects provide a valuable tool for investigations of sentience, although they have not been as extensively studied as vertebrates. By employing the comparative fields of anatomy, morphology, physiology, neurophysiology and behavior as well as considerations of theoretical and evolutionary biology, there can be a rational consideration of mental processes in insects and a sound basis for their inclusion in our scope of moral considerations.

Pain as a Criterion for Sentience

Considerable empirical evidence exists to show that a variety of invertebrates experience pain. Alumets *et al.* (1979) reported that earthworms possess B-endorphins and enkephlins which suggest the capacity for pain by functional analogy. The eminent insect physiologist, V. B. Wigglesworth

PHILOSOPHY

(1980), argued that insects experience visceral pain as well as pain caused by heat and electrical shock, while cuticular damage apparently causes no pain. He based his conclusions on "observation and simple reasoning," not intending to make an ethical statement. In a careful and critical review of physiological and behavioral methodologies, Dawkins (1980) concluded that insects have the capacity to suffer pain. Eisemann *et al.* (1984) contend that available evidence does not support the occurrence of pain in insects, "such as occurs in humans." Even with this carefully qualified conclusion, Eisemann *et al.* (1984) suggested that anesthetizing insects is desirable to guard against the possibility of pain and to preserve an attitude of respect towards living organisms. From an evolutionary view, the awareness of pain is such an enormously adaptive mechanism that it is unreasonable to simply assume that it is unique to humans. Pain may be expected in organisms whose survival can be augmented by the experience of pain, either as part of an escape mechanism or as a basis for the capacity to learn from past experience (Dawkins 1980), and insects certainly qualify in these regards.

Consciousness as a Criterion of Sentience

Sentience can be defined in terms of the consciousness of an organism. In turn, two approaches have been taken to examine the biology of consciousness: experimental and theoretical. Experimental approaches usually use thinking as evidence of consciousness. Theoretical approaches deal directly with consciousness or consider awareness as a basis for consciousness. Griffin (1976, 1984) has carefully examined both experimental and theoretical evidence of consciousness in invertebrates, although, like Wigglesworth's (1980) considerations of pain, Griffin does not extend his scientific arguments to ethics.

Experimental Criteria of Consciousness

Three types of behavior have been used in regard to the study of thinking: language, problem solving, and learning. Graven (1967), Walker (1983), Roitblatt *et al.* (1984), and Griffin (1976, 1984) have presented and reviewed considerable evidence for conscious thought in vertebrates based largely on these types of behavior.

Griffin (1984) points out that if nonhuman animals experience conscious thoughts or subjective feelings, we might be able to learn about them by interpreting the signals by which they communicate these thoughts and feelings to other animals. With regard to insects, evidence indicates that these animals, particularly social insects, engage in thoughtful communication. Recruitment of weaver ants, *Oecophylla longinoda* (Latreille), to join in a fight exhibits a property not ordinarily found in animal communication, namely, the conveying of specific information about something the communicator has not been exposed to directly but has learned about only by receiving communicative signals (Holldobler and Wilson 1978). Honeybees, *Apis mellifera* L., do not use the chain of communication of weaver ants but require first-hand inspection of a resource before communicating information about it (Lindauer 1971, von Frisch 1967). Bees use an elaborate form of symbolic communication, the so-called "dance language." As Jolly (1985) noted, this dance is the most precise and abstract communication that any nonhuman animal uses about the environment. This dance communication includes information on distance, direction, and desirability of food and potential nest sites. In communicating information about and eventually choosing a nest site, bees fulfill all of the criteria for a deliberate decision in vertebrates (Jolly 1985). These and many more examples of insect communication (Wilson 1971, Matthews and Matthews 1978, Kerkut and Gilbert 1985) demonstrate that insects exchange information, discriminate among potential recipients, and use appropriate channels under various conditions.

The second experimental criterion for thought is problem solving. Machines may adequately perform tasks in a predictable environment, but solving novel challenges requires the process of thinking. Honeybees provide two particularly relevant examples of problem solving. Alfalfa anthers are adapted for pollination by large insects, and the anthers spring back violently when contacted by honeybees. To solve this problem, honeybees learn to avoid alfalfa until food becomes scarce and then only visit the flowers whose anthers have already been tripped or bite a hole in the back of the flower to reach the nectar (Gould 1979, 1982). It may be proposed that such behavior is genetically programmed for just such cases, although this seems to be a weak argument. A second example involves the ability of individual bees to learn to visit an artificial food source. While this capability is not surprising, bees have a remarkable ability to solve an associated problem which would seemingly never occur in nature. If a food source, whose location has been learned, is moved, at first short distances and later up to 30 m at a time, bees come to realize that the food source is mobile. Individuals that visit it at a given location will later search for it at an extrapolated distance based on its previous movements (Griffin 1984). In nature no food source moves more than 30 m in a few minutes, and natural analogies to this problem would be difficult to invent. Thus, some insects can solve novel problems, and at the very least the solutions represent new applications of general concepts or abilities on the part of the insect.

A number of insects have been shown to be capable of learning under rigorous scientific conditions; these include grain beetles, cockroaches, locusts, wasps, ants, and flies (Alloway 1972, Panzo 1985, Eisenstein and Reep 1985). A three-volume compendium edited by Corning *et al.* (1973-1975) provides a comprehensive review of learning in invertebrates. Although there is no debate over the ability of insects to learn, and this capacity supports the existence of mental processes in insects, learning may not constitute sufficient evidence for thought. While it is reasonable that entities that think also learn, it is not as clear that all entities which learn also think, e.g. computers.

Theoretical Evidence of Consciousness

While it is clear that insects learn, to deny the importance of genetically predetermined behaviors in these animals is absurd. Numerous behaviors have been described and neurologically mapped as fixed action patterns resulting from releasor stimuli (Alcock 1979). The abundant role of instinct in insects brings us to the first theoretical consideration with regard to consciousness — the tacit assumption that instincts are unconscious (e.g. Gould and Gould 1982).

In an interesting consideration of complex instincts, Griffin (1984) contends that structures built by spiders and insects such as caddisfly larvae, ants, wasps, and bees are not assembled by rote instinct but via a template or a pattern within the brain which the insect makes a conscious attempt to match. In this way the problem of building structures in extremely variable circumstances and repairing unpredictable damage is not solved by a nearly infinite number of preprogrammed contingencies but by application of a general concept. It may be most parsimonious to postulate an insect's conscious efforts to match a template rather than to hypothesize a set of neural specifications for motor actions that will produce a characteristic structure under all probable conditions. In any case, Occam's razor does not exclude consciousness. Indeed it can be argued that this scientific principle requires us to accept the consciousness hypothesis as the simplest of the competing explanations of complex instincts.

A second theoretical consideration of insect consciousness is one of morphology. Fortunately, we have come a long way from Linnaeus' criteria for insects, which included the absence of a brain (Howse 1975). The central nervous system (CNS) of insects is minute compared to even the smallest mammal, but is consciousness a function of size and neural complexity? Even the smallest insect brain contains thousands of neurons, each anastomosing with dozens of others. While the content and complexity of conscious thoughts may be proportional to the volume of the CNS, an absolute, critical size necessary for thought is not supported by our current understanding of the nature and functioning of the CNS (Griffin 1984). The dogma that only a concentrated dorsal nerve cord which is enlarged at one end can support thought processes has been advocated by Grene (1978) and Walker (1983), despite considerable research which indicates that it is the pattern of organization of neurons and synapses that is critical to brain function, not the gross morphology. Indeed, headless insects can learn and exhibit memory (Alloway 1972), an accomplishment made possible by the decentralization of mental processes to the ganglia distributed along the central nerve cord. Hence, it is unconvincing to argue that the morphology of the insect CNS precludes conscious thinking. While differences in behavioral complexity are apparent between vertebrates and insects, there is no indication of profound phylogenetic differences in neurophysiology and brain function and no reason to conclude that there are any qualitative differences. Jung (1973) wrote that although he had believed insects were merely reflex automata, "We are...faced with the fact that the ganglionic system apparently achieves exactly the same result as our cerebral cortex."

Social insects behave so as to meet the communicated needs of the colony. One can construct a system which awkwardly explains social interactions such as food begging and tropholaxis without including self-awareness. However, few would argue that the social insects, and probably all insects, lack awareness of outside events; they behave according to environmental conditions, and they demonstrate the ability to communicate information about these conditions. Allowing that an insect has awareness of external events but does not have self-awareness is problematical. It is rather implausible to contend that through sensory mechanisms an insect is aware of the environment and the needs of conspecifics, but through some neural blockage the same insect is selectively unconscious of sensory input about itself.

Moral Consideration of Species

Before developing an ethical standard for the treatment of insects, it is necessary to address the question of species' rights. In fact, insects exemplify why species' rights are generally indefensible. Besides the philosophical problems of finding a basis for deriving unique rights for groups and the potential for adverse consequences when subjugating the individual to the (largely unknown) good of the group, the very practical problem of actually defining a species is epitomized with insects. Even if the rights of species could be established, it is clear from entomological literature that species are ill-defined, essentially subjective, constantly changing entities with little, if any, basis in biology other than traditional convenience of organization and expression.

The endless subdividing of species into sibling species, subspecies, races, varieties and other "infra" categories is a clear indication of the extraordinarily difficult process of defining what constitutes an insect species. In practice insect taxa are being constantly revised, split, lumped, and renamed, with frequent disagreements on whether a particular group is systematically valid. Just a single example of special interest to me is the Rocky Mountain locust, which was identified as a species in 1866, was not considered a distinct species in 1953, was resurrected as a species in 1959, and currently is considered a distinct species by some scientists but not by others (Gurney 1953, Gurney and Brooks 1959, Capinera and Sechrist 1982, D. Otte, personal communication). A realistic attempt to apply rights to species would lead to changing our ethical perspectives with every taxonomic revision, or at least those which we believe to be correct.

In addition to the problem of distinguishing species in practice, there is little agreement on the theoretical basis of species. Species can be conceptualized from evolutionary, ecological, and reproductive perspectives, and these approaches are not readily resolved by a single construct. Despite the utility of taxonomic nomenclature to the biological sciences (virtually every scientific article in biological journals refers to one or more species of animals), the species concept is, at best, a largely arbitrary, discrete point forced on an underlying continuum of relationship. Ghiselin's (1966, 1974) treatment of species as individuals forms the basis for Flower's (1986) recent argument that species (like individuals) have rights. However, it is not clear how species differ from demes, populations, races, subspecies, genera, or any other group of organisms that are spatiotemporally coherent entities made up of component parts which are able to reproduce. Moreover, it is clear that present evolutionary theory treats individuals and species as very different entities; the former is the unit of selection, the latter is most certainly not (Alcock 1978, Wilson 1980). Thus, an argument for protecting insect species is necessarily confounded by unresolved theoretical problems and, perhaps most importantly, by the practical difficulties of actually identifying a group of organisms as a species.

A Proposed Ethic

Considerable empirical evidence supports the assertion that insects feel pain and are conscious of their sensations. In so far as their pain matters to them, they have an interest in not being pained and their lives are worsened by pain. Furthermore, as conscious beings, insects have future (even if immediate) plans with regard to their own lives, and the death of insects frustrates these plans. In that sentience appears to be an ethically sound, scientifically viable basis for granting moral status and in consideration of previous arguments which establish a reasonable expectation of consciousness and pain in insects, I propose the following, minimum ethic:

> We ought to refrain from actions which may be reasonably expected to kill or cause nontrivial pain in insects when avoiding these actions has no, or only trivial, costs to our own welfare.

A reasonable expectation of death or pain in insects should be based on our intuition, experience, and inference from what we know of other animals.

Trivial pain is that which is extremely short in duration or mild in degree (e.g. decapitation and short term food/water deprivation). While many animal rights advocates may find this ethic understated, I believe that it is a philosophically sound, scientifically defensible position from which we can build further moral dialogue. Morality must deal to some degree with what is; ethical principles are not rational if they are not actualizable. Given our sociopsychological milieu we cannot reasonably expect to abolish the use of insects or other animals in the development of new technologies and the investigation of biological processes (nor perhaps should we), but we can expect to perform scientific work in such a way as to minimize, and where possible avoid, killing and inflicting pain on the organisms we study. Meaningful ethical progress will be made if philosophers and biologists accept insects as individuals of intrinsic value, warranting moral consideration, and having some moral significance which must be taken into account.

The proposed ethic shifts the burden of justification onto those who engage in practices on insects which can be reasonably expected to induce nontrivial pain. For example, Wigglesworth (1980) argued from observations that piercing the cuticle is not painful to an insect but shock and heat are painful. Such observations are useful, but more rigorous studies would be beneficial. Scientific approaches to investigations of animal suffering are elaborated in Dawkins' (1980) work; her review provides a rational starting place for considerations of pain in nonhuman animals. Shifting the burden of proof onto those who claim that a specific treatment does not cause suffering immediately expands our scope of moral consideration. This shift prevents potentially horrendous mistakes in moral judgement at the risk of overextending our moral concern. As further work is done and historical barriers give way to rational investigations of morally relevant biological processes, if some insects are found to be totally lacking in sentient capacities, we will have committed no wrongs to have acted in an overly humane fashion. Surely it is preferable to err on the side of moral consideration than on the side of moral exclusion.

While it is difficult to quantify sentience in other animals and thereby know how to balance their interests with ours, the proposed ethic can be applied to some clear examples. Even if insects are of infinitesimal moral significance, where there is no conflict with our own interests, other than simple convenience or preferences, the moral significance of insects should determine the course of events. In other words, the lives of insects and their interest in not suffering pain override our interests in convenience and expediency. The proposed ethic can be applied to the areas of research/teaching and technology.

Application of the Proposed Ethic to Research and Teaching

In regard to teaching and research the use of anesthetics prior to dissection or other potentially painful treatment of insects is ethically mandatory. In many cases an anesthetic perturbs the system under investigation no more than the induction of pain. The only exception to the anesthetic rule occurs when anesthetic is entirely contrary to the goal of the procedure, and when the procedure is the only method to answer a vital research question. Courses in which students experiment on live insects should include a discussion of insect pain if we expect students to be ethically responsible. The work edited by Westerlund (1982) is a useful resource in this regard, although some sections demand a more extreme ethic than proposed in this paper.

As a general rule there is a considerable chance for suffering when insects are overproduced in the laboratory; in large colonies the needs of insects are most easily overlooked. Excess insects and insects of unneeded developmental stages are often allowed to starve; such practices are morally indefensible. With only trivial time and effort, excess insects can be released (if this is feasible) or killed quickly if there is insufficient food or other resources. Most insects (and many other animals) can be reared in captivity without inducing suffering, as evidenced by physiological and behavioral information (e.g. Lorenz 1952). While some animals do suffer from captivity, laboratory reared insects, given ample room for normal activities (which may be more demanding for highly mobile species) and provided with adequate environmental conditions, may be better off then their feral counterparts.

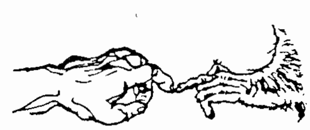
A final consideration for both teaching and research is the practice of insect collecting. A great deal of research involves some collecting, and insect collections are required in numerous biology courses. Insect collecting may be justified when it makes substantial contribution to our understanding of insects or improves our ability to protect our resources. In the context of this justification the validity of both the process and the quantities of insects collected as part of the teaching process should be critically examined. At the very least, both researchers and students should abide by the guidelines adopted by the Joint Committee for the Conservation of British Insects (in New, 1984). Although their guidelines do not specifically express moral concern for insects, they do include commendably rigorous standards for capture, killing, examination, and release of insects.

Teachers and researchers must recognize the capacity of insects to suffer and then choose procedures and experimental designs which minimize, and where possible avoid, the infliction of nontrivial pain. When a particular option accomplishes this goal at no or minimal cost to our welfare and that of other sentient beings, we are morally compelled to choose that option above all others.

Application of the Proposed Ethic to Technology

In terms of insect control practices most people, including myself, would contend that even millions of insects are of less moral significance than a single human life. Clark (1977), Singer (1977), Rollin (1981), Regan (1983), Scanlon (1983), and most other ethicists defend the protection of our food from insect damage. We have very good reason to believe that overriding the interests of certain pest species prevents vastly greater harm to ourselves. Singer (1977) contends that it is not arbitrary to hold that humans with self-awareness, abstract thought, plans for the distant future, and complex communication are of greater value than organisms without such capacities in kind or degree. It is not counter to the goals of agriculture to acknowledge the validity of the statement made by MacIver (1948), "If I tread on a woodlouse, I do wrong...but it is only a very small wrong, and to exaggerate its wrongness is sentimentality. If I kill a Colorado beetle, I do wrong by the beetle, but if I fail to kill it, I do wrong by all the growers and consumers of potatoes." However, the lives of millions of insects are not so easily discounted when compared to the moral significance of a tobacco field or of a housing development. Indeed, the control of insects on crops which are themselves damaging to human welfare, e.g. tobacco, is difficult to defend from a moral standpoint. Similarly, the control of insects to prevent cosmetic damage which does not influence the nutritional value of food becomes an issue; in this case, we place greater moral significance on our preference for visually appealing produce than on the lives of millions of insects (and the condition of the environment). Again, it seems difficult morally to justify such practices.

When provided with various methods of pest control, the moral consideration of insect life becomes a relevant issue. The philosophical foundations of integrated pest management (IPM) are detailed in an historical perspective by Perkins (1982). Entomologists are aware of moral obligations; however, few have spoken out. Perkins (1982) cites a recognition of the relationship between ourselves and the natural world as a principal consideration in the philosophical development of pest management strategies. The philosophical basis for IPM (as opposed to eradication or purely chemical control) is the recognition of humans as biological entities, firmly embedded and thoroughly dependent on a complex ecosystem in which we compete for resources. The important distinction between this view and those expressed by many ethicists is the instrumental value (being good for something) of nonhuman life, which apparently forms the basis for IPM, as opposed to the intrinsic value (having a good in and of itself) of nonhuman life which is the basis for the ethical treatment of animals. There is a philosophical relationship of IPM to the conservation movement: both are founded on a concern for our own well-being. However, this generalization should not be applied to all of the proponents of IPM; in fact, there are those such as Pimentel (1971), Pimentel *et al.* (1978), Metcalf (1980), and undoubtedly others who express concern over our treatment of other animals without the anthropocentric trappings of IPM. Pimentel's consideration of "external costs" includes concern for wildlife and natural vegetation without an immediate reference to the impact of these entities on the human condition. Rabb (in Perkins 1982) has spoken directly to our moral obligations in recognizing that living things warrant moral consideration, "The use of [technological] power is a tremendous responsibility and must be done without arrogance and with a subtle sensitivity, if not a reverence, for the value of all life." ❐



References Cited

Alcock, J. 1979. *Animal Behavior: An Evolutionary Approach.* Sinauer Associates, Sunderland, Massachusetts.

Alloway, T.M. 1972. "Learning and Memory in Insects." *Ann. Rev. Entomol.* 17:43-56.

Alumets, J., R. Hakanson, F. Sunderland, and J. Thorell. 1979. "Neuronal Localization of Immunoreactive Enkephalin and B-endorphin in the Earthworm." *Nature* 279:805.

Capinera, J.L. and T.S. Sechrist. 1982. "Grasshoppers (Acrididae) of Colorado: Indentification, Biology and Management." *Colorado State Univ. Exp. Sta. Bull.* 584S.

Clark, S.R.L. 1977. *The Moral Status of Animals*. Clarendon Press, Oxford.

Corning, W.C., J. A. Dyal, and A.O.D. Willows. 1973-1975. *Invertebrate Learning*. Vols. 1 (1973), 2 (1973), and 3 (1975). Plenum Press, New York.

Dawkins, M.S. 1980. *Animal Suffering: The Science of Animal Welfare*. Chapman and Hall, New York.

Eisemann, C.H., W. K. Jorgensen, D.J. Merritt, M. J. Rice, B.W. Cribb, P.D. Webb, and M.P. Zalucki. 1984. "Do Insects Feel Pain? — A Biological Review." *Experientia* 40:164-167.

Eisenstein, E.M. and R. L. Reep. 1985. "Behavioral and Cellular Studies of Learning and Memory in Insects." Pages 513-548.

In G.A. Kerkut and L.I. Gilbert, Eds. *Comprehensive Insect Physiology, Biochemistry, and Pharmacology*. Pergammon Press, New York.

Eisner, T. and E.O. Wilson. 1977. *The Insects*. W. H. Freeman and Company, San Francisco.

Flowers, R.W.. 1986. "Ethics and the Hypermodern Species." *Environ. Ethics* Summer: 185-188.

Frisch, K., von. 1967. *The Dance Language and Orientation of Bees*. Harvard University Press, Cambridge.

Ghiselin, M.T. 1966. "On Psychologism in the Logic of Taxonomic Controversies." *System. Zool.* 15:207-215.

Gould, J.L. 1979. "Do Honeybees Know What They Are Doing?" *Nat. Hist.* 88:66-75.

Gould, J.L. 1982. *Ethology, the Mechanisms and Evolution of Behavior.* Norton, New York.

Gould, J.L., and C.G. Gould. 1982. "The Insect Mind: Physics or Metaphysics?" Pages 269-297. In D.G. Griffin, Ed. *Animal Mind-Human Mind*. Springer-Verlag, New York.

Graven, J. 1967. *Non-human Thought: The Mysteries of Animal Psyche*. Stein and Day, New York.

Grene, M. 1978. "Basic Concepts in Cognitive Ethology." *Behav. Brain Sci.* 1:574-575.

Griffin, D.R. 1976. *The Question of Animal Awareness*. The Rockefeller University Press, New York.

Griffin, D.R. 1984. *Animal Thinking*. Harvard University Press, Cambridge.

Gurney, A.B. 1953. "Grasshopper Glacier of Montana and Its Relation to Long-distance Flights of Grasshoppers." *Ann. Rep. Smithson, Instn.*, 1952, 305-326.

Gurney, A.B. and A.R. Brooks. 1959. "Grasshoppers of the Mexicanus Group, Genus *Melanoplus* (Orthoptera: Acrididae)." *Proc. U.S. Natn. Mus.* 110 (3416).

Holldobler, B., and E.O. Wilson. 1978. "The Multiple Recruitment System of the African Weaver Ant, *Oecophylla longinoda* (Latreille) (Hymenoptera: Formicidae)." *Behav. Ecol. Sociobiol.* 3:19-60.

Howse, P.F. 1975. "Brain Structure and Behavior in Insects." *Ann. Rev. Entomol.* 20:359-380.

Jolly, A. 1985. "A New Science that Sees Animals as Conscious Beings." *Smithsonian* 15:66-75.

Jung, C.G. 1973. *Synchronicity, A Causal Connecting Principle*. Princeton University Press, Princeton.

Kerkut, G.A., and L.I. Gilbert. 1985. *Comprehensive Insect Physiology, Biochemistry, and Pharmacology.* Vol. 9 Behavior Pergamon Press, New York.

Lindauer, M. 1971. *Communication Among Social Bees*. Harvard University Press, Cambridge.

Lorenz, K.Z. 1952. *King Solomon's Ring: New Light on Animal Ways*. Thomas Y. Crowell Co., New York.

Maclver, A.M. 1948. "Ethics and the Beetle." *Analysis* 8:65-70.

Mathews, R.W., and J.R. Mathews. 1978. *Insect Behavior.* John Wiley and Sons, New York.

Metcalf, R.L. 1980. "Changing Role of Insecticides in Crop Production." *Ann. Rev. Entomol.* 25:219-256.

New, T.R. 1984. *Insect Conservation: An Australian Perspective*. Dr. W. Junk, Boston.

Panzo, F. 1985. "Recent Advances in Behavioral Plasticity in Insects and Decapod Crustaceans." *Florida Entomol.* 68:89-104.

Passmore, J. 1980. *Man's Responsibility for Nature.* Duckworth, London.

Perkins, J.H. 1982. *Insects, Experts and the Insecticide Crisis*. Plenum Press, New York.

Pimentel, D. 1971. "Ecological Effects of Pesticides on Non-target Species." *Pres. Off. Sci. Technol.* Washington, D.C.

Pimental, D., J. Krummel, D. Gallahan, J. Hough, A. Merril, I. Schreiner, P. Vittum, F. Koziol, E. Back, D. Yen, and S. Finace. 1978. "Benefits and Costs of Pesticide Use in U.S. Food Production." *BioSci.* 28:772-784.

Regan, T. 1983. *The Case for Animal Rights*. University of California Press, Berkeley/Los Angeles.

Roitblatt, H.L., T.G. Bever, and H.S. Terrace. 1984. *Animal Cognition*. Lawrence Erlbaum Associates, Hillsdale, New Jersey.

Rollin, B.E. 1981. *Animal Rights and Human Morality*. Prometheus Books, Buffalo.

Scanlon, P.F. 1983. "Humans as Hunting Animals." Pages 99-206. In H.B. Miller and W. H. Williams, Eds. *Ethics and Animals*. Humana Press, Clifton, New Jersey.

Singer, P. 1975. *Animal Liberation: A New Ethics for Our Treatment of Animals*. New York Review, New York.

Singer, P. 1977. "The Fable of the Fox and the Unliberated Animals." *Ethics* 88:119-125.

Walker, S. 1983. *Animal Thought*. Routledge and Kegan Paul, Boston.

Westerlund, S.R. 1982. *Humane Education and Realms of Humaneness*. University Press of America, Washington, D.C.

Wigglesworth, V.B. 1980. "Do Insects Feel Pain?" *Antenna*. 4:8-9.

Wilson, E.O. 1971. *The Insect Societies*. The Belknap Press of the Harvard University Press, Cambridge.

Wilson, E.O. 1980. *Sociobiology*. Belknap Press of the Harvard University Press, Cambridge.