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Observations on the conduct of 'authentic' ecology research: A cautionary tale for educators

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Abstract

The noted theoretical biologist Jakob von Uexküll noted in the beginning of the century that to understand the evolution of an organism biologists needed to understand the lifeworld (Umwelt) of the organism they studied for organisms react and adapt to their lifeworlds rather than decontextualized, transcendental worlds. In this paper, we show that in contrast to von Uexküll's precepts, the ecologists in our 2 year ethnography continuously attempted to construct a transcendental world which had decidedly human (and most often rather mundane) categories/dimensions. Based on our ethnography among ecologists, we show that their research practices ran counter to an understanding of their organisms' lifeworld, and therefore counter to a better understanding of the dynamics of the natural history of the organism and the environment within which it lives.

The research world of physical scientists starts as they walk through a door and into a special building which contains their laboratories—in which they conduct most of their research. For ecologists however, their research world starts when they walk out through the door of that special building which houses their laboratories and into the rest of the world. This is relevant to the development of (research) attitudes towards nature because ecologists learn about the research practices of their discipline in settings (in large groups in university lectures or laboratories) and with organisms (often dead¹ or preserved) quite different from the actual settings of the disciplines' research. This has important consequences for how field biologists learn to frame their understandings of the organisms they study, particularly when they conduct research on organisms which themselves interact with and have an embodied understanding of the world.

Living organisms react to the world in a way that is meaningful in terms of their own needs; they process information in accordance with their receptors, nervous systems, effectors, and in terms of their own codes. Biologists can therefore utilize causal and mechanical explanations only to a limited degree. The noted theoretical biologist Jakob von Uexküll noted in the beginning of the century that to understand the evolution of an organism biologists needed to understand the lifeworld (Umwelt) of the organism they studied for organisms react and adapt to their lifeworlds rather than decontextualized, transcendental worlds (1973). Accordingly, the task of ecologists should be to reconstruct the meaning of an animals behavior, which implies finding out which sign processes underlie this behavior (Krampen, 1986), because there is a structural correspondence/coupling between each living being and its Umwelt, that is, the world as subjectively experienced by the organism (Varela, Thompson, & Rosch, 1993). The relevant processes for an organism's actions/reactions are the sign processes in which this organism is involved. So, if researchers want to understand why lizards are behaving the way they do in their environments, they need to see the environment in the way lizards do, rather than in the way we humans do. Lizards behave and evolve because of their interaction with their perceived environments, rather than engaging in those behaviors in a transcendent world.

The construction of knowledge in field ecology often begins with fieldwork and then moves into the field laboratory.² When ecologists study the natural history of an animal they make selections—factors to be examined in the field, factors to be moved into the laboratory, and

procedures to determine how that move into the laboratory occurs and is enacted within the laboratory—but subsequently claim (implicitly in their writing) that the world reported is the world as experienced by the animals. Ecologists act as if there is a transcendental world that they can reconstruct by collecting, purifying and transforming data. The outcome of this is that claims of the “natural history” of the organism are made which are identical to the worldview of the organism, or in Uexküll’s terms, the organism’s “Umwelt.”

Elsewhere, we have argued that a reductionist worldview of ecology is developed in undergraduate students through not just the content of their ecology course but through the epistemological underpinnings of how the course itself was taught (Bowen & Roth, 1998). Further, mathematical practices developed (as part of their research) to be locally adequate and defensible leads field researchers to make claims about what preferences or behaviors “all animals” demonstrate (Roth & Bowen, 1999). Thus, broad informal assumptions or interpretations about the lizards’ world, mediated by available tools and a reductionist worldview within the community of research practice, occur at several critical junctures and determine how a transcendental world and the worldview of the animal emerges from ecologists’ activities. Drawing on ethnographic and autobiographical field notes, this paper examines how the animals’ worldview is initially framed by the researcher at these junctures—before the construction of tables and graphs to represent patterns—and what factors determine how this transcendental world within which the lizard lives, and then the anthropomorphic worldview of the lizards’ world, develops.

Research Context

As part of a study attempting to understand how ecologists are enculturated into their domain and how they learn to make sense of their world, GMB participated as a field assistant during five weeks of a field season in which Sam, a doctoral student in her third season of field work, collected field data on a lizard subspecies. In the course of this work, GMB participated³ in the data collection in both the field and the field laboratory during which extensive notes and hundreds of annotated digital photographs were recorded, formal and/or informal interviews conducted with the various participants involved in studies in the area⁴, and photocopies of paper artifacts, including data records, accumulated. Videotape records of pivotal events in the field and field laboratory were also made. This work was contextualized by drawing on notes recorded in

later months as GMB attended symposia/conferences with the graduate students engaged in this field research, socially interacted with informants⁵ at least once a week in informal settings, visited various members of the community in their laboratory settings at the universities, and observed and had discussions with members who were working as teaching assistants for various biology courses at their home universities.

During the study, active analysis of the field data was conducted by members of the research group—in part to help establish the “credibility” desired in ethnographic research (Lincoln & Guba, 1985). To counterbalance any assumptions and presuppositions about field research occurring because of his academic background in biology (B.Sc., M.Sc.) GMB emailed his field notes and annotated digital photographs daily to the second author WMR whose background was not in biology. WMR was non-native in two senses: his academic background was initially in physics research and he was removed from the research field experiencing it only through the notes and photographs. This allowed engagement in a dialogue about the focus being taken in the field observation providing direction for re-examining some issues in greater detail while in the field and also to further examine features of the fieldwork unelaborated in his initial field notes.

Participants in the field research were: Sam the lead ecologist and doctoral student who described her interests variously as investigating the ecology, the behavioral biology, and the evolutionary biology of her lizard species⁶; Stephanie, Sam’s field assistant who had completed a B.Sc. and had worked as a field assistant on other projects; Jobe, a post-doctoral fellow conducting another project in the area who Sam used as a sounding board for her research design and interpretation; various other graduate students and non-biologist volunteers who lived in or were traveling through the area, and; her supervisor and other graduate biologists who provided support or advice by phone or e-mail.

Into the “Outside”

Engaging in ethnographic research with our ecologists took us into three significant places: the university laboratory, the field laboratory (about one day’s drive from the university), and different field sites scattered in the vicinity of the field laboratory. Each spring and summer (April - September), the activities moved from the university to the field laboratory and sites. Open-air studies were conducted on most days of the week, but whether they were conducted on any specific day depended on a large number of mitigating factors warranting consideration. The other

secondary considerations (e.g., follow-up work in the field laboratory not yet completed) aside, the primary components of fieldwork could not proceed unless both the weather and the lizards themselves cooperated. The following narrative⁷ lays the terrain for the conduct of the field research and factors that shape the anthropological construction of the lizards' world.

Looking out the early morning window, Sam took a view of the sky. Having caught up on the other lab work that needed doing, she could now proceed with site work and she was prepared to start working a new field site.

Listening to a weather forecast coming from a radio station two mountain ridges away she made a judgment based on her view out the window and the comments of the radio announcer on whether today would "be a good day" to go into the field.

In the sense that Sam intends "good day", she means, 'Will the lizards be out?' 'Will it be a good day to catch lizards?' and 'Is it worth hiking in to the rock strewn, flower and weed covered hillside to where the study site is or will today be a day when it is unlikely that the lizards will be catchable?' The decision she makes is based on her sense of whether it is a good day to catch lizards which is based on considering if the lizards will be out-in-the-open in the field areas (as opposed to being in the brush or rockpiles) where they are caught "under" rocks. She is assessing whether the hike into the new area will be fruitless—there is little sense in spending the day going into the field if the chances of catching lizards are slim, for there are other issues that do need attention. Her decision is not based on whether it would be a good day for the lizards themselves, for being caught by an ecologist even with good intentions is arguably not in an individual lizards' best interests. However, the assumption could be/is made that since lizards are found at one location and not some other, that this is an example of a "good " place for the lizard to spend time, or at least the lesser of "bad" places. Thus, being situated in this locale is in the lizards' "best interest" by virtue of it being found there in the first place. So run the tautological explanations of field observations of animals in the discipline of ecology research.

It is at this point in the early morning light that the first abstractions and assumptions about the lizards' world, their individual *umwelt*, occurs, for it is here that the assessment is made by a human about conditions which will influence a lizards presence in the open, slightly rocky areas where they can best be caught. There, in the right weather conditions at the right time of year, the

“best interests” of lizards and scientists overlap, because it is in this location that one can find the other. In the other lizard “worlds,” such as in rock piles, the interaction between lizard and environment is such that the humans world essentially does not overlap that of the lizard—in other words, the lizards are uncatchable in those settings as well as in the forest. Lizards also live in those worlds, or at least our ecologists speculate they do, but those worlds are constructed in such a way that the scientists have little expectation of being able to find them there. Thus, the environment which is considered to be important to the lizard (at least implicitly in the writing, since it is what is being written about) is that one within which the human researchers can actually catch the lizards.

This “choice” of research setting highlights differences in perception. In the forest and rockpiles the lizards’ perceptual apparatus (both physically and as guided by lived experience) is so different from those of the human ecologists that their respective worlds do not overlap—their reactions and experiences within the environs of rock pile and forest are so different that they are uncatchable. In the rocky open fields, however, humans can “sense” in a way that is similar enough to how lizards sense the environment that they can find the lizards. By being able to find the lizards the assumption is made that we can make sense of, and can understand, they and their world. This concordance of perceptual apparatus is taken to be somewhat resembling a one to one correspondence—so that what the ecologist notices in research correlates with the lizards’ presence or actions are taken as direct as opposed to covarying influences. Because differences in perceptual apparatus, perspective, and Umwelt are unaccounted for, there is a tendency to treat the world as independent of the organism, thus a move towards the construction of a transcendental world has occurred.

When the decision is made to go into the field and look for lizards, the mapping of the ecologists’ perceptual apparatus onto that of the lizards is first enacted informally, as the ecologist looks for the lizard in some locales in the open, grassy area and not others, and then formally as the lizard that is caught is placed in a net of effects or influences on its’ behavior generated by the features of the environment which are measured by the ecologist.

“Habitat Measuring”.....

Habitat measurement is an important aspect of work at field research sites. In the lizard research various measurable aspects of field sites were recorded, such as distance to forest edge,

distance to nearest shrub, size of rock caught under/near, slope of the ground, and temperature under the rock at which the lizard was captured. However, descriptions of many features of the environment that may be salient to lizards—in contrast to information that can be recorded in a spreadsheet and exported into a statistics package—remain unrecorded⁸. No formal or informal record is made of birds flying by, slight breezes, the state of the flowers blooming around the study site (which change markedly over the field season), dew upon the ground, or other such features to which a lizard might attend. Instead, what is recorded is that which is recordable in the sense that can be inscribed on the externalized retina constituted by the ecologist's instruments in a reasonably unequivocal fashion—an accountable and therefore defensible feature to be measured. Most importantly, whatever is chosen to be “data” must first be transcribable to a table and then a spreadsheet so that differences can be tracked. Further, what are recorded are stable features, those that Sam can measure when she returns a week, month, or year later. In this way, the search for stable features in the environment is another way of supporting the quest for the transcendental world. Within this lies a major discontinuity between how the lizard perceives and interacts with the world and how the ecologist perceives the world of the lizards, for the lizards dynamic Umwelt shares little with the measured-as-static world of the ecologist.

The conduct of “habitat measuring” is an important aspect of the fieldwork because it is through these actions that the lifeworld of the lizard is reduced, homogenized, and carried back “into” the field and university laboratories for the structuring of the lizards' world there. The fieldwork during which “habitat measuring” occurs follows the fieldwork during which lizards are sought and caught. The measuring is a type of pulse activity occurring after several days of capturing lizards at a particular site, and is usually conducted as the last activity before a site is abandoned (for a month or so) and the next research area moved on to.

Decisions on which aspects of the lizards' habitat should be “measured” were influenced by a considerable number of factors. Sam first tended to discuss different perspectives on an issue she considered “problematic” with the people around her. These discussions often related to information read in papers, discussions held at conferences⁹, presentations seen at conferences, and observations made in the field. As part of these discussions she polled both the opinions and suggestions of the person(s) with whom she was engaged in conversation. If the issue remained unresolved, then later communication with her spouse (at a remote field site himself) or

communication with her advisor contributed to her decision. At a pivotal point a decision was made about which direction to proceed. Occasionally these decisions were long labored over as they entailed considerable previously unplanned-for effort to be enacted.

It is at this point in enacting a decision about measurement that a considerable abstraction of the lizards' world is developed, because the assumption becomes that what is seen as important by the ecologist is also seen and experienced by the lizard to be of importance. In the discussions during which these types of decisions were made, references to the lizard perspective (such as whether distance to the nearest rock is actually something considered, or even consider-able, by a lizard) were notable in their absence. The perspective taken was that of an omniscient overview of the lizards' world, the view bearing consideration that of the researcher. The "retina" through which the world of the lizard was observed and understood was decidedly human. An examination of several of these field "measures" will highlight the contrast in perspective of the human, and the lizard.

.....and Perspective/Perception.....

Developing an insight that the lizard moves through its world in a certain way, as we could detect and analyze it using various tracking apparatuses, provides us little understanding of how or why that movement occurs. Our being human has embedded within it certain embodied aspects of understanding our human world that are transparent to the point that they are ignored. As an example, when we view the world we do so with retina embedded in a skull generally observing the world from a height of 1.5 to 2 meters above the ground. It is from this vantage that we perceive, interpret, and understand the world, and conclude that it is *the* world. Our gaze falling downward sees the lizard and its environs as it does not see itself. Our gaze at its world glancing out ahead also perceives the world as the lizard cannot—we see it from our perspective, our *point-of-view*, not the lizards.

It is difficult to discuss the concerns of the lizard, the metaphorical *point-of-view*, because there is little to substantiate a claim that we, the authors, understand the lizards' world enough to offer a contrast with the ecologist's understanding. There is however another perspective-based *point-of-view* that can be contrasted with that of the field researcher, the angular perspective of how the lizard observes the world within which it lives. For us to adopt a lizards-eye view, as a start we must lay upon the ground with our head on its side and glance askew.

The world of the “rocky field” is now reduced to a considerably textured world of dark and light, roughness and scattered terrain with fissures abounding. Limited in visual depth, deeply steeped in incredible complexity and the unknown. The lizard glances forward but a few dozen centimeters, for beyond that the tangle is visually impenetrable. Not living ‘over’ this part of the world, it is almost living under it now, and actually does so completely at times moving from ‘on top’ to ‘under’ this world as the need and whim strikes. Belly against the ground, head under the grass, gazing at pebbles balanced at eye level, the lizard moves within a snarled jungle of vegetation and moguls.

Standing up and glancing down we¹⁰ again look at the scattered rocks, tangled grasses, and drifts of wood and other material at our feet. For us to traverse that ground is a matter of a few steps combined with an awareness of all objects that lay in our field of view, to the lizard it is a sojourn into the (unknown?) textures of its world. What for us is mundane to the point of not consciously noticing, to the lizard is a complex and unknown environ. We can survey the whole domain at one glance, the lizard cannot—the lizard does not view and walk over that world as we do, but rather travels through it. Thus, for a researcher to measure the distance to the nearest rock pre-supposes that the lizard has an awareness of the presence of that rock.

Against the view of the land when laying on the ground with the closest eye gazing outwards juxtapose a lizard moving across the field. For us to measure the distance to the nearest rock is unambiguous. Two meters? Just hold the tape measure. Four meters, drape the tape measure over grass, shrubs, other rocks, and fallen logs. Four meters and thirteen centimeters is the measure. Record it in the field book. From our perspective, from our *angle* of view standing vertically beside one rock and looking at the other the distance is unremarkable. The terrain between unremarkable. Un-noted. The distance itself is inscribable, for it cleanly fits into a table and then a spreadsheet. The organic and inorganic clutter between where the lizard was captured and the next nearest rock is, however, not worthy of mention. Unworthy of recording—until perhaps one lays on the ground and tries to observe one location from the other. Then some sense of the lizards’ view develops. But this view, the viewpoint of the lizard, is not taken in this research. And so the complexity of its world over four meters is reduced, reduced to being effectively

eliminated as the number alone is recorded into a table. The measured distance fits into the table for analysis, the lizards world does not and so remains unrecorded.

Many other such reductions, simplifications, and other de-complexifications of the lizards world further occur as the habitat is “measured.” Does a lizard discriminate between rocks based on size, especially when madly scrambling to escape a predator? The decision to only “use rocks 10cm in size and above,” “nearest shrubs one meter across at the base,” or rockpiles that are “this big” are decisions based on how *we* perceive the world and the lizard’s place in it, as well as based on an idea of measurement embedded in our culture but unlikely to be found in the world of the lizard.

To a lizard one can imagine that a rock of 20 cm width, one deemed suitable in the research protocols for recording in the table, is useless if one cannot get under it, although it might possibly be useful to scramble behind. A 9-cm rock with a small crevasse between it and the moss beneath into which a lizard can scramble is a potential hiding spot. Lizards react to opportunity when evading a predator, they are unlikely to be planning. Unlikely to be measuring. A rock is a rock, or more importantly an opportunity to be utilized: to hide behind, escape detection, or just escape. To a field researcher, however, seeing many such “little” rocks (less than 10 cm) as found in many areas of the field sites, means they are hard to categorize and would probably result in irrelevant data incapable of being correlated, related, varied, against any other variable. Smaller and smaller rocks complexify a categorization scheme to the point where it is unworkable, because of their immense numbers. If all lizards were caught within a few decimeters of small rocks then little is discovered. But, in a co-varying world, excluding small rocks and creating categories of measurement which include the scarcer larger rocks more widely scattered presents the potential for multivariate analysis and significant relationships with other variables chosen using similar boundaries. The lizards’ world includes small rocks, with the potential for use by them. By re-formulating the lizards’ world to include large rocks as relevant, and small rocks as irrelevant regardless of their potential utility or crevasse offerings, we construct a world for the lizards that is ours, based on our *point-of-view*, not theirs, our requirements for analyzing covariation, not their world. By constructing this world as we do we can then compare one parsing of the environment (rock, irrelevant rock) against another (shrub, irrelevant shrub) in their effect on some dependent variable. Subsequent claims in the research writings about the

importance of rock size to lizards neglect to make the distinction between the lizards experience of their world¹¹ and the contingencies of analysis and measurement forced upon the researcher in creating that world. Multivariate analysis does not reveal patterns in lizard behavior, the lizards' world, but rather expose decisions made by ecologists in mapping our view of the world onto the lizards' lifeworld.

.....Shaping the Lizards' World as Constructed in the Field Lab

These measures of the environment, viewed to be representative of the lizards' world, are transported back to the field laboratory to construct within its walls a microworld within which the lizards can be placed. These lizard microworlds are constructed with the intent that the important characteristics of the lizards "outside" world continue to exist within the field laboratory. As far as Sam is concerned this parallelism must be present so that her field lab "findings" can be claimed to be extensible to the lizards in the field and so that such claims are defensible to her peers. To her it is vitally important that the visible aspects of the lizards laboratory-based world be attended to and comparable with its "field" world, for this is the only way to defend the overall claims of discovery in the field laboratory as being representative of the lizards' external world to the broader community of ecologists. Several aspects of the outside world are brought into the field laboratory as some of the research work moves from the field to the field laboratory: habitat is reconstructed as individual enclosures for the lizards; predator avoidance is reconstructed as "sprint speed" down a trough-like track; mate choice and ability to hide from predators is constructed along an index of color and mottling; and, dietary regimes are implemented as consumption of a single species of food—crickets.

LIVING

Within the field lab the ecologist literally "constructs" habitats for the lizards which are perceived as both adequate and, to the necessary degree, representative of the lizards external environment.¹² Within these enclosures lizards are kept, fed, and monitored. This construction of a "holding" facility for lizards represents the mapping of the humans perceptual apparatus onto that of the lizards to provide "habitat" which overlays that of the outdoors with regards to the lizards experience.

Examining these internal enclosures further reveals which aspects of the lizards environment are considered to be of importance to their survival by the human, particularly in this year as Sam re-designed them to try and address a problem in reproductive rates in the previous year that she decided was attributable to the enclosure design. Thus, these enclosures allow us to “see” some of the overlap between the humans’ perceptual apparatus and that which is attributed to the lizards. That the “enclosures” were to be constructed to the needs of the lizards warranted considerable attention by Sam thereby revealing some of the specifics of the environment considered essential to lizard survival.

Lizard enclosures were built in rows on the floor out of rough wood obtained from the discard pile of a lumber mill. They were approximately 30 cm wide, 60 cm long and 16 cm deep. They each had a screened lid recessed into the top of the enclosure which rested on a 2 cm wide wooden lip. Sixty watt incandescent bulbs were suspended over each of the cages approximately 20 cm above the screen.

Each enclosure had clean dirt spread across the bottom to a depth of about 3 cm and 3 rocks, all roughly 15 cm across, were placed in “a pile under the light to facilitate basking behavior.” Crickets were placed in the cage and the lizards could be observed stalking and consuming them. Lights were sometimes turned on and off depending on the cloudiness outside—although this was not strictly adhered to. Water was sprayed using a spritzer bottle into the enclosure every few days, especially when it was raining out side. (Sam indicated for both of these conditions (light and moisture) that her intent was to expose lizards to the same conditions they would experience outdoors. However, despite her stating this several times, there were many times it was cloudy outdoors and the lights were on, sunny outdoors when the lights were off, and with moisture levels maintained inside which did not at all correspond to those outside. Thus, despite the stated intent of parallelism, it was rarely achieved.)

Several features of these enclosures warrant consideration in this discussion. First, these enclosures were a dramatically de-contextualized version of the outdoor life. The screech of owls, the slither of predatory snakes, the crush of rocks flipped by bears were all absent. In the process of being pursued in the outdoors the lizard has many options open which facilitate its escape, but these complexities lizards experience as part of their everyday world are also absent from the

enclosures. It is of little wonder that the lizards maximum “sprint speed” (described below) declined with increased time spent in the lab.

Unlike lizards, quarks, quasars, mesons, microbes, or plants, do not behave¹³ back at you. The lizard’s interaction with the ecologist is one in which each participant is constructed by the other—first in the field where the lizard responds to the ecologist as she was a predator, then in the laboratory enclosures where the reaction is much more benign. Here in the laboratory, the scientist has become an inert part of the lizard’s day to which a response is unnecessary. Here again, the interests of the lizard and scientist overlap—each essentially ignoring the other except at critical times of measurement. The enclosures on the floor, with lizards that “bask” on the rocks and under the lightbulbs, are passed back and forth by one, two, three researchers as they walk back and forth in the lab. The lizards, under wire mesh less than half a meter away, do not react. This fits in with the scientists’ wishes, for constantly reacting lizards would be of some concern. The two worlds, scientists’ laboratory world and lizards’ microworld coexist without conflict and seemingly without overlap.

In the laboratory the lizards are still “individuals”, the transformation to generic lizards has not yet occurred (see Roth & Bowen, 1999), the world of the lizards have not yet undergone that final homogenization into a “report” but are still recognized and dealt with as individual beings. This is unlike the treatment of “subjects” of study in other sciences for physicists generally do not consider single subatomic particles as individuals, nor do botanists usually construct separate plants as “individuals” in their research as do biologists who work closely with animals. However, although the lizards have not (yet) been collectivized, their world of activity has been reduced through a series of observations and inscriptional movements into a homogenous and simplified environment going beyond the construction of their enclosures.

RUNNING

In an effort to discern relations between “sprinting” abilities of the lizards and a myriad of other measurable factors (sex, tail length, forearm and hindleg length) the individual lizards were encouraged to run—an outside observer might say were chased—along a 2-meter long, 10cm wide path with a lightly ridged rubber bottom. Such a surface is unlike any the lizards experience in the field itself, for we saw no comparable “open” area in their field environment. Other than the

rare expanse of open rock, which offers crevasses and a markedly different purchase for their clawed feet, flat and open areas without cover are nonexistent.

When chased outdoors lizards dash from rock to plant cover to log, frequently freezing without movement when underneath ground objects. In the course of their day escapes from predators which involved short dashes of movement would be the norm—for lizards are rarely chased by predators that can flip over rocks and move their cover thereby exposing them. Other movement through the day—searching for food, mates or escaping smaller aggressors—would also involve rapid short dashes or movement under cover from log to rock to shrubbery.

Such natural movements however are incompatible with a scientific, transcendental notion of “speed.” To the lizard, it is not the speed one can attain when avoiding a predator, it is the ability to avoid the predator itself by any ruse—speed, agility, or cleverness—or likely a combination of all of these. Slower lizards may well compensate by being sneakier. However, only one of these aspects influencing “escape” is easily frameable within human constructs of understanding: speed. So it is lizard speed that warrants scientific study. “Speed” or velocity is a construct inculcated in North American students early in their school careers, usually in grade 8 or 9: average velocity is the straight line distance an object travels and the time it takes to travel that distance. Although in their world lizards are rarely able to travel in straight-line distances for any length it is not difficult to design an apparatus to test their ability to travel in such a manner—in fact, scientific norms of standardization would require such a test, for the alternatives are unfeasible to measure. By heating lizards to a single temperature (for standardization purposes), laying out a track (such as described above) with a dark pillowcase at the end for the lizard to run towards (the logic being that a lizard will run to a dark area to hide in it) then lizards can be encouraged to run down the track while being timed. In such a manner, repeated racing of the track becomes another standardizing tool that affords calculation of average speed, and therefore correlation to such features as “tail length” or “number of offspring produced.”

It is through the analysis of the average track “speed” of lizards correlated with other measured aspects of the lizard (such as tail length, leg length, or head width) that the lizard and its lifeworld are constructed. If tail length is found to correlate with speed (as reported at a conference), then further inferences can be made about the importance of tail size to lizard survival. If tail size also correlates with the number of offspring borne (as was also reported), then

further importance can be attached to the importance of the tail, despite the influences of the researcher and her tools on the choice of variables and their operationalization. As covarying exists between the measured variables it is concluded that these obviously must be the important variables because they were measured and significantly correlate—ignoring that these variables were initially chosen *because their measures were at hand*. It is this circularity that results in claims of what features of the lizards' environment (which variables in the study) are important to the lizard, when it is really those that are of importance to the researcher.

HIDING

In their everyday paths, through the scattered world of the field, lizards dart through areas heterogeneous in shade and color. Watching lizards outdoors it can be seen, or rather inferred (for they are rarely actually seen unless out on rocks), that they blend invisibly into the tan, grey, brown and green backdrop against which they live—or so it would seem to our eyes. This type of protective coloration is a form of “hiding” from predators, for if a lizard is invisible it is a moot question whether its location is in the open or under a rock. It is only when humans violate their environment, flipping over a rock under which they are hiding, that they are noticeable. For a second, both the scientist and the lizard, the predator and the prey, are frozen in time, neither moving. Then, as if by an unspoken cue, the hand of the researcher darts down and the lizard itself accelerates off. It is in the effective coordination of the two protagonists that the “real science” can begin, that the former can begin to “measure” the latter against the instruments of the discipline.

One of these instruments used to measure lizards is a Munsell chart,¹⁴ which is used for determining a standardized color and speckling. Originally developed for categorizing soil colors, they are now used extensively by artists, paintmakers, and other professions that need to deal with standardized color. It is the aspect of “standardized” that is important when it comes to using Munsell charts to “measure” lizard color. How this standardization occurs with the lizards is another example of the imposition of anthropomorphic constructs on the world of the lizard.

Several factors were controlled to standardize color viewing on the lizards. Ambient light was controlled and standardized by holding all trials in a white paper lined box with a single light source within which the lizard and Munsell charts could be held. These color comparison charts affords a literal framing of lizards and their color in a manner such that it could later be inscribed

in a table and compared/shared with other lizard researchers who may have used the same scale. The Munsell color sample acts as an intermediary between the lizard itself and the number inscribed in a table. The following field note excerpt describes GMB's first observations of color measuring:

Sam then set-up for doing the color analysis of the lizards. Color analysis takes place in a box placed sideways with a clip-on lamp (designed to maintain consistent light for day-to-day consistency) and the color/speckling (she uses 1, 5, 10, 20%) standard sheets being in the box...Sam brings over her first lizard and asks Stephanie to record the numbers she calls out. Sam first calls out a number representing the percent black, and then laboriously examines the lizard against the color standards. Moving the lizard back and forth from hole to hole in the cards (I didn't really understand until I did it) and switching cards back and forth three or four times until she finally announced a number followed by two more representing hue, value, and then chroma based on the closest match to the lizard. She sets out a thermometer on the counter to record the temperature of the room which is done...

Sam has some concerns about the color of the lizard as affected by dust/dirt after the first one and spends a bit of time wiping it, realizes it's about to shed, and decides that she's going to keep track of shedding schedules to see if that's related to basking and the color. . . . Sam is concerned about the color categorizing being "repeatable" and "consistent" and "without any observer bias on color measure." The percentage dark coverage was okay, but some of doing the color was difficult - you had to be consistent about where you were looking both generally (center back behind the shoulders) and specifically (the outer edges of some scales were more lightly colored) and it seemed that the lizards colors were sometimes between the ones available.

Several features of this exercise distinguish its conduct from the "background" against which lizards themselves or a predator would perceive the color of another lizard. Most notable are: the standardized light from an "natural light" incandescent bulb, the dust removal, and the specific location on the shoulder viewed through the holes in the Munsell chart. Lizards in the real world

are dusty, that is an aspect of their lived world. Dust, however, is inconsistent and therefore, in the scientific world, needs to be removed so that standardization can occur. Also, predators also do not focus their eyes merely on a 1-cm wide circle of other lizards backs but on which part of the lizard they catch sight of. The predators or lizards are thus engaged in semiotic behavior. A lizard predator “reads” the environment and if the lizard provides some contextual clues in the Umwelt of the predator, it is going to be chased and perhaps captured. To counteract this, the lizard has to place itself in its environment in such a way that it becomes difficult to impossible to spot—and thus itself engages in the semiotic behavior of dissimulation.

These standardizations of measure enacted by the ecologists represent another placing of the perceptual apparatus of our scientific measures on the world of the lizard such that the lizard world is reduced and decomplexified. How we “see” the color of the lizard, mediated by the tools of measurement, the desire for defensible standardized approaches, and the tools into which the values are recorded (tables, spreadsheets) may well provide consistency or inconsistency in the ecologists’ analysis, but is unlikely to have much overlap with how a predator or lizard perceives another lizard.

EATING

Feeding occurred every two to four days, although this changed over the duration of time in the field, ostensibly for reasons related to the lizards’ needs. After several weeks of feeding the lizards every two days, a visiting researcher related that her own collection of lizards needed much less frequent feeding (herpetologists are noted for keeping large living collections of lizards, snakes, etc.). Subsequently, although the field lizards were all pregnant (only females being kept) when the “collection” lizards of the biologists were not, Sam reduced feeding frequency to those of the herpetologist with the collection. However, despite the rationale Sam provided for reducing the feedings, our field observations suggest that the time commitment involved with feeding the ever larger number of lizards was also a factor that influenced the decision. As the season progressed, and the number of captive lizards increased, Sam was more frequently commenting on the time it took to feed the lizards and, only being half-way through the field season, was concerned about the time commitment that feeding took.

Body mass was measured weekly and this information was used to triangulate food consumption. Although there was a count of crickets in each feeding period allowing the lizards’

consumption to be monitored, crickets were also notorious “escape artists” and it was recognized that this did not necessarily give a clear indication of consumption. By monitoring body mass changes, our ecologists determined whether a lizard’s dietary needs were met. The lizard mass measurements also mediated decisions regarding when to enact field site visits, such as in late afternoon to return male lizards to the site of their capture.

The lizards’ diet is another example of the de-complexifying of the lizard world in two ways. First, lizards now had a vastly restricted area (their enclosures) in which to “hunt” the crickets. Due to the size of the enclosures, the crickets had many fewer avenues of escape. Secondly, the lizards were restricted to a cricket diet from their ordinary varied selection of small (~one-centimetre long) invertebrates. This “adequacy” of the crickets for the lizards is another human interpretation of the lizard Umwelt, a decision mediated by the availability of crickets at a nearby pet store. This standardization of individual crickets as the unit of analysis for consumption (lizard dietary consumptions were counted as ‘one cricket, two cricket...’) of monitoring of lizard dietary consumption had aspects of variation which were unconsidered. The nutritional value of individual crickets varied widely both observably in their size, in which considerable variation existed, but also in their own internal state—how recently had a cricket itself eaten? Despite this variation, the crickets became homogeneous units of analysis in the dietary world constructed for the lizard thus fulfilling a research desire to monitor food consumption (for later correlative analysis) but in a manner least impinging on the time necessary for the collection task itself.

DISCUSSION

In the social sciences there exists a considerable debate whether the categories chosen by researchers are appropriate for understanding the world of human individuals and their communities. Structuralist approaches are often critiqued for their insensitivity to the characteristic concerns, understandings, and worldviews of the people whose behavior is to be explained. Behavioral ecology is a science concerned with understanding the natural history and behavior of organisms as part of their role in specific ecological settings. In this paper, we argue that in a similar fashion to structuralist analyses of human behavior, behavioral ecologists construct their categories in decidedly anthropocentric terms. In both the field setting and the field laboratory the lifeworld of the lizard is shaped so that it conforms to the perceptual lens of the discipline and its measurement tools. In their everyday research work, field biologists attempt to

construct lizards and their environment as transcendental objects. However, this transcendental world is not truly transcendental, but rather thoroughly anthropomorphic in that it topicalizes features and perspectives salient in a human world, not those of the lizards, the birds of prey who consume them, or other inhabitants of that world. The world of concepts into which the lizards are constructed is a world that is independent of local constraints. Scientists' attempts in arriving at a world independent of local particulars leads to practices in which they de-complexify and homogenize the world of the lizards (and its parts); cleaning the lizards, chasing them through channels with rubber tracks that don't exist in their own worlds, bringing them to the same temperature, etc.

As a result, scientists concerned with the behavior and natural history of animal species map their animal species against the Procrustean beds of human categories. For example, the characteristics of lizards' field habitats were construed by the ecologists we studied in terms of the distances to the closest rocks, bushes, trees, and forest boundaries. However, one may question whether these categories are relevant from the perspective of lizards, their Umwelt. For example, a forest boundary at a distance of 25 meters may far exceed any habitat size that is exploited by the lizard. Human categories also influenced in significant ways the design of the "miniature habitats" that were constructed in the field laboratory as holding areas and to study captured animals. From these interior-ized "worlds" much insight is gained into the homogenization and decomplexification of the lizards' world occurring through the investigative moves and then conclusions of field researchers. So what field biologists measure and study may be completely irrelevant to the lizard, or framed in such a way that it reifies characteristics salient in human Umwelts, such as "forest edge," but whose choice now suggests that this feature is a factor that needs to be considered. By choosing variables for measure based on our view of the world, we make claims about those measures which may be irrelevant to the lizards in the first place. If there is a statistically significant relationship between behavior and distance to the forest edge, then ecologists construct the relationship as something significant, if there is no relationship then it is constructed as a relationship that is not significant. What is never questioned, once a variable such as forest edge is "identified," is whether the variable being considered is even salient in the lizards' world. The meaning we attribute to the world is no doubt "real" to us, but this reconstitution has little to do with the world of the animal. This is not to suggest that as researchers we can ever

completely adopt the lifeworld perspective of the animals we study, but not even considering the tension between our choices and their lifeworld consigns us to unreflectively making choices that are quite experience-distant to the animal.

The activities of the field researchers and their activities in the lab, as they attempt to construct a transcendental world within which they intend to place lizards, demonstrates that conducting research with animals that have a sense of the world themselves is a different activity than that conducted by other scientists, such as physicists, who are trying to understand the phenomena in the world. Figure 1a diagrammatically illustrates the view of natural phenomenon that scientists studying non-sentient phenomena construct in attempting to understand those phenomena. However, to study organisms which themselves have a sense of the world, to understand their *Umwelt* as von Uexküll (1973) advocates, biologists would need to construct an understanding such that the agency of the lizards in the world and their reactions to the world were accounted for (such as depicted in Figure 1b). Understanding an organism's place in the environment is as much about understanding the perception of that organism in its environment and its reactions to those perceptions as it is understanding the phenomena which constitute that organism's world. It is an attempt to understand dynamic interactions, because the lizards are responding to the researchers' presence in the field just as much as the researchers are responding to the lizards. However, what this paper illustrates in part is that there is little difference in how ecologists construct the world and the way that Figure 1a depicts the world as constructed by physical scientists such as physicists and chemists.

[Insert Figure 1 about here]

The reductionism which occurs in the practice of ecology research dramatically de-complexifies the world of the organisms being studied, and in part this is mediated by the tools available to perceive their environment. With the hymenoptera (e.g., the bumblebee), we developed a better sense of their world as tools were developed which more closely emulated the bees perceptual framework. At what point did we know we were not seeing the world as the bee did?—when we developed equipment ourselves to perceive UV and Polarized light. Until the development of those tools we did not know we did not perceive the bees world as they did, and hence did not know we should be trying to. Thus, in this study we demonstrate that ecologists do not know which aspects of the lizard world are accurately understood and, despite all of the

mediations of research design and analysis, assume they experience the world in the same fashion as do the lizards. Only new perceptual tools will allow us to recognize any folly in this view(ing) of the world.

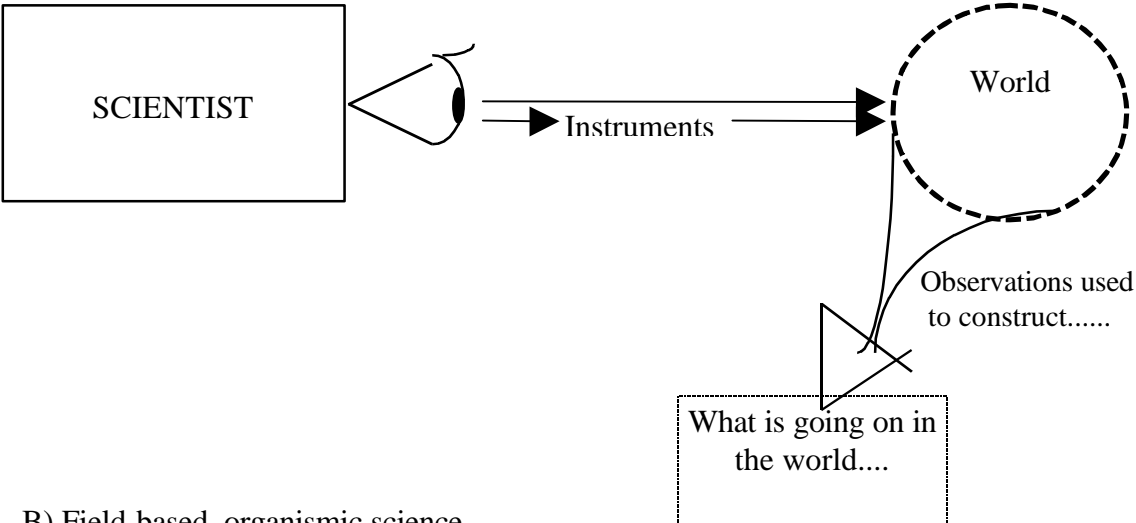
Understanding how the field of ecology constructs knowledge claims and research methods has significant implications for policy development on environmental issues. By understanding that ecologists (and we as a society) construct an anthropocentric lifeworld for organisms, we can better understand how to deal with environmental and political problems such as commercial extinction of species such as cod, species extinction, and conflicts between different managed and commercially-exploited resources (e.g., the interests of forest and salmon industries may be different in that logging practices destroy salmon spawning grounds). However, to address this issue a better understanding of the enculturation process of ecologists (and students in general) is necessary. It is not that ecologists do not develop a sense of connectedness to their organisms, for this lizard ecologist clearly did—and it is argued that developing “a feeling for the organism” (Fox Keller, 1985) is a common experience of scientists (Gould, 1984). However, what we have argued is that the tools with which the environment of the lizard is perceived are applied in a manner that is considered unproblematic—and this seems to be little reflected upon. In part this might arise because undergraduate ecology courses, unlike those of the physical sciences, are taught in settings—lectures, labs with structured activities, seminars—which are quite unlike those at which the research is actually conducted (Bowen, 1999). More importantly, however, is that it is rare that these educational settings actually contain any non-human living organisms that students engage with for any length of time—there is little opportunity in a four-year degree to gain any experience in understanding the perspective of the organism being studied. Although it is not possible to say that if the concerns, issues, and practices of ecology were taught along with prolonged engagement with live organisms that ecologists would more consciously try to understand the worldview of the organisms they were studying. However, it is clear that one consequence of not engaging with animals for any length of time in undergraduate study is the placing of an anthropocentric worldview over that of the worldview of the animals. This suggests that even pre-service teachers with biology (and environmental science) backgrounds enter into their teaching programme with a perspective on the world which runs counter to many of the concepts we wish to promote in environmental and ecology education.

Implications for Education

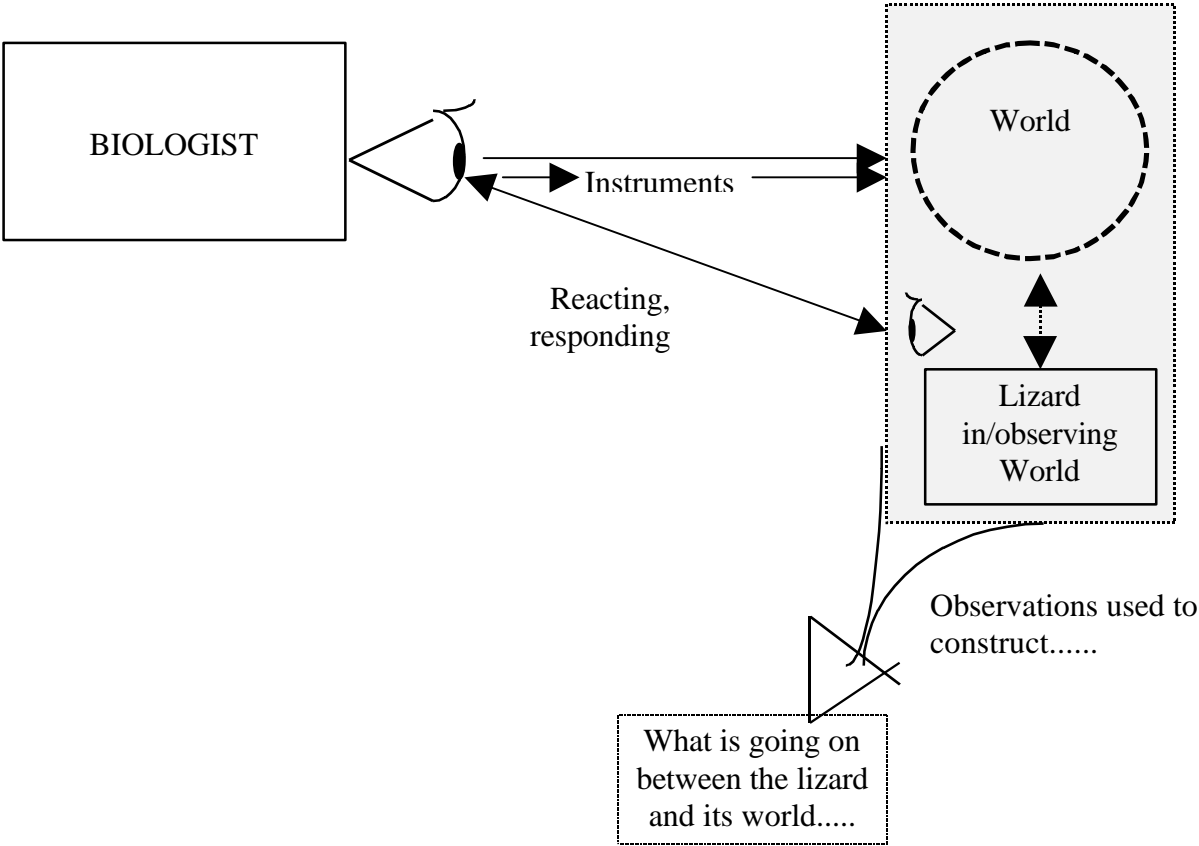
It is apparent from this work with ecologists that it is quite difficult for us, as humans, to escape our human view and human perspective on the world. We suspect that engaging students in a process where they conduct studies congruent with those of field ecologists, as current science and environmental educational reforms suggest, without the broader concerns in which ecologists embed their studies and interests, would encourage them to develop a reductionist world-view running counter to actually understanding the complexity of ecological relationships. This suggests that if educators are to encourage students to enact “authentic” practices when teaching students about ecology, they also need to work reflexively with the students so that they examine the limitations of their findings—in part helping them recognize that what they understand through their research is not an abstract, unbiased perspective on natural phenomena but one which is deeply rooted in their own human view of the world—a view which is not that of the organisms they are studying but one which may actually dramatically under-determine those experiences.

Figure 1. Diagrammatic representations of (a) physicists or chemists viewing their research world contrasted with (b) a biologist understanding an organism in its lifeworld.

A) Laboratory-based, non-organismic science



B) Field-based, organismic science



Notes

¹ The dissection of dead animals results in animals being regarded as “mere specimens” and develops/reinforces a cultural understanding of science and its beliefs about the use of and power over animals (Solot & Arluke, 1997).

² In this paper the term “field laboratory” will be used to refer to the building site at the field research site. This field laboratory is often much less of the specialized setting within which chemists and physicists and geneticists are found, but is typified by collections of data records into which the measures from the field are added, the presence of the lizards themselves, and some specialized equipment used in laboratory activities with the lizards. At the conclusion of the field season collected data, samples, and some lizards are physically transported and relocated to the laboratory found at the university.

³ We used apprenticeship as ethnographic method. See, Coy, M. (1989).

⁴ Other field biologists were also conducting research projects on snakes, frogs, and birds in the area and the lizard project itself had various assistants over the duration of the summer.

⁵ The term “informants” in this usage represents the revolving membership in the community, not a “set” body of individual members.

⁶ These are not contradictory as the fields conceptually overlap and in essence constitute different lenses through which the same data may be observed and collected. However since the “ecology” aspect is experience-near to the field work GMB conducted and the “evolutionary biology” aspect is experience-distant (essentially being developed in the interpretive stage back at the university lab) she will be referred to in this paper as an ecologist.

⁷ Narratives such as this are re-constructions based on information provided by informants.

⁸ Finlayson, A.C. (1995) suggests that early anecdotal evidence from fishermen concerning the decline of cod stocks off of Newfoundland was disregarded because it was not transferable/transformable into the data recording and analysis tools being used by the biologists.

⁹ Sam discussed information learned in informal discussions at conferences far more frequently than that learned in formal presentations (see Bowen, 1999). This may be related to the nature of presentations at many biology conferences where papers are related as ‘works-in-progress’ as opposed to completed documents.

¹⁰ Whether this “we” is the ecologist, the social scientist, or the reader, is immaterial, for the visual perspective is that adopted by humans, and it is this physical visual perspective being highlighted here.

¹¹ Scientific writings do not just exclude the agency of the organisms being studied, but also of the humans who engaged in making the decisions in the research. This lack of human agency in scientific writings authorizes both the knowledge claims and research methodologies (see Gross, 1996; Latour, 1987).

¹² In this, the enclosures constructed for the lizards in the field laboratory become similar to the construction of cages in zoos which (mis)represent the animals in settings of our world, not theirs (see Malamud, 1998).

¹³ A distinction between “behave” and “react” is necessary. Various atomic and sub-atomic particles of interest to physicists (e.g., electrons, photons, etc.) do respond or react to the presence of the research apparatus. “Reacting” differs from “behavior” in that there are not aspects both of short term change, such as learning, or long term change, such as evolution, which result in changes in the behaviour unlike that which is found in physics. The same classification can also be made along the lines of semiotic behavior (including plants and animals). See Krampen (1986) and Sebeok (1986).

¹⁴ Use of Munsell colour charts in soil work is described extensively by Latour (1995) and Goodwin (1996). The Munsell charts used in this ecology work had small holes in them (approx 1.5 cm across) over which was a sample of the standardized colour and it’s associated code. A small portion of the sample (i.e., the lizard) can be viewed surrounded by a reference color. The referent color patches therefore always “frame” the object of interest.

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