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The epistemology of plant protection: Honduran *campesino* knowledge of pests and natural enemies

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ABSTRACT

Folk knowledge of the natural environment, including pest control topics, is highly uneven. Examples from Honduran peasant farmers show that rural people have extensive folk taxonomies and much cultural lore for relatively conspicuous organisms that are of perceived cultural importance, such as social bees and wasps. Conspicuous but unimportant subjects, like sphecid wasps, fit into shallow taxonomies and have less community knowledge associated with them. Important but difficult-to-observe topics, such as bean leaf diseases, may have poorly developed folk taxonomies, and are sometimes linked with beliefs that are incongruent with western science. Unimportant and difficult-to-observe creatures such as parasitic wasps are generally neither known nor named. This scheme allows pest control workers to classify organisms, whether natural enemies or pests, according to the level of community knowledge, and to anticipate the unique opportunities and challenges that each kind of folk knowledge offers.

RESUME

La connaissance populaire de l'environnement naturel, y compris des sujets relatifs à la lutte contre les fléaux, est très inégale. Des exemples recueillis parmi les paysans Honduriens montrent que les ruraux disposent de taxonomies populaires étendues et de beaucoup de connaissances sur des organismes relativement visibles qui ont une importance culturelle reconnue comme les abeilles sociales et les guêpes. Des sujets visibles mais sans importance, comme les guêpes sphécides, s'intègrent bien dans des taxonomies superficielles et la connaissance de la communauté en ce qui les concerne est moindre. Des sujets importants mais difficiles à observer comme les maladies des feuilles de haricot peuvent avoir des taxonomies populaires peu développées et sont parfois liés à des croyances incompatibles avec la science occidentale. Des créatures sans importance et difficiles à observer, comme les guêpes parasites, ne sont en général ni connues ni nommées. Ce programme permet aux agents de lutte contre les fléaux de classifier les organismes, qu'il s'agisse d'ennemis naturels ou de ravageurs, selon le niveau des connaissances dont dispose la communauté et d'anticiper les opportunités et les défis uniques que chaque genre de connaissance populaire offre.

INTRODUCTION

> "People usually do not classify exhaustively unless organisms are important or conspicuous. The Fore of New Guinea have a single word for all butterflies, although species are as distinct as the birds they do classify in Linnaean detail." (Gould, 1980)

In this brief statement, Stephen Jay Gould identifies the two most important factors that influence the development and complexity of folk taxonomies: importance and conspicuousness. I would further emphasize that it is not enough for a set of organisms to be important or conspicuous: they must be important *and* conspicuous or people will fail to classify them extensively. The really deep and rich folk taxonomies and the impressive bodies of folk knowledge are those for organisms (or other things or ideas) which are important and conspicuous. As Gould's example shows, conspicuous butterflies are not treated to an exhaustive taxonomy because they are not important.

In this paper I define 'important' as meaning 'of perceived value or harm to the local people', including economic use and physical pain. For example, humans perceive wasps as important because their stings hurt and occasionally kill people. Whether or not a creature is conspicuous or easily observed depends on its size, colour, movements, time of activity and perceived risk to the observer, and is also influenced by cultural attitudes (such as 'all insects are bad').

Importance and ease of observation can be visualized as two axes which divide folk knowledge into four cells, with different taxonomic structures and unique classes of knowledge (Figure 1). In the upper right-hand cell of the figure are the important, easily observed topics like social insects, weeds, farm tools and

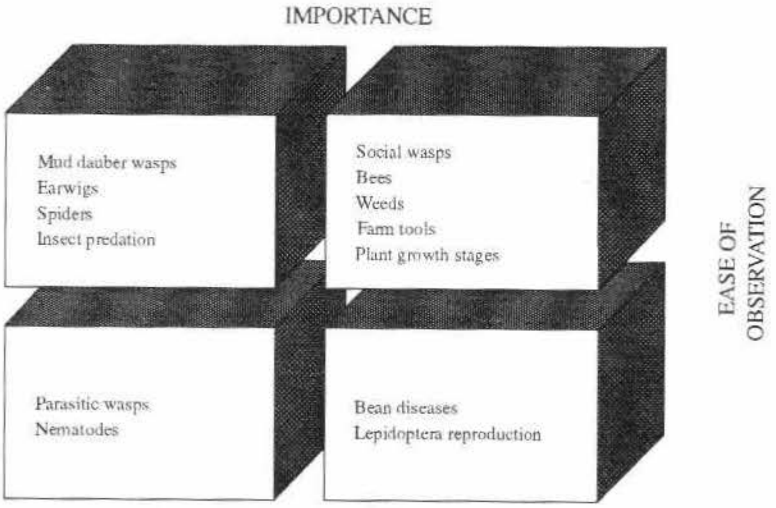

Figure 1 Four classes of farmer knowledge

plant growth stages. These domains are rigorously classified and well understood. The upper left-hand cell includes easily observed but unimportant entities like the Fore's butterflies and, for Honduran *campesinos* (peasant farmers), earwigs, spiders and mud-dauber wasps. These animals are named but are neither highly differentiated taxonomically nor connected with much cultural lore. The lower right hand cell includes important but difficult-to-observe topics such as many plant diseases and lepidopteran (moth and butterfly) reproduction. These are named and, although not split into many folk categories, are the focus of cultural beliefs which may be at odds with western science. The lower left hand cell holds unimportant and difficult-to-observe topics like parasitic wasps, which *campesinos* are generally unaware of, and do not name.

Although many of my prime examples come from insect taxonomy, this division of kinds of knowledge can account for much indigenous technical knowledge about the natural environment. This scheme is about ideas rather than biological organisms *per se*. Some organisms are easy to classify according to one of the four classes of knowledge, while others must be teased apart. Honduran folk knowledge of ants, for example, falls in at least two classes: stinging behaviour and seed eating are in the 'important, easy to observe' class, while ant reproduction and predation fall in the 'unimportant but easy to observe' cell (Figure 1). Ant reproduction is easy to observe - as *campesinos* kick open ant nests they notice the ants scurry off with larvae. Farmers understand that, like bees, ants care for their young in nests, but the notion is of little practical value to *campesinos*. I have arbitrarily classified ant predation in the 'unimportant, easy to observe' class, but it shares some properties with the 'unimportant, difficult to observe' class. Because *campesinos* do not know that ants prey on insects, ant predation is not perceived to be important. But when they find out that ants help control pests, the idea does become important. Although ant predation is potentially important, and easily demonstrated, *campesinos* do not notice it for at least three reasons:

* it is not as obvious as ant reproduction, as the ants often forage at night and hunt over large areas (while ant reproduction takes place in small, discrete places)

* a cultural bias that insects do not eat other insects discourages the observation

* much of the prey taken by ants is early instar larvae and insect eggs, so is not very easy to see.

CLASSES OF KNOWLEDGE

Conspicuous and important: 'thick taxonomies'

Conspicuous and important phenomena tend to be organized into many folk categories, in a taxonomy five or six layers deep (see Figure 2). Conspicuous and important organisms are often labelled at the biological species level. Explanations of these phenomena - the quality of honey, the painfulness of wasp stings - are often couched in 'positivist' terms, that is, the explanations are consistent with scientific knowledge and acceptable to scientists.

While it may seem obvious that important, conspicuous things are better understood and split into more categories than unimportant, inconspicuous items, much of the debate in ethnoscience has revolved around the relative importance of morphology and economic use in determining nomenclature (Hunn, 1982; Turner, 1988), with less attempt to reconcile or synthesize both perspectives. There has been such a strong tendency to study the important and conspicuous that ethnoscience gives the impression that all of folk science is profound and highly ordered. Several motives lead anthropologists to study folk taxonomies. One is the search for cognitive structure (either universal or culture-bound) in semantics. Human universals in the organization of folk taxonomies suggest that all peoples see the world in comparable ways (Berlin, 1973; Brown & Chase, 1981; Hays, 1983; Boster, 1987). Documenting detailed semantic paradigms satisfies our desire to demonstrate the intellectual equality of all humankind and helps anthropologists portray the (generally poor, marginalized) people they have studied as intelligent, observant and thoughtful. Ethnoscience, the branch of anthropology most concerned with folk taxonomies, has highlighted many examples of detailed folk knowledge of nature. Examples include studies of animals (Hunn, 1977), insects (Wyman & Bailey, 1964) and soils (Behrens, 1989). Berlin's work on Tzeltal folk botany (Berlin *et al.*, 1974) is often cited as an example of how peasant farmers know the names of, and uses for, thousands of plants.

Profound knowledge is not limited to living beings. Honduran *campesinos* name each part of common agrarian implements like ploughs and yokes in great detail. Elsewhere I have described how small-scale Honduran farmers precisely divide the stages of a maize plant's growth cycle by a series of about eleven verbs, comparable to the numbered vegetative and reproductive stages of maize phenology used by agronomists (Bentley, 1989). Current work with entomologist Ronald Cave shows that Honduran *campesinos* generally categorize social bees to the species level. *Campesinos* must gauge bee defence strategies and honey quality to decide whether to chop down a tree down and split it open for honey. The European honey bee, which stings, was introduced by the Spaniards to Central America (and recently replaced by an Africanized sub-species); native American bees are stingless but each species has a defence mechanism. Some retreat into their nest when disturbed, and peer out of the entrance, others swarm the intruder, delivering hundreds of bites on the face and neck. One species secretes a burning liquid onto an attacking vertebrate's skin. Honey quality is as variable as the type of defence the bees mount. *Campesinos* classify various kinds of honey as medicinal, good to eat, nasty and potentially poisonous. The honey of at least one species is spurned because people see the bee foraging on dog faeces. Hondurans distinguish over half a dozen small, black bee species at the level of the biological species. Much like entomologists, who use keys or diagnostic differences to separate taxa, *campesinos* sort bees by the unique features of architecture (generally the shape of the nest entrance), behaviour (especially how they enter and leave the nest), and morphology. For example, *campesinos* notice that the diminutive, golden *quema quema* (*Trigona*

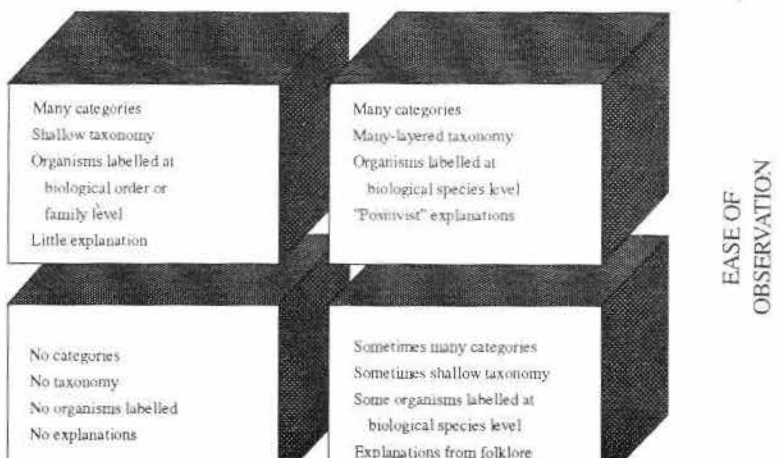

Figure 2 Characteristics of four classes of farmer knowledge

pallens) (Hymenoptera: Apidae), which oozes poison and visits dog dung, has green eyes, distinguishing it from the *jimerito* (*T. jaty*), a mild-mannered, medicinal honey maker.

The Vespid family, better known in English as 'paper wasps' for their intriguing fibrous nests (Hansell, 1989) is classified with almost as much attention. *Campesinos* recognize that some species are so tame they can live under the eaves of houses, staying in permanent association with people without stinging. Others hurl themselves on passers-by and sting viciously. One tiger-coloured species (*Protopolybia acutiscutis*), about the size of the housefly, is known as the 'underwear remover' (*quitacalzón*) because a horde of the wasps silently and systematically crawls throughout the victim's clothing before launching a painful stinging attack that raises welts many times larger than the wasps. People who can't leap into a river are often forced to strip. Some wasp stings are said to induce fever and one is alleged to cause choking. As if these different levels of pain and aggression were not enough reason for rural folk to label vespids at the biological species level, one species of *Brachygastra* also produces up to a gallon of honey, which is harvested. A couple of *Polybia* species make smaller amounts of honey, and some people toast their larvae to eat.

Just as *campesinos* can discriminate between related bee species when they have a good reason to, they may lump together social wasps that are economically similar. A good taxonomist can distinguish *Polybia occidentalis* from *P. diguetana* by putting them under the stereoscope and scrutinizing their yellow stripes. *Campesinos* differentiate them by nest shape: one is oval and the other is longer. Although rural Hondurans recognize the two species as different, they give them the same name, because their difference is not important, both are mild-mannered, have only moderate stings, and produce tiny amounts of honey. Many species of *Polistes* and *Mischocyttarus* are all lumped together with one folk name (e.g. *catala*), although *campesinos* easily admit that there are different kinds, which they can distinguish by colour, size and nest habit. The difference between these wasps is not considered important; they make no honey and are not especially aggressive. Although *campesinos* generally perceive wasps as important, the poorly distinguished ones are near the fuzzy cognitive border between the halves of nature which are perceived as important or unimportant.

Conspicuous but unimportant: strings of folk genera

Conspicuous but unimportant phenomena are often classified in a taxonomic structure with many categories, but few levels - shallow strings of dozens of names with no subordinate and few superordinate categories (see Figure 2). Conspicuous but unimportant organisms are often labelled at the biological family or order level. There is little attempt at explanation, positivist or otherwise, for phenomena in this group.

As much as we like to portray traditional rural people as able taxonomists, exhaustive studies of folk taxonomies often reveal many animal names with little paradigmatic structure. Hunn (1977) found that for Tzeltal speakers of Mexico, 106 of 335 individual names for animals were classed as birds, another 45 as mammals, while 184 names, many of which were insects, were not included in higher taxonomic levels (except for that of 'animal') and most of the 335 names include no subdivisions.

I use the phrase 'folk genus' for the term linguistic anthropologists call 'generic taxon', as an analogy to the Linnaean genus. In any language, folk genera form the most important, basic, cognitively salient taxonomic level (e.g. English 'fly') and are occasionally divided into folk species (e.g. 'house fly', 'horse fly'). Folk and scientific taxonomies are both formal classificatory schemes, but they contrast in two important ways: inclusion of sub-categories and treatment of Linnaean species. While most Linnaean genera are subcategorized into several species, most folk genera are not. Many folk genera correspond to Linnaean species (e.g. English folk genera 'horse', 'sheep' and 'maize') while others correspond roughly to the biological family (e.g. 'ant', 'mosquito', 'grass') or order category (e.g. 'dragonfly', 'earwig'). Some folk genera, like the English 'butterfly', include several families but not the whole order.

Honduran *campesinos* do not think of any bugs (terrestrial arthropods) other than honey producers as beneficial, so most insects are classified in a shallow taxonomy and are given folk genus names with no species subdivisions. *Campesinos* lump the entire order of Dermaptera (earwigs) together as *tijerillas* (little scissors), just as most spiders are undifferentiated *arañas* and all dragonflies (order Odonata) are merely *caballitos del diablo*, 'the devil's little horses'. Being conspicuous is no guarantee of even a unique name for animals with no perceived economic importance. The mud-dauber wasps (family Sphecidae) are highly conspicuous, building nests shaped like organ pipes, footballs and mud clods on houses and other buildings. *Campesinos* see the wasps hauling spiders or grasshoppers into the nests and know that they rear their young there, but because sphecids are useless and harmless to *campesinos* they are merely lumped into the residual category 'just wasps', sharing the name avispa with the vespids and other wasps. Many *campesinos* claim that sphecids have no name, or that they do not know it.

Important but difficult-to-observe: the enigmas

Important but difficult-to-observe phenomena may or may not have complex taxonomies, depending on biological factors (see Figure 2). For example bean diseases in Honduras are poorly classified, with viral and fungal disease, nutritional deficiencies and other ailments all grouped together. Some insect pests are classified at the biological species level, although knowledge of their behaviour, especially of their reproduction, may be poorly understood. 'Folkloric' explanations (e.g. spontaneous generation), often at odds with positivist science, are much more common than they are for other kinds of knowledge.

Nothing is more maddening than a real problem with no obvious solution, like many insect pests and crop diseases. Multiple diseases are more difficult to observe and differentiate than one disease. *Campesinos* confuse many bean diseases (Bentley, 1991) but because there is only one major maize disease in Honduras, maize ear rot, farmers are able to focus on the disease and acquire a body of knowledge comparable to that of plant pathologists. Honduran *campesinos* have formed the same hypotheses as specialists for solving this disease problem, including increased soil fertility, quicker drying of the grain, burning crop residues, and bending the maize plant over (Bentley, 1990).

Voracious worms that seem to appear fully grown from nowhere, others that descend on a field by the thousand overnight and diseases that wipe out whole fields rank high on the importance scale, but are hard to observe. Magico-religious explanations or other 'odd' unscientific-sounding beliefs about insects and other organisms are likely to occur in the important but difficult-to-observe cell.

Although insect pests are some of the few insects other than bees and wasps which *campesinos* classify at the biological species level, farmers have a poor understanding of caterpillar reproduction. The *cogollero*, or whorlworm (*Spodoptera frugiperda* - Lepidoptera: Noctuidae) is an endemic maize pest which *campesinos* perceive as chronically lowering crop yields. Because it is very tiny when it first hatches and glides through the air on a silk thread, landing inconspicuously on the earth and making its way to maize plants, *campesinos* do not notice the *cogollero* in its early instars. They notice the little windows the tiny larvae carve in maize leaves, eating off the green tissue and leaving a transparent film in the centre, but many fail to distinguish those windows from the damage of leaf miners, a host of small insects of different orders which work in the completely opposite way, by eating out the interior of the leaf. *Campesinos* notice whorlworms when they are large caterpillars eating the tender new tissue of the maize whorl, and burying themselves in their own faeces. Farmers believe that the worms are generated spontaneously by the corn plant itself, citing as evidence the fact that smashed whorlworms are green, like maize plants (see Bentley & Andrews, 1991).

One of the odder beliefs about insect pests in Honduras involves the gregarious grasslooper, *Langosta medidora*, (*Mocis latipes* - Lepidoptera: Noctuidae). Because it completes its life cycle in 19 to 36 days (King & Saunders, 1984) and lives in wild grasses, it can appear overnight in certain maize fields. Although maize is not the grasslooper's preferred food, if it runs out of favoured grasses the third or fourth generation after the start of the rainy season may hit a farmer's maize field like a disastrous act of God. Coming as though from nowhere, the masses of chewing caterpillars can turn a ripening corn patch to bare stalks and central veins in a day or two. Rural folk around Danlí, Honduras, believe that a field attacked by medidora can be saved with a magico-religious rite called *cruzar la milpa* (crossing the corn field). The praying practitioner walks diagonally through the field both ways, sometimes sprinkling holy water and usually making little crosses of maize husks or worms in the corners and centre of the field. Then the owner is told not to go into the field for nine days and the worms will disappear. Keith Andrews (Crop Protection Department, El Zamorano, personal communication, 1988) points out that nine days is just long enough for the medidora to pupate and disappear as if by magic. While he tends to see an element of chicanery in this practice, I don't. The farmers I talked to suggested that the ritual specialists were only paid a labourer's day's wages. 'Crossing a corn field' gives some Honduran farmers a supernatural support that provides the psychological comfort to get on with farming. Although the rite is practised in a relatively small area of eastern Honduras along the Nicaraguan border, it is spreading into the Valley of Jamastrán, which was settled recently by migrants from southern Honduras, where the practice is unknown. It may strike plant protection specialists as ironic that a magical practice can spread spontaneously while many of our technologies are not adopted after massive extension efforts.

So far I have discussed material factors (size, mobility etc.) which influence how easy an organism is to observe. Cultural attitudes also affect how people see the world around them, even though those attitudes may have been shaped in part by the biological structure of that world. For example, Hondurans, both *campesinos* and most of the middle class, believe that all insects are bad except bees. Virtually all insects are thought to be herbivorous. While this belief may have a basis in the observation of abundant plant-eating insects in the tropics, it also affects *campesinos*' vision of their fields as being virtually under siege to insect pests. Farmers over-react to the relatively large, brightly coloured, diurnal *Diabrotica* spp. beetles. Although crop scientists believe that the beetles rarely do economic damage, *campesinos* often apply pesticides as soon as they notice *Diabrotica* in their fields.

Difficult-to-observe and unimportant: the empty quarter

Because difficult-to-observe and unimportant phenomena are not usually categorized, they fit into no folk taxonomies and are not labelled at any levels of biological classification (see Figure 2). They are accompanied by no folk explanations. Many organisms are neither named nor paid any attention to, because they are both difficult to observe and not perceived as important. Because they are so small, often microscopic, none of the four major families of parasitic Hymenoptera in Honduras is even recognized by farmers, let alone seen as pest controllers. Each herbivorous insect has at least one parasitoid wasp, and sometimes dozens, as well as nematodes, flies and other tiny organisms whose lives are intertwined with the host they feed on and kill. If not for these little creatures, Central American farmers would starve; yet the wasps are neither named nor known. While sitting with a pair of farmers in a maize field a parasitic wasp landed on my knuckle. Seizing this opportunity to see how farmers perceived this natural enemy, I held my hand up to one of the men and asked him what it was. "It's an ant," he said, as he smeared it into my finger.

NATURAL AND INTELLECTUAL ENVIRONMENTS

This framework of farmers' knowledge attempts to balance the anthropologists' wonder at indigenous knowledge with the technocrats' bias that peasant farmers are ignorant and superstitious. Before going on to discuss how the four classes of knowledge can inform participatory technology generation, I argue that the farmers' natural and intellectual environments call for technology generation with farmer involvement.

Some smaller geographical regions, like Central America, have more environmental variation than scientists can design IPM technology for (Andrews & Bentley, 1990). There is important environmental variation even within a single community: some farms are much larger than others, some fields lie along river banks and others on fragile hillsides. There is an almost infinite number of agrarian environments, each with different pest profiles and research demands.

Many farmers are innovators who think creatively to solve their own problems. Virtually all farmers try new crop varieties. The irrigation systems built by Honduran *campesinos* are feats of community engineering. Each one is a work of art, tailored to a particular stretch of rough country, carrying water thousands of metres from canyon streams, around hills and over precipices. Farmers in central Honduras have recently invented a horse-drawn plough, a narrow hoe for cultivating garlic, and a triangular hoe to dig trenches for chemical fertilizer. Many similar farmer innovations from Honduras and other countries could lengthen this list. Farmer creativity is a potential resource for solving problems in diverse natural environments - and 'farmer participation' is now cited so often that its arguments hardly need be repeated.

However, the farmer participation trend has created more rhetoric than results. While sociological differences between researchers and farmers (Chambers, 1983) may be largely responsible, there may be other, less obvious reasons why farmer involvement has so far failed to live up to its promise. There may be an implicit assumption that, as farmers are wise and creative, their participation is uniformly helpful and is limited only by the researcher's commitment to collaboration. We need to consider how farmers have different depths of knowledge for different kinds of knowledge, and that farmer-scientist interactions should be shaped by the pattern of knowledge (Figure 3).

RECOMMENDATIONS FOR RESEARCH AND DEVELOPMENT

Important and easy-to-observe

As this class includes farmers' most familiar topics, this is where scientists can learn the most from them. Rhoades' (1989) familiar example of diffused light potato storage falls into this class. Scientists learned about the technology from farmers in Kenya and successfully spread it to farmers around the world (see page 12).

Farmers are expert at intercropping, a traditional practice now widely assumed to limit pest populations by increasing environmental diversity, providing habitats for natural enemies and making it harder for the phytophagous insects to find food (Altieri, 1987). Sustainable weed control must be based on technologies without herbicides or fossil fuel; traditional weed control with manual and animal-drawn tools is the obvious starting point for such technologies.

Just a few of the other topics where science can learn much from traditional peoples include:

* management of native American meliponid bees, raised since pre-Columbian times
* behaviour of other large social insects
* use of smoke to protect seed maize from weevils
* pharmaceutical and nutritional value of 'non-weeds' and other wild plants.

Farmers' knowledge should especially be relied upon to set research agendas, instead of allowing scientists'

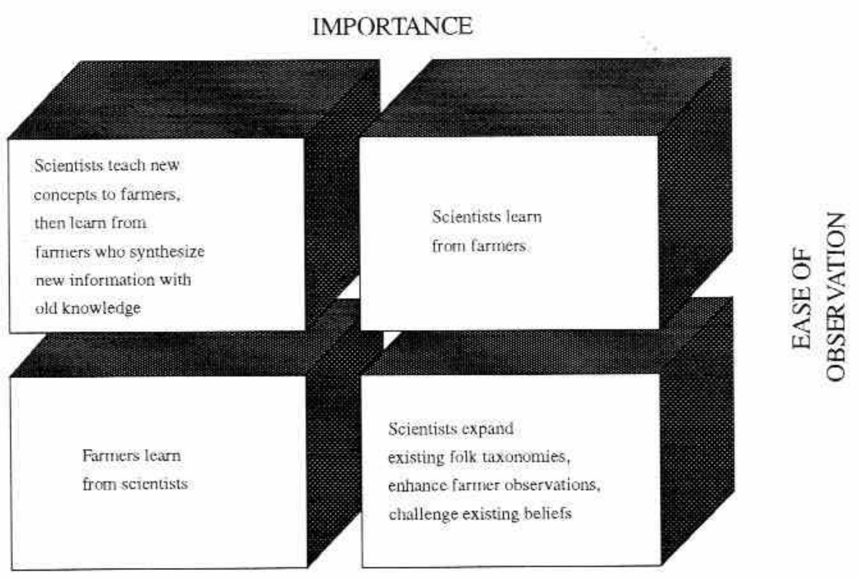

Figure 3 Style of participation according to class of knowledge

often esoteric disciplinary interests to drive research. (Unused maize-drying buildings in Honduras, abandoned water harvesters in Arizona's Papaguería [Bentley, 1987] and failed, large-scale, capital-intensive irrigated rice schemes in West Africa are just some of the monuments to planners' and scientists' arrogance.)

Not important but easy-to-observe

This class may offer the greatest opportunity for collaborative research. By teaching farmers things they do not know about certain easily-observed organisms, farmers may gain an enhanced perception of some of the species around them, and then learn more about them by continued observation. Some topics - mud-dauber wasps, defoliating caterpillars on wild plants or mushrooms - are easy to observe but unimportant to farmers, and to most scientists too. Other topics offer a source of new ideas for both scientists and farmers. The most obvious example is the predatory insects. Because earwigs, social wasps, ants, certain true bugs (Hemiptera) and praying mantises are easy to observe, if we let farmers know that these creatures help control crop pests, they can teach themselves how to conserve and manipulate these natural enemies. Farmers often gratuitously destroy wasps and ants to avoid being stung. A farmer who kicks apart an ant nest forces the ants to waste energy rebuilding the nest, possibly even using their own larvae as emergency rations instead of preying on armyworms and other pests. Scientists often feel obliged to develop a technology to extend to people. In his keynote address to this seminar, Robert Chambers criticized this notion, arguing that we should extend precepts, not packages (see page 12). The 'unimportant but easily observed' class of knowledge is especially suited for extending precepts. Teaching farmers that ants eat insects gives them a reason to see ants in a new light, re-evaluate them as natural enemies and then learn how to manipulate them.

In Honduras my colleagues and I use bee, wasp and ant reproduction as a starting place for discussing insect metamorphosis with farmers; explaining fly reproduction (which they partially understand) and moth and beetle reproduction (which they do not understand) in terms of hymenopteran reproduction (which they do understand).

Scientists can help shift farmers' notions of insect predation from the unimportant to the important side of the chart, by teaching them about it. As farmers blend new information with old knowledge and new observations, they may create new, synthetic ideas and technologies which scientists would not have invented. We experienced one such case in Honduras. The entomologist Keith Andrews attempted an experiment with the predatory *Polybia* spp. wasp, moving hives onto maize fields, but was frequently stung and most of the wasp colonies soon absconded. Andrews abandoned the idea in the early 1980s. Not long afterward he explained wasp predation to a group of farmers, and one of the farmers, Wilfredo Flores, began moving nests. In 1989 another entomologist, Ronald Cave, and I discovered that Flores had begun moving nests on his own. *Campesinos* traditionally move nests from brush to avoid being stung while clearing land. They start learning about wasp relocation as children, bringing hives into rural schoolrooms and releasing them, hoping to terrorize the teacher and other students.

Important but difficult-to-observe

This class represents the greatest challenge to scientists because it sometimes implies changing beliefs rather than adding new information. It is a heterogeneous class where I have identified three styles of intervention (expanding existing taxonomies, enhancing farmer observation, and challenging existing beliefs).

Expanding existing taxonomies

When I first came to Honduras in 1987, some agronomists ridiculed the *campesinos*' use of the word 'ice' (*hielo*) for plant disease (see Bentley, 1991). The agronomists mistakenly thought that farmers believed that their crops froze. After Guillermo Cerritos and I studied the problem and explained that 'ice' labels most plant diseases but does not imply that the plants actually freeze, many agronomists who work with farmers adopted the term. At least one successful extension agent, Werner Melara, explains to farmers "as you know, there are many kinds of ice" and then explains the different symptoms and causes of various diseases, essentially filling in a traditional category, 'ice', with a new taxonomy of 'fungus, virus, bacteria', etc.

Enhancing farmer observation

If farmers are interested in a topic and lack the tools of observation to fully appreciate it, one tactic is to share novel methods of observation with them. In a study of maize ear rots, the major disease of maize in Honduras, we found that *campesinos* know virtually all that phytopathologists know, except for the causal agent (Bentley, 1990; del Río, 1990). So in over a dozen villages in the remote interior we set up a microscope and showed the fungus to *campesinos*, and we explained how this kind of fungus was like mushrooms that they were familiar with, but smaller. We then invited the *campesinos* to suggest possible control tactics. They proposed dozens of ideas, of which we eventually tested three for control of the disease: burning crop residues, bending the maize plant or removing leaves or tassel at physiological maturity, and trials of (native) maize varieties.

Challenging existing beliefs

This may be more difficult. Many Honduran *campesinos* say that agrochemicals spontaneously generate insect pests. They say that the first pests were seeded in chemical fertilizer so the people would be forced to buy insecticide, but each one they bought contained the seeds of yet another pest, trapping the farmers on a conspiratorial chemical treadmill. If farmers realized the true relations between pesticide and pest populations, they may be able to wean themselves off agrochemical dependency. Farmers understand very well that physiological traits are inherited by the offspring of people, livestock and crops - and they readily grasp the idea of insects being selected for genetic resistance to pesticides. Farmers also accept the idea that natural enemies are killed by insecticides. After a week with a group of farmers, I congratulated myself on having spent days carefully building a logical framework for changing the idea of spontaneous generation that was nevertheless consistent with the local culture. In a final discussion, however, one of the farmers suggested, and the others agreed, that agrochemical companies seed insects in products. We still have a lot to learn about changing existing beliefs.

Unimportant and difficult-to-observe

On the other hand, adding completely new concepts is easier. Although *campesinos* do not know about parasitic wasps, they enjoy the topic. We use photographs and live parasites in bottles to expose *campesinos* to the subject. We also find it easy to introduce farmers to the notion of entomopathogens by analogy with humans: just as people get sick and sometimes die because of disease, so do insects. We show farmers cadavers of insects killed by disease. This subject offers promise because of the growing importance of biological insecticides as alternatives to chemicals. Basic knowledge about disease may help farmers accept the biological control agents, even though they take days instead of minutes to kill pests.

CONCLUSIONS

I have suggested that gaps in indigenous technical knowledge can be predicted using a two by two matrix of 'importance' and 'ease of observation'. A similar matrix that took into account the tools of observation and occupational interests of other groups could be used for fishermen, bus drivers, bankers, entomologists and others. While farmer participation in research is now widely promoted, it has failed to live up to its initial promise and has generated few technologies. Honestly confronting the limitations as well as the strengths of indigenous technical knowledge may help scientists have more fruitful interactions with farmers.

Technical collaboration with farmers should be based on learning what the people know and what they don't know, figuring out what they need to know, teaching it to them in a way that is consistent with what they know, and then learning from them as they synthesize new information with old knowledge.

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DISCUSSION

J. Farrington (*ODA, London, UK*). The work you are doing with farmers looks very interesting, but what kind of wider-scale application does it have for scientists - are you thinking of some kind of training programme, for example, where they are taken through similar experiences themselves, or are you going to produce a manual that they could work with - what is the bridge between your field experience and a wider programme to influence the way scientists behave?

J. W. Bentley. We are doing a course on biological pest control based on these notions, developing different ideas in different ways, according to how farmers perceive them to begin with. An example of something well known to farmers that is important and easy to observe, is weeds - farmers know that weeds compete with crops, yet people earning good salaries waste their time writing pamphlets explaining that weeds compete with crops, take up nutrients, take up water, compete for sunlight - the farmers know all this, and the agronomists are wasting valuable resources. A topic as difficult to perceive as parasitic wasps must be explained to farmers - they can understand it, but it has to be explained very carefully. At least in Honduras, farmers do not understand that there are insects which eat other insects - the lack of that knowledge is the source of much pesticide abuse in Central America. It is important to realize that farmers do research on their own, they do a lot of experiments, and can think of a lot of technologies on their own. If we just enhance their knowledge with more ideas, they will do better experiments and will come up with a lot of technology that we cannot come up with.

P. Nkunika (*Department of Biology, University of Zambia*). How long have you been working on this project, and how long do you expect it to continue? How do you see perceptions of knowledge developing over that time?

J. W. Bentley. The work has been going on for four years, and we expect it to continue for a further three to five years, and maybe more. My perception of the farmers has changed with time. I started with the 'ethnoscience' bias - I thought farmers knew everything. But that was because I was an anthropologist working in isolation. When you start to work with biologists, and they set you a research agenda to ask farmers about parasitic wasps, and entomopathogens, and things an anthropologist would never think of, then you find that farmers do not understand these things. My first experience in Honduras was very frustrating, as I found that there were many things farmers didn't know, which seemed to reconfirm the agronomists' bias that farmers know much less than they do. Out of frustration I started to look where the light was brightest, at topics that I knew farmers understood, and only after that was I able to put this scheme together. Often in plant protection we are working on topics where we know more than the farmers do, but we should not let that give us a sense of false security, that we are smarter than them, because we have microscopes, and professional meetings like this one. As far as how the farmers' perceptions are changing, that is hard to tell, but they are very interested. They are fascinated by natural enemies, and it is great fun to demonstrate to farmers how ants and wasps eat insects, and to learn with them in the field.

N. D. Jago (*NRI, Chatham, UK*). The sort of things you are learning about farmers' ignorance also help us to understand our own ignorance - Dr Chambers' presentation demonstrated how closed all our minds are. Knowledge can come from many sources - on our project in Mali, we live in the millet fields, and through wandering around in the fields at night we accidentally learned that the millet head miner moth males sing to the females, which turned out to be a very important discovery. Neither farmers nor researchers normally see what is happening in the field at night.