GENERIC SPECIES AND BASIC LEVELS: ESSENCE AND APPEARANCE IN FOLK BIOLOGY

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ABSTRACT.—Results indicate that the same taxonomic rank is cognitively privileged for biological induction in two diverse populations: people raised in Michigan, and Itzaj Maya of the Peten rainforest. This is the generic species — the level of oak and robin — which is coextensive with Berlin's folkgeneric rank but with a distinct theoretical sense. The findings are unaccounted for by similarity-based models of category formation and induction because such models cannot simultaneously yield different measures of privilege. For example, Rosch and her colleagues suggest that life forms — the level of tree and bird — rather than folkgenerics comprise the "basic level" for many Americans. Rosch, like Berlin, advances such domain-general models of similarity to account for privileged categories as maximally informative clusters of perceptual attributes that best represent "objective discontinuities" in nature. However, this favors cross-cultural differences in the rank privileged in induction as a function of differences in familiarity with the natural environment. Although our data indicate some relative downgrading of knowledge to a higher rank among industrialized Americans and upgrading to a lower rank among silvicultural Maya, these differences are clearly a second-order effect. To account for the absolute privilege of generic species in diverse cultures, a domain-specific view of folkbiology is offered. It favors the idea of the generic-species level as a partitioning of the ontological domains of plant and animal into causal essences. The attribution of essence, and the biological expectations that go with it, is in part independent of actual experience or degree of perceptual familiarity with the kind in question. This reflects a cognitive division of labor between domain-general perceptual heuristics and domain-specific learning mechanisms, which may be an evolutionary design.

RESUMEN.— Nuestros resultados indican que el mismo rango taxonómico es privilegiado cognoscitivamente en dos poblaciones diferentes: gente que creció en Michigan, en los Estados Unidos de Norteamérica, y Mayas Itzaj de la selva tropical del Petén en Guatemala. Este rango taxonómico es la especie genérica — el nivel del <u>encino</u> y el <u>petirrojo</u> — que coincide con lo que Berlin llama el nivel genérico 'folk' pero tiene un sentido teórico distinto. Los modelos de formación de categorías e inducción basados en la similitud no pueden dar cuenta de estos resultados porque tales modelos no pueden producir simultaneamente diferentes medidas de privilegio. Por ejemplo, Rosch y sus colegas sugieren que son las formas de vida — el nivel al que pertenecen <u>árbol</u> y <u>pájaro</u> — más que los genéricos 'folk' las que comprenden el "nivel básico" para muchos norteamericanos. Rosch, al igual que Berlin, propone tales modelos de similitud, generales a todo dominio, para explicar las categorías privilegiadas como conjuntos, maximamente informativos, de atributos perceptuales que mejor representan las "discontinuidades objetivas" de la naturaleza. Esto, sin embargo, favorece las diferencias entre culturas en el rango privilegiado en la inducción como función de las diferencias en familiaridad con el medio ambiente. Si bien nuestros datos indican cierta disminución relativa del conocimiento hacia rangos superiores entre los norteamericanos industrializados, y un aumento del conocimiento hacia rangos inferiores entre los silvicultores mayas, estas diferencias son claramente un efecto de segundo orden. Para responder al privilegio absoluto de la especie genérica en diversas culturas, ofrecemos una perspectiva específica de dominio de la biología 'folk'. Esta perspectiva favorece la idea del nivel de la especie genérica como una división de los dominios ontológicos <u>planta</u> y <u>animal</u> en esencias causales. La atribución de esencia, y las expectativas biológicas que conlleva, son independientes en parte de la experiencia real o el grado de familiaridad perceptual con la clase en cuestión. Esto refleja una división cognoscitiva del trabajo entre la heurística perceptual de dominio general y los mecanismos de aprendizaje de dominio específico, división que puede ser un diseño evolutivo.

RÉSUMÉ.—Notre enquête indique que dans deux populations distinctes, les habitants originaires du Michigan aux États-Unis et les Maya Itzaj de la forêt dense humide du Petén au Guatemala, le même rang taxinomique est cognitivement privilégié lors du processus inductif de connaissance des éléments biologiques. Il s'agit de l'espèce générique — le niveau de <u>chêne</u> et de <u>rouge-gorge</u> — qui est coextensive au niveau du générique populaire de Berlin mais qui a un sens théorique différent. Ces résultats ne peuvent s'expliquer par des modèles de la formation catégorielle et de l'induction fondés sur la similarité, car de tels modèles ne peuvent fournir en même temps une appréciation des différentes échelles de mesure de prédilection qui sont à l'œuvre. Par exemple, Rosch et ses collègues suggèrent que pour de nombreux Américains, les formes de vie — le niveau d'<u>arbre</u> et d'<u>oiseau</u> — constituent le "niveau de base" au lieu des génériques populaires. Comme Berlin, Rosch propose de tels modèles de domaines généraux de similarité pour rendre compte des catégories privilégiées en tant que groupes porteurs d'information maximale d'attributs perceptuels représentant le mieux les "discontinuités objectives" de la nature. Toutefois, ceci laisse croire à des différences culturelles relatives à la sélection inductive du rang qui seraient fonction de différences de familiarité avec le milieu naturel. Bien que nos données indiquent un appauvrissement relatif du savoir vers le haut (les rangs supérieurs de la taxinomie) chez les habitants industrialisés du Michigan et un enrichissement relatif du savoir vers le bas (les rangs inférieurs de la taxinomie) chez les Maya

forestiers, ces différences constituent évidemment un effet secondaire. Une perspective spécifique au domaine de la biologie populaire peut rendre compte de la prédilection absolue pour le niveau de l'espèce générique dans diverses cultures. Selon cette perspective, le niveau de l'espèce générique serait le résultat d'un morcellement des domaines ontologiques de plante et d'animal en essences causales. L'attribution de l'essence — et les attentes biologiques qui l'accompagnent — est partiellement indépendante de l'expérience concrète ou du degré de familiarité perceptuelle avec la sorte en question. Ceci reflète une division cognitive du travail, entre une heuristique perceptuelle orientée vers le domaine général et des mécanismes d'apprentissage tourné vers le domaine spécifique — ce qui pourrait relever d'un schéma évolutif.

INTRODUCTION[1]

This paper uses a standard tool of cognitive psychology — inductive inference — to explore the cognitive validity of folkbiological ranks. In particular, the study tests whether there is a psychologically privileged rank that maximizes the strength of biologically relevant inferences, and whether this privileged rank is the same across cultures. The crucial question is whether and where in the taxonomic hierarchy a breakpoint or sharp change in inductive strength occurs. The issue directly bears on ideas concerning the basis for the cognitive appreciation of living kinds.

For example, findings by Rosch and her colleagues suggest that members of an industrialized society see category members as fairly similar up to the life-form level, that is, the level of tree or bird (Rosch, Mervis, Gray, Johnson, and Boyes-Braem 1976; see Zubin and Köpcke 1986 for Germany). If so, the major breakpoint or elbow in inductive confidence in such cultures should appear between the life-form level and higher levels. In contrast, observations by Berlin and his colleagues on the salience of the folkgeneric — the level of oak and robin — suggest that the breakpoint in a small-scale subsistence society should be between the folkgeneric level and higher levels (Berlin, Breedlove, and Raven 1973). In the following paragraphs we develop these ideas to motivate the present experiment.

Ever since the pioneering work of Berlin and his colleagues, ethnobiological evidence has been accumulating that human societies everywhere have similar folkbiological structures (Berlin, Breedlove, and Raven 1974; Hunn 1977; Hays 1983; Brown 1984; Atran 1990; Berlin 1992). These striking cross-cultural similarities suggest that a small number of organizing principles universally define systems of folkbiological classification. Folkbiological groups, or taxa, are organized into ranks, which represent an embedding of distinct levels of reality. Most folkbiological systems have between three and six ranks. Taxa of the same rank are mutually exclusive and tend to display similar linguistic, biological, and psychological characteristics.

Ranks and taxa, whether in folkbiological or scientific classification, are of different logical orders, and confounding them is a category mistake. Biological ranks are second-order classes of groups (e.g., species, family, kingdom) whose elements are first-order groups (e.g., lion, feline, animal). Folkbiological ranks seem to vary little, if at all, across cultures as a function of theories or belief systems; in

other words, such ranks are universal but not the taxa they contain. Ranks are intended to represent fundamentally different levels of reality, not convenience.[2]

The most general folkbiological rank is the folk kingdom. Examples are <u>plant</u> and <u>animal</u>. Such taxa are not always explicitly named, and represent the most fundamental divisions of the biological world. These divisions correspond to the notion of "ontological category" in philosophy (Donnellan 1971) and psychology (Keil 1979). From an early age, it appears, humans cannot help but conceive of any object they see in the world as either being or not being an animal and there is evidence for an early distinction between plants and nonliving things (Inagaki and Hatano in press). Conceiving of an object as a plant or animal seems to carry with it certain assumptions that are not applied to objects thought of as belonging to other ontological categories, like the categories of substance or artifact (Keil 1989; Mandler and McDonough 1996).

The next rank down is that of life form. Most taxa of lesser rank fall under one or another life form. Life-form taxa often have lexically unanalyzable names (simple primary lexemes), such as "tree" and "bird," although some life-form names are analyzable, such as "quadruped." Biologically, members of a life-form taxon are diverse. Psychologically, members of a life-form taxon share a small number of perceptual diagnostics: stem aspect, skin covering, and so forth (Brown 1984). Life-form taxa may represent adaptations to broad sets of ecological conditions, such as competition among single-stem plants for sunlight and tetrapod adaptation to life in the air (Hunn 1982; Atran 1985). Classifying by life form may occur early on: two-year-olds distinguish familiar kinds of quadruped (e.g., dog and horse) from sea versus air animals (Mandler *et al.* 1991).

The core of any folk taxonomy, according to Berlin, is the folkgeneric level. Like life-form taxa, folkgeneric taxa are often named by simple lexemes, such as "oak" and "robin." Sometimes, folkgenerics are labeled as binomial compounds, like "hummingbird." On other occasions, they may be optionally labeled as binomial composites, such as "oak tree." In both cases the binomial makes the hierarchical relation apparent between generic and life form.

Folkgenerics often correspond to scientific genera or species, at least for the most phenomenally salient organisms, such as larger vertebrates and flowering plants. On occasion generic species can correspond to local fragments of biological families (e.g., vulture) , orders (e.g., bat) and — especially with invertebrates — even higher-order biological taxa (Atran 1987a; Berlin 1992). Folkgenerics may also be the categories most easily recognized, most commonly named and most easily learned by children in small-scale societies (Stross 1973). Indeed, ethnobiologists who otherwise differ in their views of folktaxonomy tend to agree that one level best captures discontinuities in nature and provides the fundamental constituents in all systems of folkbiological categorization, reasoning and use (Bulmer 1974; Hunn 1982; Ellen 1993).

In what follows, we use the term "generic species," rather than "folk genera/ folk generic" (Berlin 1972) or "folk species/folk specieme" (Bulmer 1970), for three reasons.[3] First, a principled distinction between biological genus and species is not pertinent to local folk around the world. The most phenomenally salient species for humans, including most species of large vertebrates, trees, and phylogenetically isolated groups such as palms and cacti belong to monospecific

genera in any given locale (cf. Hunn 1977).[4] Closely related species of a polytypic genus in a locale are often hard to distinguish, hence no readily perceptible morphological or ecological "gap" can be discerned between them (Diver 1940).

Second, the term "generic species" reflects a more accurate sense of the correspondence between psychologically privileged folkbiological groups and historically privileged scientific groups (Stevens 1994). During the initial stages of Europe's world-wide "Age of Exploration," the number of species increased an order of magnitude. Foreign species were habitually joined to the most similar European species; that is, to the generic type in a "natural system." Historically, then, the distinction between genus and species did not appear until the influx of newly discovered species from around the world compelled European naturalists to mnemonically manage them within a worldwide system of genera built around (mainly European) species types (Atran 1987a).

Third, the term "generic species" reflects their dual character. As privileged mnemonic groups, they are akin to genera in being those groups most readily apparent to the naked eye (Cain 1956). As privileged causal groups, they are akin to species in being the principal loci of evolutionary processes responsible for the appearance of biological diversity (Mayr 1969). In Western science, the dual character of this privileged level of folkbiological taxonomy eventually "fissioned" into species (Cesalpino 1583) and genera (Tournefort 1694).

People in all cultures spontaneously partition the ontological categories ani-mal and plant into generic species in a virtually exhaustive manner. "Virtually exhaustive" means that when an organism is encountered that is not readily identifiable as belonging to a named generic species, it is still expected to belong to one. The organism is often assimilated to one of the named taxa it resembles, but sometimes it is assigned an "empty" generic-species slot pending further scrutiny (e.g., "such-and-such a plant is some [generic-species] kind of tree," cf. Berlin in press). This partitioning of ontological categories seems to be part and parcel of the categories themselves: no plant or animal can fail in principle to belong uniquely to a generic species.

Moreover, data from developmental psychology suggests that young children presume each distinctive living kind to have an "essence," or underlying causal nature, which is responsible for the typical appearance of that kind (Gelman and Wellman 1991). At first this presumption involves only global understanding that the readily visible outsides of living kinds are produced by, but perhaps different from, their initially invisible insides. Children initially lack concrete or specific pieces of knowledge about each kind (Simmons and Keil 1995). Over time, they try to flesh out the causal properties of these presumed essences as responsible for growth (Hickling and Gelman 1995), inheritance (Springer and Keil 1989), and complementary functioning of distinct body parts in a living kind (Hatano and Inagaki 1994). Such intrinsic causal essences, which are universally presumed to be both teleological (unlike the mechanical causes affecting inert substances) and internally directed (unlike externally fashioned artifacts), appear to be unique to the cognitive domain of living kinds and primarily identified with generic species.

Generic species may be further divided into folkspecifics. These taxa are usually labeled binomially, with secondary lexemes. Compound names, like "white

oak" and "mountain robin," make the hierarchical relation transparent between a generic species and its folkspecifics. Folkspecifics that have tradition of high cultural salience may be labeled with primary lexemes, such as "winesap" (a kind of apple tree) and "tabby" (a kind of cat). In general, whether and how a generic species is further differentiated depends on the cultural significance of the organisms involved. Occasionally, an important folkspecific taxon will be further subdivided into contrasting folkvarietal taxa: for example, short-haired tabby versus long-haired tabby. Folkvarietals are usually labeled trinomially, with tertiary lexemes that make transparent their taxonomic relationship with superordinate folkspecifics and generic species, for example "spotted white oak."

Thus, in addition to generic species, people everywhere tend to form groups that are both subordinate and superordinate to the level of privileged groups. This regular classification of "groups under groups... is not arbitrary like the grouping of stars in constellations" (Darwin 1859:431). Rather, cultures across the world organize readily perceptible organisms into a system of hierarchical levels that are designed to represent the embedded structure of life around us, with the generic-species level being most informative. In some cultures, but not all, people may develop "theories" of life that are meant to cover all living kinds, such as Western theories of biology (Carey 1985; Atran 1995a). But the very possibility of such theorizing would not exist without a universal construal of generic species to provide the transtheoretical basis for scientific speculation about the biological world. Different biological theories — including evolutionary theory — initially arose to account for the apparent constancy of "common [generic] species" and for the apparent similarities and differences between them (Wallace 1889:1; Mayr 1969:37).

Given these observations, results of psychological studies of privilege or basicness are striking and puzzling. In a justly celebrated set of experiments Rosch and her colleagues set out to test the validity of the notion of a psychologically privileged taxonomic level (Rosch et al. 1976). Using a broad array of converging measures they found that there is indeed a "basic level" in category hierarchies of "naturally occurring objects," such as "taxonomies" of artifacts as well as living kinds (cf. Brown, Kolar, Torrey, Troung-Quang, and Volkman 1976). For artifact and living kind hierarchies, the basic level was where: (1) many common features are listed for categories, (2) consistent motor programs are employed for the interaction with or manipulation of category exemplars, (3) category members have similar enough shapes so that it is possible to recognize an average shape for objects of the category. For example, subjects were able to list many more features for chair or dog than for furniture or mammal, but few added features for kitchen chair or terrier. They could also readily construct an average image for chair or dog but not for furniture or mammal. Rosch et al. also found that basic-level categories are preferred in adult naming, the level first learned by children, and at which categorization was fastest.

Thus, work by Berlin and Rosch both indicate a privileged level in category hierarchies. Moreover, both claim that this privileged take on naturally occurring objects is directly tied to objective discontinuities in the real world. These objective discontinuities provide the information-rich bundles of perceptual attributes that presumably allow a domain-general perceptual processing mechanism to carve up nature at its fundamental joints.

But here's the rub that motivates the present study: The basic level that Rosch *et al.* (1976) hypothesized for artifacts was confirmed (e.g., hammer, guitar); however, the hypothesized basic level for living kinds (e.g., maple, trout), which Rosch initially presumed would accord with Berlin's generic rank, was not. Instead of maple and trout, Rosch *et al.* found that tree and fish operated as basic-level categories for American college students. Except for very familiar animals (e.g., dog, chicken), Rosch's basic level for living kinds corresponds to Berlin's life-form level.

To explore the cognitive basis for this apparent discrepancy between Berlin and Rosch, we introduce the examination of inductive inference into our study. Inductive inference allows people to extend knowledge beyond their immediate experience and beyond the information they are given, and is a crucial part of category formation and use (Rips 1975; Smith and Medin 1981). Although neither Berlin nor Rosch explicitly deal with inductive inference, such inferences are arguably central to understanding preference for certain categories. For what is privileged about cat relative to mammal or tabby is that the amount of information that can be inferred about the category may be maximized at the level of cat. Thus, knowing that a tabby eats fish, it may be prima facie reasonable to infer that all cats eat fish, but unreasonable to infer from this that all mammals eat fish. Moreover, knowing that a short-haired tabby eats fish is likely as good an indication that all cats eat them as it is that all tabbies do.

If a privileged level carries the most information about the world, categories at that level should strongly support a wide range of inferences about what is common among members. Inferences to a privileged category (e.g., white oak to oak, tabby to cat) should be much stronger than inferences to a superordinate category (e.g., oak to tree, cat to mammal). Moreover, inferences to a subordinate category (e.g., spotted white oak to white oak, short-haired tabby to tabby) should not be much stronger or different than inferences to a privileged category.

The hypothesis motivating our experiment is that the privileged taxonomic level for biological induction is absolute, in the sense of remaining constant across culture, and not relative, in the sense of varying across cultures. Unlike relative privilege, absolute privilege is not primarily driven by general notions of perceived similarity, experience, or cultural expertise. Instead, the absolute inductive privilege of the generic-species level may be anchored in cognitive assumptions peculiar to a universal domain of folkbiology. The idea is that people everywhere presume essential kinds to be the main loci of causal processes that govern the apparent structure of the biological world, even if the superficial and underlying properties of such kinds are at first little known (Atran 1987b; Medin and Ortony 1989; Gelman, Coley, and Gottfried 1994).

Although we expect members of these widely divergent cultures to show absolute psychological privilege at the generic-species level, we may also find evidence of the effects of devolution of folkbiological knowledge leading to secondary differences in induction patterns across cultures. Specifically, Dougherty (1978) argues that lack of contact with the natural world leads to knowledge decay at more specific levels; thus Americans may show secondary privilege for higher-order taxa. Likewise, Itzaj dependence on intimate interaction with the biological world, coupled with a silviculture tradition, may lead to secondary privilege for lower-order taxa.

In addition to examining the competing claims of absolute versus relative privilege, our experiment must also deal with claims for a more general sort of reasoning heuristic, which we deem progressive privilege. What is missing from most perception-based or similarity-based accounts of category formation in class-inclusion hierarchies is an explanation of how inferences are made across the taxonomy from one category to another. Such an explanation is necessary to understand the work that categories do in taxonomic reasoning, and is crucial to any understanding of underlying (biological) relationships. In one of the most elegant attempts to explain similarity-based taxonomic inference to date, Osherson, Smith, Wilkie, López, and Shafir (1990) depict an inferential argument as categorical if its premises and conclusion take the form *All members of C have property P*, where C is a natural category like ROBIN or BIRD, and P remains the same across premises and conclusions. An example is *Guernsey cows are susceptible to mad cow disease; therefore all cows are susceptible to mad cow disease*. The argument is psychologically strong to the extent that belief in its premises engenders belief in its conclusion. Osherson *et al.*'s model is based exclusively on an evaluation of the perceived or presumed similarities between premise and conclusion categories.

The prediction of progressive privilege that follows from this model is that for any given premise category held constant at a particular taxonomic level, argument strength should decrease the higher the level of the conclusion category. Thus, inductive strength should decrease incrementally from varietal to specific, varietal to generic species, varietal to life form, and varietal to kingdom. Also, for any given conclusion category held constant at a particular level, argument strength should increase as one changes the premise category to one that is closer to the conclusion category. For example, inductive strength from varietal to generic species should be less than from specific to generic species.[5] By contrast, our hypothesis entails that absolute rather than progressive privilege will account for inference patterns across folkbiological ranks.

METHODS

Itzaj participants.—Twelve Itzaj — six men and six women — living in the village of San José, Petén, Guatemala participated in the study.[6] Itzaj are Maya Amerindians living in the tropical forest region of Petén, Guatemala. Until recently, men devoted their time to shifting agriculture, hunting, and silviculture, whereas women concentrated on the myriad tasks of household maintenance. The Itzaj comprised the last independent native polity to be conquered by Spaniards (in 1697), and have preserved virtually all ethnobiological knowledge recorded for Lowland Maya since the time of the initial Spanish conquest (Atran 1993). Despite the current awesome rate of deforestation and demise in use of Itzaj language and culture, the ethic of traditional Maya silviculture is still very much in evidence among the generation of our informants who range in age from 50 to 80 years old (Atran, Medin, Lynch, Ross, Vapnarsky, and Ucan Ek' in press). Participants spoke Spanish as well as Itzaj, but testing was exclusively in Itzaj. They were acquainted with the first author, and at relative ease in the testing situation. All were compensated for their participation.

Michigan participants.—The 21 American participants were five men and 16 women who ranged in age from 17 to 25. They were self-identified as people raised in Michigan, and recruited through an advertisement in a local campus newspaper. All were paid for their participation.

Itzaj materials.—Based on extensive fieldwork with the Itzaj, we chose a set of Itzaj folkbiological categories of the kingdom (K), life-form (L), generic-species (G), folkspecific (S), and varietal (V) ranks. We selected three plant life forms: *che'* = 'tree', *ak'* = 'vine', *pok~che'* = 'herb'/'underbrush'. We also selected three animal life forms: *b'a'al~che' kuximal* = 'walking animal', i.e., mammal, *ch'iich'* = 'birds including bats', *käy* = 'fish'. Three generic-species taxa were chosen from each life form such that each generic species had a subordinate folkspecific, and each folkspecific had a salient varietal.[7] Although some Itzaj life-form names are composites (e.g., *b'a'al~che' kuximal*) while others are primary lexemes (e.g., *ch'iich'*), previous experiments indicate that this linguistic difference has no impact on inference patterns within Itzaj life forms (López *et al.* in press; Atran in press). Categories used and their approximate English translations are presented in Table 1.

TABLE 1.—Natural kind stimuli used in Itzaj study.

Folk Kingdom	Life Form	Generic Species	Folk Specific	Varietal
animal (*b'a'al~che' kuximal* & *ch'iich'* & *käy*)				
	mammal (*b'a'al~che'*)			
		agouti (*tzu'*)		
			green agouti (*ya'ax tzu'*)	
				large green agouti (*noj ya'ax tzu'*)
		squirrel (*ku'uk*)		
			red squirrel (*chäk ku'uk*)	
				female red squirrel (*chäk ku'uk uchupal*)
		spider monkey (*tuuchaj*)		
			black spider monkey (*b'ox tuuchaj*)	
				male black spider monkey (*b'ox tuuchaj uxib'al*)
	bird (*chi'iich'*)			
		vulture (*ch'om*)		
			black vulture (*b'ox ch'om*)	
				red-headed black vulture (*b'ox ch'om chäk upol*)
		hawk (*ch'uy*)		
			water hawk (*ch'uy-il ja'*)	
				black water hawk (*b'ox ch'uy-il ja'*)
		woodpecker (*kolonte'*)		
			red woodpecker (*chäk kolonte'*)	
				black-backed red woodpecker (*chäk kolonte' b'ox upach*)
	fish (*käy*)			
		catfish (*lu'*)		
			village catfish (*lu'-il kaj*)	
				large village catfish (*noj lu'-il kaj*)

TABLE 1.—Continued.

Folk Kingdom	Life Form	Generic Species	Folk Specific	Varietal
		mojara (*b'ox*)		
			yo'mojara (*yo' b'ox*)	
				small yo'mojara (*mo'nok yo' b'ox*)
		sardine (*chilam*)		
			red-tailed sardine (*chäk~nej chilam*)	
				male red-tailed sardine (*chäk~nej chilam uxib'al*)
plant (*che'* & *pok^che'* & *ak'*)				
	tree (*che'*)			
		papaya tree (*p'ut*)		
			village papaya tree (*p'ut-il kaj*)	
				yellow village papaya tree (*k'än put'-il kaj*)
		nance tree (*chi'*)		
			savanna nance tree (*chi' chakän*)	
				green joom savanna nance tree (*ya'ax joom chi' chakän*)
		hogplum tree (*ab'äl*)		
			forest hogplum tree (*ab'äl-il k'aax*)	
				forest jobo hogplum tree (*job'o' ab'äl-il k'aax*)
	herb (*pok^che'*)			
		cordoncillo (*pu'uk che'*)		
			male cordoncillo (*pu'uk che' uxib'al*)	
				narrow male cordoncillo (*pu'uk che' uxib'al käs chawak*)
		tomato (*p'ak*)		
			breast tomato (*chu'chu' p'ak*)	
				sweet breast tomato (*ch'uuk chu'chu' p'ak*)
		chili pepper (*ik*)		
			sweet chili pepper (*ch'uuk ik*)	
				red sweet chili pepper (*chäk ch'uuk ik*)
	vine (*ak'*)			
		bean (*b'u'ul*)		
			tzama bean (*tzäma' b'u'ul*)	
				red tzama bean (*chäk tzäma' b'u'ul*)
		squash (*k'uum*)		
			chuyut squash (*chuyut k'uum*)	
				spring chayut squash (*k'ik'i'ix chuyut k'uum*)

Pretesting with Itzaj (Atran 1995b; López *et al.* in press; Atran in press) showed that participants were willing to make inferences about hypothetical diseases. The properties chosen for animals were diseases related to the 'heart' (*puksik'al*), 'blood' (*k'ik'el*), and 'liver' (*tamen*). For plants, diseases related to the 'roots' (*motz*), 'sap' (*itz*), and 'leaf' (*le'*). The properties were chosen according to Itzaj beliefs about the essential, underlying aspects of life's functioning. Thus, the Itzaj word *puksik'al*, in addition to identifying the biological organ 'heart' in animals, also denotes 'essence' or 'heart' in both animals and plants. The term *motz* denotes 'roots', which is considered the initial locus of the plant *puksik'al*. The term *k'ik'el* denotes 'blood' and is conceived of as the principal vehicle for conveying life from the *puksik'al* throughout the body. *Itz'* denotes 'sap', which functions as the plant's *k'ik'el* 'blood'. The *tamen*, or 'liver', helps to 'center' and regulate the animal's *puksik'al*. The *le'*, or 'leaf', is the final locus of the plant *puksik'al*.

Properties used for inferences about animals had the form, "is susceptible to a disease of the <blood> called <X>." Similarly, properties used for plant inferences had the form, "is susceptible to a disease of the <root> called <X>." For each individual question, "X" was replaced with a phonologically appropriate nonsense name (e.g., "eta") in order to minimize the repetitiveness of the task. The disease types were randomized across trials.

Each participant responded to a total of 53 questions in which he/she was told that all members of a category had a property (the premise), and asked whether "all," "few," or "no" members of a higher-level category (the conclusion category) also possessed that property. The premise category was at one of four levels, either life-form (e.g., L = bird), generic-species (e.g., G = vulture, i.e., *aj-ch'om* = Cathartidae), folkspecific (e.g., S= black vulture, i.e., *aj-b'ox ch'om* = *Cathartes aura*), or varietal (e.g., V = red-headed black vulture, i.e *aj-b'ox chom chäk u-pol* = mature exemplars of *Cathartes aura*). The conclusion was drawn from a higher-level category, either kingdom (e.g., K = animal), life-form (L), generic-species (G), or folkspecific (S). Thus, there were ten possible combinations of premise and conclusion category levels: L→K, G→K, G→L, S→K, S→L, S→G, V→K, V→L, V→G, and V→S. For example, a folkspecific-to-life form (S→L) question might be, "If all black vultures are susceptible to the blood disease called eta, are all other birds susceptible?" If a participant answers "no," then the follow-up question would be "Are some or a few other birds susceptible to disease eta, or no other birds at all?"

For questions using a folk-kingdom category as the conclusion (L→K, G→K, S→K, V→K), wording reflected several facts about Itzaj names for high-level folkbiological categories. In Itzaj, the term for animals (*b'a'al~che'*, literally 'forest-thing') polysemously refers to: (a) the animal kingdom as a whole (including invertebrates, birds, fish); (b) the more restrictive grouping of quadrupeds (*b'a'al~che' kuximal* = 'mammals' or 'walking animals', *b'a'al~che' kujiltikub'aj* = 'reptiles' or 'slithering animals', *b'a'al~che' kusiit* = 'amphibians' or 'jumping animals'); (c) the mammals alone. Moreover, as in many languages (Brown 1984), there is no single label for the plant kingdom in Itzaj, although there is a numeral classifier, *teek*, used for all and only plants (e.g., *jun-teek ixi'im* = a maize plant or 'one-plant maize'). So, for inferences with a conclusion category of animals or plants, the category was presented as a concatenation of major life forms not mentioned in the premise. For example, "If all papaya trees were susceptible to disease

"beta" of the leaves, would (all, few, or no) herbs and vines and grasses also be susceptible?"[8]

Michigan materials.—The corresponding life forms for the American students were: mammal, fish, tree, bush, and flower (on "flower" as an American life form see Dougherty 1979). From each life form, we selected three subclasses (e.g., for tree: oak, maple, pine), chosen on predominantly linguistic grounds to correspond to taxa of the generic-species rank. Specifically, generic species are salient taxa often named by simple, primary lexemes (unanalyzable names such as maple or eagle) whose immediate superordinates (life-form taxa) are also named by primary lexemes (tree, bird). We selected subclasses of generic-species taxa to correspond to folkspecifics and varietals, using secondary and tertiary lexemes: for example, sugar maple and spotted sugar maple, or bald eagle and white-collared bald eagle. A complete list of categories used is given in Table 2.[9]

TABLE 2.—Natural kind stimuli used in Michigan study.

Folk Kingdom	Life Form	Generic Species	Folk Specific	Varietal
Animal	Mammal	Deer	Whitetail Deer	Northern Whitetail Deer
		Tiger	Bengal Tiger	White-collared Bengal Tiger
		Squirrel	Gray Squirrel	Brown-backed Gray Squirrel
	Bird	Lark	Meadow Lark	Northern Meadow Lark
		Eagle	Bald Eagle	White-collared Bald Eagle
		Sparrow	House Sparrow	Brown-backed House Sparrow
	Fish	Trout	Rainbow Trout	Northern Rainbow Trout
		Shark	Hammerhead Shark	White-collared Hammerhead Shark
		Bass	Largemouth Bass	Brown-backed Largemouth Bass
Plant	Tree	Maple	Sugar Maple	Spotted Sugar Maple
		Oak	Red Oak	Common Red Oak
		Pine	White Pine	Eastern White Pine
	Bush	Elderberry	American Elderberry	Spotted American Elderberry
		Juniper	Eastern Juniper	Eastern Rocky-Mountain Juniper
		Azalea	Torch Azalea	Common Torch Azalea
	Flower	Lily	Day Lily	Eastern Day Lily
		Violet	Blue Violet	Common Blue Violet
		Marigold	Marsh Marigold	Spotted Marsh Marigold

The properties used in questions for Michigan students were "have protein X," "have enzyme Y," and "are susceptible to disease Z." These were chosen to be internal biologically-based properties intrinsic to the kind in question, but abstract enough so that, rather than answering what amounted to factual questions, participants would likely make inductive inferences based on taxonomic category

membership (Osherson *et al.* 1990; Heit and Rubinstein 1994). Because some Michigan participants would refuse to give extreme answers of "all" and/or "none," the possible response categories used were "all or virtually all," "some or few," and "none or virtually none." Again, ten types of questions, varying levels of premise and conclusion categories, were presented. Each Michigan participant was presented with a total of 56 questions.

Itzaj procedure.—Questions were presented in random order, varying question levels (premise and conclusion), life-form and generic species, and disease type. The procedure was carried out in the Itzaj Maya language. Participants were tested in San José, Petén, Guatemala, in either a field research station or in homes in the town. Participants were told that foreign researchers wished to learn more about the plants and animals of Petén, and that the Itzaj could help with this.

Michigan procedure.—The questions were presented one at a time, orally, in random order, varying question levels (premise and conclusion), life form and generic species, and question type (protein, enzyme, disease). The procedure was carried out in a laboratory setting.

RESULTS

Responses were scored in two ways. First, we totaled the proportion of "all or virtually all" responses for each question (e.g., the proportion of times respondents agreed that if red oaks had a property, all or virtually all oaks would have that property). Second, we calculated "response scores" for each item by scoring a response of "all or virtually all" as 3, "some or few" as 2, and "none or virtually none" as 1. A higher response score reflected more confidence in the strength of the inductive inference. Scores were analyzed using t-tests with significance levels adjusted to account for multiple comparisons. Finally, a regression analysis of the data was also performed.

FIGURE 1.
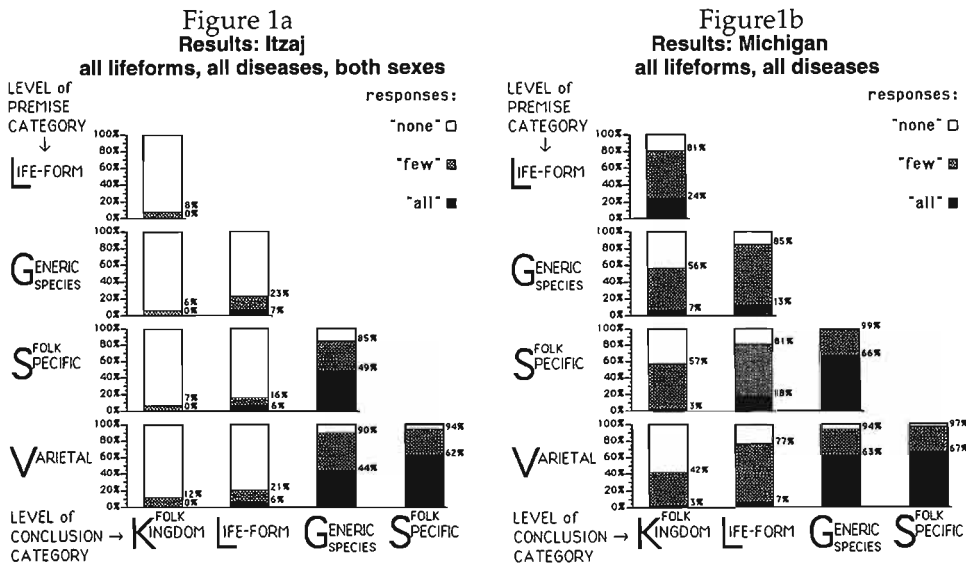
The main results of the present study are depicted graphically in Figure 1. Figure 1 summarizes the results from Itzaj and Michigan informants collapsed across life forms, and shows the proportion of "all," "some/few," and "none" responses. For example, given an inference from the folkspecific rank to the generic-species rank (hereafter S→G, e.g., "If all red squirrels have a property, will all squirrels have that property?"), 49% of responses indicated that "all" squirrels, (rather than "some" or "none") would possess the property given that red squirrels did.

The results are organized to address three major questions. First, is the generic-species rank absolutely privileged with respect to inductive inference? Second, is there evidence for relative privilege in folkbiological reasoning patterns, such as devolution of inductive preference to the life-form level among Americans or upgrading of inductive preference at the folkspecific level among Maya? Third, is there evidence of progressive privilege along the lines of Osherson *et al.* (1990), such as a monotonic decrease in inference strength from lower to higher ranks? After initially addressing these questions, we refine our presentation with a regression analysis (Table 3) and a breakdown of results by life form.

Moving along the main diagonals in Figure 1 is equivalent to changing the levels of both the premise and conclusion categories while keeping their relative level the same (with the conclusion level one higher than the premise level). Moving horizontally within each graph corresponds to changing the conclusion category while leaving the premise category constant. Both of these comparisons bear on the question of the absolute privilege of the generic-species rank. Finally, moving vertically within each graph corresponds to changing the premise category while holding the conclusion category constant. These comparisons are relevant to the Osherson *et al.* hypothesis of taxonomically progressive privilege.

Absolute privilege of the generic species.—First, we ask whether induction patterns point to a single inductively privileged level. Coley, Medin, and Atran (in press) examined inferences from a given rank to the adjacent higher-order rank (i.e., V→S, S→G, G→L, L→K), and found a sharp decline in inference strength to taxa above the generic-species level. This elbow in the curve indicated that both American students and Itzaj elders inductively privilege generic-species. We expect the same pattern: V→S and S→G inferences should be nearly equal and similarly strong, and there should be a significant drop in the strength of inferences for taxa ranked higher than the generic species.

As can be seen in Figure 1, results support the view that the generic-species is privileged for both American and Itzaj informants. As predicted, proportions of "all" responses do not differ between V→S and S→G responses, but drop significantly between S→G and G→L inductions: using a within-subject ANOVA and a post-hoc test of pairwise comparisons, for Itzaj $t(134) = 5.98$, $p<.0001$; for Michigan participants $t(259) = 10.38$, $p<.0001$. Finally, G→L inferences do not differ from L→K differences. An examination of combined "all," "few," and "none" response scores reveals the same pattern. For both Itzaj and Michigan participants, only the difference between S→G and G→L inductions is significant along the main diagonal: Itzaj $t(134) = 8.99$, $p<.0001$; Michigan $t(259) = 10.60$, $p<.0001$.

Another way to examine the idea of absolute privilege is to hold the premise constant and examine variations in inductive strength to varied conclusion cat-

egories. Moving horizontally in Figure 1, if the premise is held constant and the conclusion category varied for "all" responses, then Itzaj inferences to the generic-species level are still consistently higher than to the life-form level: for S→L vs. S→G, t(134) = 6.32, p<.0005; for V→L vs. V→G, t(134) = 5.70, p<.0005. Inferences to folkspecifics do not differ significantly from those to generic species, and inferences to life forms do not differ from those to the folk kingdom. For the Americans, the pattern is almost identical: For S→L vs. S→G, t(247) = 8.94, p<.0005; for V→L vs. V→G, t(244) = 11.41, p<.0005. Inferences to folkspecifics are no stronger than those to generic species.

In sum, inferences to the generic species and lower ranks were high and equivalent, and a sharp drop or elbow in inductive strength was found for inferences ranked higher than the generic species. This pattern provides further support for the view that in widely divergent cultures, taxa of the generic-species rank are privileged for inductive inference.

Relative privilege in folkbiological reasoning patterns.—We also looked for evidence of a downgrading of inductive strength to higher ranks among industrialized Americans through attrition of knowledge, and an upgrading of inductive strength to lower ranks among silvicultural Maya through expertise. Of course, the evidence presented above, showing that both ecologically inexperienced Americans and ecologically experienced Itzaj privilege taxa of the same rank, argues against a simple relativist account of cultural differences in folkbiological knowledge. However, the overall effects of cultural experience on folkbiological reasoning may be reflected in more subtle ways that do not undermine the absolute privilege of the generic species across cultures.

Holding the premise category constant and varying the level of the conclusion category, we find in combined response scores some evidence for increased inductive strength for higher-order taxa for Americans versus Itzaj. Both Americans and Itzaj show the largest break between inferences to generic species versus life forms, but Americans show a consistent pattern of rating inferences to life-form taxa higher than to taxa at the level of the folk kingdom: G→K vs. G→L t(253) = 4.81, p<.0005; S→K vs. S→L t(253) = 5.33, p<.0005; V→K vs. V→L t(242) = 5.76, p<.0005. Itzaj show no such differences. Although for Americans both the generic-species and life-form levels are "special" inductively, the generic species is still significantly more so.

In contrast, overall response scores indicate that Itzaj privilege only generic species. But the possibility remains that Maya ecological expertise, particularly in the realm of silviculture, does add marginally significant inductive strength to the lower rank. We further explore this possibility below through regression analysis and an examination of each life form.

Progressive privilege across taxonomic ranks.—By extension, the similarity-based model of taxonomic reasoning proposed by Osherson *et al.* (1990) predicts that inductive strength should be a monotonically decreasing function of the rank distance between premise and conclusion categories; that is, the closer the premise category is to the conclusion category, the stronger the argument should be. In other words, the Similarity-Coverage model predicts that inductive strength should increase if one holds the conclusion category constant and increases the level of

the premise category. We were able to directly test this hypothesis by moving vertically through Figure 1.

Results reveal little support for this hypothesis. When "all" responses are considered for the Itzaj, varying the level of the premise category does not change inductive strength. For the Michigan participants, two such comparisons produced significant differences. First, S→L inferences were reliably higher than V→L inferences: t(249) = 2.79, p =.03. However, this pattern was not continued at the next rank: G→L inferences are no stronger than S→L. Second, L→K inferences were reliably higher than G→K inferences: t(169) = 3.07, p =.01. For example, participants consider it significantly more likely that all animals have a protein X if they are told that all birds possess it than if told that all larks possess it.

When combined "all," "few," and "none" responses are considered, results are identical for Itzaj; varying the level of the premise category does not change inductive strength. Likewise for the Americans, the only significant difference in the predicted direction is that L→K inferences are higher than G→K inferences: t(169) = 3.73, p =.002. In sum, our results show that only for Michigan informants does a single premise change (G→K vs. L→K) consistently produce a significant increase in inductive strength for "all" responses as well a combined "all," "few" and "none" responses. The lion's share of inductive strength for both the Americans and the Maya is based almost entirely on the conclusion category no matter how distant the premise category, especially if the conclusion is a generic-species. This does not support Osherson *et al.* (1990).

Regression analysis.—An alternative method of analyzing the data is via a regression analysis, using the Premise and Conclusion levels as categorical factors, as well as life form, type of question asked, and the sex of the participant. The results of this regression are shown in Table 3.

TABLE 3.—Results: Regression analyses. For each factor partial correlation (% of total variance) result in **boldface** indicates it is statistically significant (F > 4)

Itzaj:	'all' vs. 'few'/'none'	'all'/'few' vs. 'none'	response score R
Conclusion = K vs. L G S	**-.086 (0.7%)**	**-.149 (2.2%)**	**-.148 (2.2%)**
Conclusion = K L vs. G S	**-.428 (18.3%)**	**-.601 (36.1%)**	**-.610 (37.2%)**
Conclusion = K L G vs. S	**-.135 (1.8%)**	-.055 (0.3%)	**-.117 (1.4%)**
Premise = L vs. G S V	+.033 (0.1%)	+.001 (0.0%)	+.001 (0.0%)
Premise = L G vs. S V	+.010 (0.0%)	+.008 (0.0%)	+.011 (0.0%)
Premise = L G S vs. V	+.022 (0.0%)	-.059 (0.3%)	-.016 (0.0%)
	other significant factors		
sex of participant = male	**+.204 (4.2%)**	**+.150 (2.3%)**	**+.218 (4.8%)**
life-form = fish	**+.121 (1.5%)**	**+.167 (2.8%)**	**+.189 (3.6%)**
life-form = vine	**-.088 (0.8%)**		

* no other significant main effects for: other life form; any disease type

TABLE 3.—Continued.

Michigan:	'all' vs. 'few'/'none'	'all'/'few' vs. 'none'	response score R
Conclusion = K vs. L G S	-.090 (0.8%)	-.296 (8.8%)	-.257 (6.6%)
Conclusion = K L vs. G S	-.508 (25.8%)	-.183 (3.4%)	-.442 (19.5%)
Conclusion = K L G vs. S	-.026 (0.1%)	-.034 (0.1%)	-.049 (0.2%)
Premise = L vs. G S V	+.098 (1.0%)	+.124 (1.5%)	+.140 (1.9%)
Premise = L G vs. S V	+.023 (0.1%)	+.020 (0.0%)	+.016 (0.0%)
Premise = L G S vs. V	+.049 (0.2%)	+.101 (1.0%)	+.099 (1.0%)
other significant factors			
sex of participant = male	+.101 (1.0%)		+.059 (0.4%)
question = disease	+.063 (0.4%)		
life form = mammal		-.122 (1.5%)	-.066 (0.4%)
life form = bird		-.066 (0.4%)	
life form = fish		-.089 (0.8%)	

* no other significant main effects for: other life form; any question type

Absolute privilege.—For Itzaj, the lion's share of the variance (37.2%) is accounted for by whether the conclusion category is either above the generic-species level or not, once again indicating the privileged status of the generic-species rank. By comparison, the splits based on the life-form and folkspecific conclusion levels account for much less of the variance (2.2% and 1.4%, respectively). There are, however, two other significant factors. First, the sex of participant is notable: male subjects gave significantly stronger inductions than females (4.8%). Second, the fish life form stands out: Itzaj give stronger inductions for fish (3.6%). This is most likely because the Itzaj believe water is the best carrier of disease.[10] For American subjects, the generic-species level conclusion is most privileged (19.5% of the variance for a conclusion level of K-or-L vs. G-or-S, versus 6.6% and 0.2% for splits based respectively on the life-form and folkspecific conclusion levels). Again, the generic-species emerges as the overall privileged rank for induction.

Relative privilege.—Regression analysis revealed a sensitivity to differences among lower-order ranks among the Itzaj that was absent among Michigan subjects. For Itzaj participants, the folkspecific level accounted for small but significant variance (1.4%) beyond the generic-species. For Michigan participants, unlike the Itzaj, the folkspecific level is not differentiated from the generic-species level (0.2%, not significant).

This analysis also confirmed stronger inferences to higher-order taxa among Americans than Itzaj. For Americans, the life-form split has relatively strong effects (6.6% versus 2.2% for Itzaj). This effect of life-form level conclusion stems almost entirely from an increase in "few" responses. Thus, regression reveals further evidence of North American devolution relative to the Itzaj.

Distinctions among life forms.—Results conform to our expectations: taxa of the generic-species rank are inductively privileged for both Americans and Itzaj; little use of general reasoning heuristics is seen, and American folkbiological reasoning

patterns are somewhat devolved relative to those of the Itzaj. Yet, this pattern varies somewhat by life form for both groups. For Itzaj, the main pattern, in which only generic species are privileged, is shown for mammal, bird, herb, and vine life forms. For fish, however, the key conclusion level appears to be the life form (fish), not the generic-species (catfish, mojara, sardine). As noted above, Itzaj believe water to be a privileged carrier of disease, so there may be a confound with the property used in the inductions.

For the Itzaj tree life form, there is a significant difference between inductions using conclusions at the generic-species versus folkspecific levels suggesting that Itzaj confer special privileged status upon tree folkspecifics. Itzaj are forest-dwelling Maya who have a long tradition of agroforestry that antedates the Spanish conquest (Atran 1993). A strong ethic of reciprocity in silviculture still pervades the Itzaj, which involves Maya tending trees in order that the forest tend the Maya (Atran *et al.* in press). Figure 2 indicates that the special knowledge and expertise that Itzaj have concerning trees thus conceivably translates into an upgrading of biological interest in tree folkspecifics. In sum, the Itzaj pattern reflects both the overall privilege of the generic species as well as the importance of lower-level distinctions, at least for kinds of trees.

FIGURE 2.

Results: Itzaj, tree lifeform
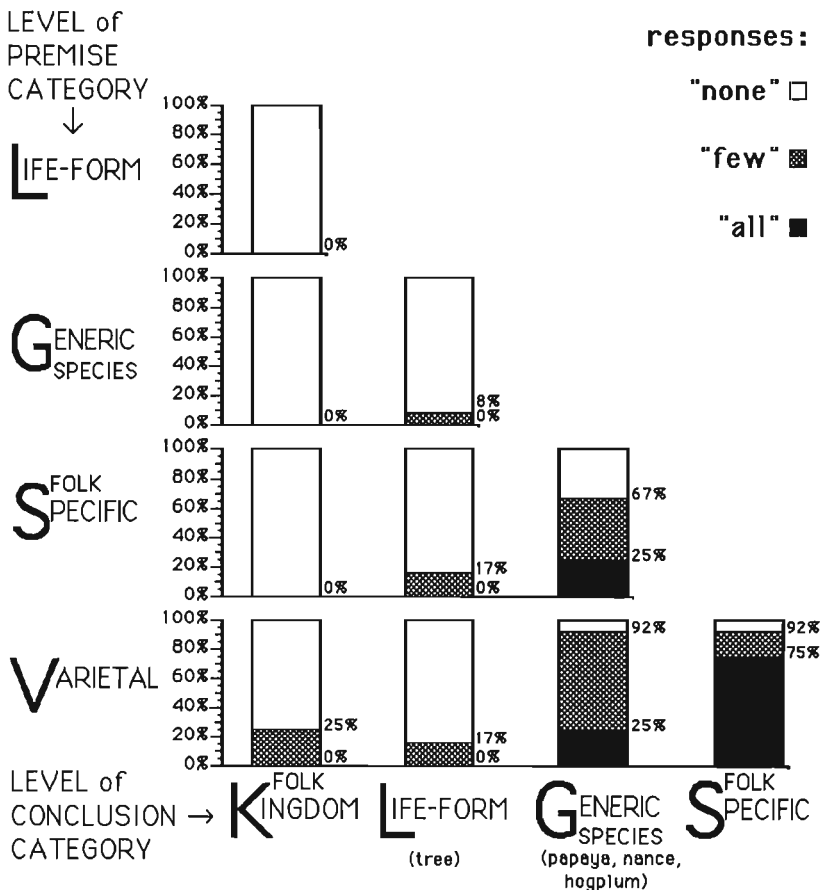
Michigan participants show an exclusive generic-species pattern for the bush and flower life forms. The situation is more complicated for other types of organisms. For fish, there is a significant difference in the proportion of "all" responses for S→L vs. S→K inductions (39% vs. 4%, t(44) = 2.99, adjusted p =0.02), which helps produce an overall difference in response score (t(44) = 3.41, p =0.008). Similarly, there is a marginally significant increase in the proportion of "all" responses for birds when the conclusion category is "bird" (L) instead of "animal" (K) (25% vs. 0%, t(38) = 2.31, p = .1). In both cases, Michigan subjects confer some privileged status upon the life-form conclusion categories "fish" and "bird" (although less privilege than the generic-species level, for which pairwise comparisons are significant between adjacent horizontal cells).

GENERAL DISCUSSION

The data presented above clearly indicate a decisive break in inductive strength just above the rank of generic species. The results highlight the generic-species rank as inductively privileged for both American college students and Itzaj Maya. This perhaps surprising commonality contrasts with other evidence we present supporting the downgrading of American folkbiological knowledge versus the upgrading of Maya knowledge, which mitigates the exclusive privilege of the generic species. We find that the Americans have more faith in inferences to superordinate life-form taxa than Itzaj, and Itzaj differentiate among subordinate taxa more than do the North Americans.

In a previous attempt to reconcile the discrepancy between Berlin's observations and Rosch's data, Dougherty (1978) argued that the basic level is a variable phenomenon that shifts as a function of general cultural significance and individual familiarity and expertise (cf. Tanaka and Taylor 1991). Thus, most folk in industrial societies have little familiarity with, knowledge of, and use for various species of trees, fish, birds, and so forth. As familiarity with the biological world decreases, there is a gradual attrition of folkbiological knowledge up the hierarchy, with the basic level devolving from the generic-species to life-form levels. So far so good. But the devolution story makes a stronger prediction: the privileged level for a small-scale society living close to nature should be subordinate to the privileged level for an industrialized society. Our data evinces no such pattern. We now take up the implications of these findings.

In a recent survey of the field of cognitive anthropology, D'Andrade (1995:176-177) describes two competing accounts of "the universal and rapid learning of natural kinds." One position, which he attributes to Atran, holds that evolution has disposed humans to "learn that plants and animals form natural kinds with a special ease and readiness." A competing position, which D'Andrade attributes to Rosch, holds that natural kinds are universally learned so rapidly because "natural kinds have very special structures with many co-occurring attributes." He argues that the debate is presently undecided because:

> evidence for a universal theory of essences is not at this point compelling. However, this area of cognitive anthropology is not well explored, and it may be that even where evidence of a formulated theory of essences is lacking; it can be shown that people have models of plants and animals that implicitly contain the ideas of essence and natural kind.

In what follows, we suggest that such a model of essences for plants and animals is implied by our data , and that this model is specific to the domain of folkbiology (cf. Atran 1987b). Nevertheless, our data also suggest a significant but secondary role for general, experience-based heuristics.

In striking contrast to the rich debate over the descriptive adequacy of accounts of folkbiological taxonomy, there has been little attempt to provide an explanatory account of the psychological mechanisms and processes that actually produce folkbiological groups. A notable exception is Hunn's (1976) "perceptual model," arguably the most influential proposal in ethnobiology (Berlin 1978). This model accords with Rosch's (1973, 1978) general account of the cognitive structure of perceptual and semantic categories in hierarchical structures. These are variants of what psychologists call "similarity-based models" (Smith and Medin 1981), which organize perceptually identifiable categories on the basis of correlation or covariation of stimulus attributes. With such models, one learns to recognize a particular instance of a category by being exposed to multiple instances of the category numerous times. This implies, as Boster (1991) puts it, "the source of biological similarity judgments is in the world, not in the brain."

To illustrate the story from a similarity-based point of view: because the attributes of having a bark, large canines, and a terrestrial habitat usually co-occur only when a dog is present, then their co-occurrence will probably figure in all and only those feature-sets generally associated with the category dog. The mind will "automatically" tend to cluster perceptible features into "gestalts" of maximally covariant attributes, or basic-level categories, because of the "objective" discontinuities that exist in nature. Notice that for the model to work, it is not imperative that any particular feature always be necessary for defining category membership, nor that a given set of features always be sufficient. All that is required is that the exemplars exhibit a readily apparent "family resemblance" among a community of attributes (Rosch and Mervis 1975; Hunn 1982).

Because the processing mechanism is a general-purpose device that can pick out perceptual stimuli from whatever source, it should operate across any cognitive domain that involves separated clusters of perceptual attributes. This includes categories occurring naturally in everyday biological and social contexts as well as those constructed (e.g., artifacts). Later research has tended to confirm Rosch *et al.*'s findings, further showing that the basic level extends to artificial and natural categories, as the level that people most readily recognize and which children most easily name and learn (Waxman 1991; cf. Lassaline, Wisniewski, and Medin 1992).

The same attribute-clustering strategy can be applied recursively at higher and lower levels (Hunn 1976). Thus, the simultaneous presence of fur and live-born offspring might figure in the feature-set that distinguishes the category mammal from other superordinate-level life forms, such as bird, fish and so forth. Similarly, a large body-length to body-height ratio, when added to the feature-gestalt for dog, might figure in the feature-set that distinguishes the subordinate-level category dachsund from other types of dog. The basic level, then, is that above which relatively much information is lost, and below which little information is gained. That is, there is a large gain in information when going from the superordinate or life-form level to the basic level, and there is only a slight gain in information going from the basic level to the subordinate or specific level.

Thus, both anthropology and psychology suggest that privilege or basicness could be a function of correlated features or properties producing natural clusters which are psychologically salient. These salient chunks should organize both category organization and reasoning involving categories (Anderson 1990). Compelling at this view is, however, it is inadequate to describe our findings (cf. Medin 1989). The challenge is to explain why the generic-species rank is privileged for both Maya, who have relatively extensive contact with the natural environment, and American students, who have relatively little. The key problem is that the linguistic and perceptual criteria for basicness used by Rosch *et al.* point to the life-form level as privileged but, as we have just seen, the breakpoint in induction appears at the more specific rank of generic species.

The inadequacy in such accounts of privileged levels may be failure to distinguish domain-general perceptual mechanisms for best clustering stimuli, from domain-specific mechanisms for best determining loci of biological information. To explain Rosch's data, it may indeed be sufficient to rely on domain-general, similarity-based mechanisms. Such mechanisms may generate a basic level in any number of cognitive domains, but not the privileged level of folkbiology. To explain Berlin's data may require, in addition to domain-generic perceptual heuristics, domain-specific mechanisms for the formation of biological categories that are not similarity-based.

Along these lines, a "living-kind module" would involve a domain-specific sort of causal reasoning which may be called "teleo-essentialist" (Atran 1995a; Keil 1995). The idea is that universal, possibly innate, principles lead people to believe that visible morpho-typical patterns of each readily identifiable generic species, as well as non-obvious aspects of biological functioning, are causally produced by an underlying essence. The nature of this essence is initially unknown, but presumed. The learner (e.g., a child) then attempts to discover how essences govern the heritable teleological relations between visible parts, how they link initially ill-perceived internal parts to morpho-typical parts through canonical patterns of irreversible growth, and how they determine the stable and complex functioning of visible and non-obvious parts. Virtually all people, in all cultures, cannot help but follow through this spontaneously triggered "research program," which compels them to deepen and extend the domain of information relevant to living kinds within a taxonomic framework that focuses attention on generic species.

Notice that a generic species may fail to be "basic" in Rosch's sense of a maximally rich cluster of readily available perceptual information, but still privileged as a maximally rich bundle of anticipated biological information. In other words, domain-specific constraints on categorization and category-based reasoning may diverge from domain-general constraints. When and where they do, the expectation is that domain-specific constraints are paramount.

In small-scale societies, adults as well as children learn about generic species just by being told about them, or by seeing a single instance. In our society, one need only describe a single instance in a picture book or point to an isolated example in a zoo or museum to have an adult or child instantly extend that poor and fragmentary instance of experience to indefinitely extendible category. The taxonomic position of the category is immediately fixed as a generic species. This fixture

"automatically" carries with it a complex internal structure that is partially presumed and partially inferred, but by no means directly known.

How can people conceive of a given category as a generic species without primarily relying on perception? Ancillary encyclopedic knowledge often may be crucial. Thus, one may have detailed perceptual knowledge of dogs but not of oaks. Yet a story that indicates where an oak lives, or how it looks or grows, or that its life is menaced may be sufficient to trigger the presumption that oaks comprise a generic species just like dogs do. But such cultural learning produces the same results under widely divergent conditions of experience in different social and ecological environments. This indicates that the learning itself is strongly motivated by cross-culturally shared cognitive mechanisms that do not depend primarily on experience.

In conjunction with encyclopedic knowledge of what is already known for the natural world, language is important in targeting privileged kinds by triggering biological expectations in the absence of actual experience or knowledge of those kinds (Gelman and Coley 1991). Language alone, however, would not suffice to induce the expectation that little or poorly known generic species are more biologically informative than better known life forms for Americans. Some other process must invest the generic-species level with inductive potential. Language alone can only signal that such an expectation is appropriate for a given lexical item; it cannot determine the nature of that expectation. Why presume that an appropriately tagged item is the locus of a "deep" causal nexus of biological properties and relationships? Why suppose at all that there is such a nexus that spontaneously justifies and motivates expectations, inferences, and explorations relating little known or nonobvious aspects of a presumably fundamental biological reality?

It is logically impossible that such presumptions come from (repeated exposure to) the stimuli themselves. In other words, input to the mind cannot alone cause an instance of experience (e.g., a sighting in nature or in a picture book), or any finite number of fragmentary instances, to be generalized into a category that subsumes a rich and complex set of indefinitely many instances and stimuli. This projective capacity for category formation can only come from the mind, never from the world alone. The empirical question, then, is whether or not this projective capacity is simply domain-general, or also domain-specific. For any given category domain — say, living kinds as opposed to artifacts or substances — the process would be domain-general if, and only if, one could generate the categories of any number of domains from the stimuli alone together with the very same cognitive mechanisms for associating and generalizing those stimuli. As we have seen, current domain-general similarity models of category formation and category-based reasoning fail to account for the taxonomic privilege of the generic-species level across cultures.

CONCLUSION

Our findings suggest that fundamental categorization and reasoning processes in folkbiology are rooted in domain-specific conceptual presumptions and not exclusively in domain-general, similarity-based (e.g., perceptual) heuristics. People

in subsistence versus industrialized cultures may differ on the level at which organisms are most easily identified, but still believe the same absolute level of reality is privileged for biological reasoning, namely, the generic-species rank. This is because they presume the biological world to be partitioned at that rank into non-overlapping kinds, each with its own unique causal essence, or inherent underlying nature, the visible products of which may or may not be readily perceived.[11] People anticipate that the biological information value of these preferred kinds is maximal whether or not there is also visible indication of maximal covariation of perceptual attributes. This does not mean that more general perceptual cues have no inferential value when applied to the folkbiological domain. On the contrary, our evidence points to a significant role for such cues in targeting basic-level life forms as secondary foci for inferential understanding in a cultural environment where biological awareness is poor, as among many North Americans. Possibly there is an evolutionary design to a cognitive division of labor between domain-general perceptual heuristics and domain-specific learning mechanisms: the one enabling flexible adaptation to variable conditions of experience, and the other invariably steering us to those abiding aspects of biological reality that are both causally recurrent and especially relevant to the emergence of human life and cognition.

NOTES

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[2]Generalizations across taxa of the same rank thus differ in logical type from generalizations that apply to this or that taxon. Termite, pig, and lemon tree are not related to one another by a simple class-inclusion under a common hierarchical node, but by dint of their common rank — in this case the level of generic species. A system of rank is not simply a hierarchy, as some suggest (Rosch 1975; Premack 1995; Carey 1996). Hierarchy, that is, a structure of inclusive classes, is common to many cognitive domains, including the domain of artifacts. For example, chair often falls under furniture but not vehicle, and car falls under vehicle but not furniture. There is, however, no ranked system of artifacts: no inferential link, or inductive framework, spans both chair and car, or furniture and vehicle, by dint of a common rank, such as the artifact species or the artifact family.

[3]Botanists and ethnobotanists tend to see privileged groups as akin to scientific genera (Bartlett 1940; Berlin, 1972; Greene 1983). Plant genera in particular are often groups most easily recognized without technical aids (Linnaeus 1751). Zoologists and ethnozoologists tend to view them more like scientific species (Simpson 1961; Diamond 1966; Bulmer 1970), where reproductive and geographical isolation are more readily identified by behavior (Mayr 1969).

[4]For example, in comparative studies of Peten Maya and people from rural Michigan and the urban Chicago area, we found that the majority of mammal and tree taxa in both cultures correspond to scientific species, and most of these taxa also correspond to monospecific genera (López, Atran, Coley, Medin, and Smith in press; Atran in press; Medin, Lynch, Coley, and Atran in press).

[5]The actual magnitude of these changes in inductive strength with specificity of premise and conclusion categories depends on how much similarity changes with specificity. Unless there is some independent measure of similarity, similarity relations become parameters to be estimated from the data. Thus, the Osherson *et al.* induction model could account for a finding of a large drop in inductive strength as the conclusion category moves above the generic-species level <u>or</u> the breakpoint being above the life-form level, depending on which shift led to the larger drop in within-category similarity; however, it cannot simultaneously account for both findings.

[6]Although the subject sample is small, previous experiments have shown that findings for any 12 Itzaj are sufficient to represent a statistically reliable "cultural consensus" (López et al. in press; Atran in press; cf. Romney, Weller, and Batchelder 1986).

[7]For vine, we found only two generic species with both folkspecific and varietal distinctions.

[8]The grass life form, *su'uk*, was introduced to reflect the full range of plant life forms.

[9]A reviewer pointed out that Northern Meadow Lark is actually a Meadowlark, which is not a lark. It is doubtful, however, that the students knew this since, in a separate experiment, they were only able to identify most exemplars of local bird species as simply "bird."

[10]A reviewer suggested that the fish life form, which contains fewer subordinate taxa than other life forms, is more like a generic species than other life forms, such as the bird or tree life forms. Yet, Itzaj believe that certain subordinate fish taxa, such as *nate'* (*Petenia splendida*) and *aj-b'ox* (chichilids), have distinctive heart/essences (*puksik'al*), whereas others, like *aj-k'än b'ox* (yellow chichilid) and *aj-ya'ax b'ox* (blue/green chichilid), share a common *puksik'al*. Moreover, it is clear from justifications Itzaj give for their inferences that water facilitates contagion among fish. A follow-up inference study using different properties may settle the matter.

[11]By contrast, a partitioning of artifacts (including those of organic origin, such as foods) is neither mutually exclusive nor inherent: some mugs may or may not be cups; an avocado may be a fruit or vegetable depending upon how it is served; a given object may be a bar stool or a waste bin depending on the social context or perceptual orientation of its user; and so on.

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