TAHITIAN ETHNOZOOLOGICAL CLASSIFICATION AND FUZZY LOGIC

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RESUME :

Two aspects of the Tahitian (Eastern Polynesia) classification of terrestrial animals are examined in the light of nomenclature.

1) The recent history of the Tahitians' ethnozoological knowledge shows how the classification of a meager insular fauna has evolved after the introduction of new species and with an ever faster acculturation. Three significant stages are presented : the end of the pre-European era in the 18th century, the missionary period in the 19th century, and finally the present time.

2) The usual models, imitations of scientific taxonomies, are associated with a two-valued, true or false logic. In the Tahitian system, however, the assignment of generic taxa to biological forms partakes of a more subtle and less precise multivalued logic. The corresponding mathematical theory has been developed in recent years under the name of "fuzzy sets theory". It gives us a glimps of the possibility of constructing more satisfying models.

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TAHITI.

The classification of terrestrial animals in Tahiti and the neighboring islands (Society Islands, Eastern Polynesia) will be presented in its broad lines. Two aspects of it will be examined : its evolution during recent history, and the type of logic implied by this classification in its present state.

A few points about vocabulary and method ought to be made clear. Organisms are grouped into classes, the taxa (bird, plant, moor buzzard). These taxa occupy different levels in the taxonomy, a hierarchic structure established by comparison of the taxa through the means of the relation of inclusion. This relation is one of partial ordering permitting comparison only between nested taxa (animal, kingfisher). The procedure needs to be filled out. In as far as the Tahitian classification is concerned, it would seem that the taxa show characteristics permitting them to be rearranged into ethnobiological categories like those described in a recent article (Berlin et al., 1973). According to research carried out by these authors, popular taxonomies contain a maximum of 5 levels. At level 0 is to be found the unique beginner of the taxonomic tree : plant, animal. On level 1, the not very numerous life forms : tree, mammal, vine. On level 2 the very numerous generic taxa : oak, quail. They make up the essential part of the classification. On level 3, the specific taxa, less numerous, subject to binomial designation : post oak, blue quail. Finally, there sometimes exists a level 4 : varietal taxa, which are still less numerous. Two categories only, and therefore only two levels, are obligatory : the unique beginner and the generic taxa.

Three periods of the history of Tahiti are representative of successive stages of the Tahitians' ethnozoological knowledge. They are the end of the pre-European era, the missionary period, and the present age. The pre-European era ends in 1767 when the navigator, Wallis, reaches Tahiti ; the end of this period is accessible through certain written documents available to us. Thirty years later, the missionary period begins with the arrival of the first representatives of the London Missionary Society in 1797.

Finally, the third period is the end product of a protracted process of acculturation that profoundly transformed Tahitian society (1).

The end of the pre-European era.

Knowledge and beliefs connected with the animal world must be considered as lost, for the most part. However, certain texts collected by the missionary, John Muddridge ORSMOND (in Henry, 1928) make it possible to reconstruct, at least partially, the state of the pre-European taxonomic system. The most interesting in this regard are the mythological texts, at once didactic and poetic, handed down by the great priests of the ancient religion : "Order Finally Established" and "Division of Property" (Henry, 1928, pp. 395-398, pp. 418-420). They alternate questions and replies on the theme of the creation of the world. By the usage made of terms denoting animal classes, it is possible to locate these classes in relationship to each other. Thus, this study appeals primarily to nomenclature, and not to a hard to interpret juxtaposition or similarity of species, which the content of these texts may sometimes suggest. This does not imply in a general way that unnamed groupings of living species may not appear as significant across certain aspects of Tahitian culture : technical knowledge, myths, etc. But, besides the fact that it is relatively hard to come by any certainty on this matter for the historical period, it has appeared to us in the present situation that the nomenclature reflects the classification of terrestrial animal species.

Tahiti's terrestrial fauna was poor in its number of species, particularly for big size animals. Mammals were represented only by the dog, the pig, and the rat. On the other hand, there were dozens of species of birds and small sized animals such as arthropods and various insects.

Table 1 presents the main divisions of the pre-European classification. There were two kinds of life forms one of which bears the name of taxa, manu, as well as the unique beginner of the classification. This particularity shows up, moreover, in other Polynesian languages and still persists today in certain varieties of the Tahitian language. Perhaps this connects up with the make-up of the terrestrial fauna in which birds were a dominant element. In its general sense of "terrestrial animal", the word manu contrasts with such terms as i'a "aquatic animal", rā'au "plant", etc.

Table 1. Classification of terrestrial animals at the end of the pre-European era.

Life form	Generic taxa	Specific taxa
Start		
manu terrestrial animal	.....	
	mo'o lézard	mo'o 'arara lézard strié
		mo'o urĩ lézard sombre
	'iore rat	
	'urĩ chien	
	pua'a cochon	
manumanu very small animal	.....	
	neonuo moustique	
manu winged insect	.....	
	vini perroquets sp.	vini rura perruche nonette (vini kuhlii)
		vini pauri perroquet sp.
		vini pãnei perruche nonette (vini peruviana)
	ruoe carpophage (Ducula aurorae)	
	pũrohua papillon de nuit	
	pano papillon de jour	
	oT'ao "libellule"	

In its restricted sense, manu may be translated by "bird, winged insect" ; it designates the "flying animal" life form. The second life form is manumanu "very small animal". The term manumanu is formed by doubling or reduplicating the word manu, a common procedure in Tahitian which attributes the idea of smallness and multiplicity.

These two life forms cover only a part of the "terrestrial animal" domain. The generic taxa pua'a "pig", 'urī "dog", 'iore "rat", mo'o "lizard", for instance, are not assigned to life forms. The classification extends right up to specific taxa, particularly for birds. These specific taxa are subject to binomial designations ; this observation fits into the general model proposed by BERLIN et al.

The missionary period.

Attempts to introduce new species began at the time of the first contacts with the navigators. A procedure commonly utilised to name new species is pointed out by BERLIN (Berlin et al., 1973, p. 222). In its simplest form, it has been applied mainly to plants in Tahiti. It consists of giving to the new species the name of a species already known to which it is likened. This name is followed by a qualifying word so that the two species may be distinguished by specifying that one of them is foreign (popa'ā) and that the other is native or indigenous (mā'ohi) or of Tahiti. Doubling the number of names could not suffice to name the introduced animals. The number of terrestrial mammals being apt as analogical models being slight, the new classes created had to have more than two elements. A more varied binomial terminology is required (table 3). The terms pua'a "pig", 'urī "dog", and 'iore "rat" of the earlier period have acquired a greater degree of generality and have become names of life forms. This is made explicit in the DAVIES dictionary of 1851 : pua'a "larger animals that have hoofs", 'urī "quadrupeds that have claws, except for the rat". The binomial appellations thus created are generic names (table 2).

The terms pua'a mā'ohi "pig", 'urī mā'ohi "dog", 'iore mā'ohi "rat", although textually attested (ANONYMOUS, 1875) were no doubt of infrequent occurrence, the simple forms pua'a, 'uri, 'iore being usable under ordinary circumstances without lending to any confusion.

Table 2. Classification of terrestrial animals, missionary period.

Start	Life forms	generic taxa	specific taxa
manu terrestrial animal			
	manumanu very small animal	...	
		rō ant	rō upo'o nui, lit., big-headed ant
			rō 'āvae roa, lit., long-legged ant
		naonao mosquito	
	manu bird, winged insect	...	
		'ōma'oma'o	'ōma'oma'o uri lit., dark 'ō.
			'ōma'oma'o puafau lit., yellow 'ō., long-billed warbler (Conopoderas caffra)
		vini species of parrots	vini pā'ura lit., red vini
			vini rehu lit., gray vini
			vini tea lit., light vini
			vini pāuri lit., dark vini
		pepe butterfly	
		pī'ao dragon-fly	
	pua'a hoofed animal	...	
		pua'a horofenua horse	
		pua'a niho goat	
		pua'a mā'ohi pig	
	'urī big, clawed animal	...	
		'urī ta'ata monkey	
		'urī pi'ifare cat	
		'urī mā'ohi dog	
	'iore small, clawed animal	...	
		'iore pereau bat	
		'iore mā'ohi rat	

At the time when the new animals were being imported to Tahiti, bible teaching was being diffused by the missionaries. For their needs in translating the bible into Tahitian, the missionaries created great numbers of animal names from Hebrew, Greek, and Latin. With but a few exceptions, such as ass 'ātini (written asini), the names of these animals call up no image for the Tahitians. The Tahitian conception of life forms caused some trouble for the translators who had to find expedients for transposing over into Tahitian judaic ideas about the animal world :

manu 'āvae maha "quadruped" manu, land animal + 'āvae, leg, foot, paw + maha, four, lit., four-footed animal.

manu pererau "bird" manu, land animal + pererau, wing, lit., winged animal.

pua'a "wild (?) animal" pua'a, hooved animal, pig.

The present age.

Generally speaking, familiarity with nature is declining. The essential data serving to describe the present state of affairs was gathered from informants from one of Tahiti's neighboring islands where the way of life, still close to nature, is more favorable than in Tahiti to the persistence of this kind of knowledge. This island belongs to the same linguistic and cultural unit, in spite of a few dialectal variations.

The expression te mau mea ora "living beings" or "living things" may be found in both the old texts collected at the beginning of the nineteenth century (Henry, 1962, p. 352) and in the Tahitian translation of the Bible. Informants were interrogated as to the meaning that they attributed to the term. Those persons consulted between the ages of 45 and 65 years gave consistent explanations. The domain of living beings extends to the whole creation , everything that was not made "by the hand of man". These are land animals, water animals, plants, but also stones, the sea, astral bodies, etc. The way in which life shows itself (movement, respiration, growth, etc.) is considered as being more or less obvious, according to the case. In as far as stones are concerned, for instance, it is supposed to be very distinct. Stones live, grow, can have beneficent powers (stones to draw fish towards fishing spots) or dangerous/ powers (places for supernatural beings to stay), finally they die by a process of deterioration, like plants. Therefore, the class manu "terrestrial animal" is

Table 3. Generic names of animals applied to new life forms during the missionary period.

pua'a "hooved animal"

pua'a mā'ohi "pig" pua'a, pig + mā'ohi, indigenous, lit., native pig.

pua'a horo fenua "horse" pua'a, pig + horo, run + fenua, terre, lit., pig running on the ground.

pua'a niho "goat" pua'a, pig + niho, horn, lit., horned pig.

pua'a toro "bovine" pua'a, pig + toro, bull (borrowed from Spanish), lit., bull pig.

pua'a māmoe "sheep" pua'a, pig + mā attenuating prefix + moe, sleep, lit., sleeping or sleepy pig (?), or unknown foreign origin (DAVIES, 1851, appendix).

'urī "big clawed animal"

'urī mā'ohi "dog" 'urī, dog + mā'ohi, indigenous, lit. native dog.

'urī pi'ifare "cat" 'urī, dog + pi'i, climb + fare, house, lit., house-climbing dog.

'urī ta'ata "monkey" 'urī, dog + ta'ata, person, lit., dog man.

'urī 'aiava "seal" 'urī, dog + 'ai, dwell + ava, pass, lit., dog that lives in the passes (Andrews, 1944 ; Davies, 1851) (2).

'iore "small clawed animal"

'iore mā'ohi "rat" 'iore, rat + mā'ohi, indigenous, lit., native rat.

'iore pererau "bat" 'iore, rat + pererau, wing, lit., winged rat.

'iore popa'ā "rabbit" 'iore, rat + popa'ā, foreign, lit., foreign rat.

part of a larger set of the mau mea ora "living things" where myth, philosophical speculation, biological observation are not considered as separate domains of knowledge, but rather as integrated. On this subject, one may observe that, for a long while, zoological treatises in Europe gave descriptions of fabulous animals : chimera, unicorn, etc.

In general, the informants are not very much aware of the existence of the extended meaning of manu "terrestrial animal". This sense appears almost uniquely in such questions as Maha terā manu ? "What is that animal ?". A question of this type is suitable for any kind of terrestrial animal, but not for an aquatic animal.

Three life forms are present in table 4. The manumanu "very small animals" include named items (ra'o, fly, etc.) but also organisms that are not designated with any greater precision : small flies around fruit, microbes, etc. The class of manu "birds, winged insects" comprises almost one less level than in the preceding era. The specific taxa are hardly represented, except by the two varieties of reef herons, 'ōtu'u (Egretta sacra), one white 'ōtu'u 'uo'uo, and the other grey 'ōtu'u 'ere'ere. Certain species of birds have actually disappeared since the nineteenth century and those remaining are less widely distributed as the biological equilibrium has been modified.

A new life form 'animara "big non-flying animal" has taken the place of pua'a "hooved animals" and 'urī "big clawed animals". This class includes domestic and exotic animals. It is hard to set its boundaries.

The meanings of certain generic names appearing in the missionary era (table 3) are now obscured. A popular etymology makes the goat pua'a niho (< pua'a, pig + niho, horn, lit., horned pig) a toothed animal because of the only modern meaning of niho "tooth", while there exists an old meaning of niho "horn" (Jaussen, 1898 ; Davies, 1851). The archaic name of cat pi'ifare or 'urī pi'ifare (< 'urī, dog + pi'i, climb + fare, house, lit., house-climbing dog) is that of an animal that calls in the house according to a popular etymology current amongst the Tahitians, as the only meaning of pi'i remaining is "to call" (White, 1967, p. 328). Other changed or abridged names : mīmī "cat" (< French mimi) ; pārehenua "horse" instead of pua'a horofenua ; māmoe instead of pua'a māmoe. Amongst the names of exotic animals, some are borrowings : taita "tiger" (< English), rāpiti

Table 4. Classification of land animals at the present time

Start	Life forms	Generic taxa	Specific taxa	
manu terrestrial animal	ʻanimara big, non-flying animal (domestic and exotic animals)	⋮		
		pua'a papa hippopotamus		
		tuita tiger		
		ruto wolf		
		mīmī cat		
		ʻurī dog		
		pua'arehenua (pua'ahoro-fenua) cheval		
		pua'a niho goat		
		pua'atoro cow		
		pua'a pig		
	manu bird, winged insect	⋮		
		ʻōtuʻu reef heron (Egretta sacra)	ʻōtuʻu ʻereʻere reef heron, gray variety	
			ʻōtuʻu ʻuoʻuo reef heron, white variety	
		tava'e red-tailed tropic bird (Phaeton rubricauda)		
		ma'uroa white-tailed tropic bird (Phaeton lepturus)		
		ua'ao red-footed booby (Sula sula)		
		noha (indeterminate petrel) (Pterodroma species)		
		manu pātia wasp	manu pātia ʻuteʻute red wasp	
			manu pātia ʻereʻere black wasp	
		pūrehua moth		
		pepe butterfly		
		pī'ao dragon-fly		
	manumanu very small animal	⋮		
		rō ant	rō māineine lit., tickling ant	
			rō hohoni, lit., biting ant	
			rō ʻereʻere, lit., black ant	
		ʻarauʻauʻa woodlouse		
		hitihiti sea louse		
		ra'o fly		
		naonao mosquito		

"rabbit" (< English), others have been composed by comparison with familiar animals : puaʻa pape "hippopotamus" (< puaʻa, pig + pape, water, lit. water pig or hog), moʻo taehae "crocodile" (< moʻo, lizard + taehae, wild savage, lit., ferocious lizard ; this name also designates monitors in old texts).

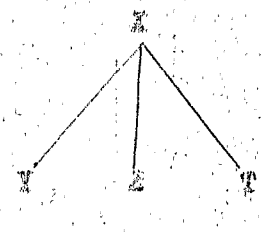
For the sake of completeness, observe that the classification just described is from amongst the more conservative. At the other extreme, with the more highly acculturated informants, the Tahitian categories are assimilated to their approximate French equivalents :

manu "bird" instead of "bird or winged insect"
menumanu "insect" instead of "very small animal"
ʻanimara "animal" instead of "big non-flying terrestrial animal" (the meaning manu "terrestrial animal" disappears).

The logic of ethnobiological classifications.

We should like to draw attention to a difference that shows up between scientific classification and ethnobiological classification, at least at a certain level of the Tahitian example.

In the classifications regularly described that end up in a taxonomy, the structure of the tree may be considered as the result of a sequence of elementary operations consisting of successive partitions. A taxon X located at level n of the taxonomic tree is divided into taxa from level n+1 of lesser extent Y, Z, T for example whose union is X.



These operations are those of the regular theory of sets. The steps that they entail come from Boolean logic, a true and false two-valued logic. Let it be clearly understood that the componential definitions partake of the same logic, even if they include many [illegible] features.

It cannot be denied that such models produce suitable descriptions in a great many instances. But, when one interrogates Tahitians about assigning animals to life forms, the most remarkable fact is their hesitations, their contradictions, and even the impossibility for them to classify certain ones, even though they are often animals quite familiar to them. An attempt has been made (Bright J. & Bright W., 1965) to describe a classification bringing into play "sphere of influence" relationships. The reactions of the informants suggest orientation towards this kind of many-valued logic, which takes into account the fact that the elements or members do not carry the same weight within a class. Within the taxa which have been called life forms, there exists a central zone, one might say, containing a certain number of members that are highly representative of the life form concerned and a marginal zone of less representative or doubtful members. Informants' ideas about their classification throws light for us on their attitude. They themselves specify the characteristics of two of the life forms. The manumanu are animals of "small size" and the manu are animals "that fly" (the third life form which includes mainly domestic and exotic animals has no such obvious characteristic). Such propositions conform faithfully to the concept of fuzzy sets (ex. : within the set of men, the fuzzy sub-set of men of great size). This mathematical theory, called fuzzy sets theory, has been developed these last years by mathematicians such as L. A. ZADEH and has just been presented in French (Kaufmann, 1973).

This theory is a generalisation of set theory and provides a new way to approach the problems that we are raising. Some explanation is in order. In the ordinary theory of sets from which the usual taxonomical models derive, a member belongs or does not belong to a set (or a sub-set) as has been said above.

In order to generalize this theory, it is necessary to introduce the notion of characteristic function. For each sub-set (in the ordinary sense) of a set E, a characteristic function $f_A(x)$ is defined, which, being given any member x whatsoever of E, takes the value 1 when x is a member of the set A, and in the opposite case, the value 0. If E represents the human race and A the set of human beings of masculine sex, the function $f_A(x)$ has the value of 0 when x represents a woman and 1 when x represents a man. The logic associated with this is two-valued : true proposition 1, false proposition 0.

In the fuzzy sets theory, this characteristic function may take values other than 0 and 1, for instance all values between 0 and 1 (most general many-valued logic). A fuzzy sub-set is then defined by the values that its characteristic function takes for the various members of the set in which it is included. Within the set of employees of an enterprise, the fuzzy sub-set of employees of big size would be defined by assigning sizes to the various employees, which would be made up of sizes between 0 and 1, if one were to take the precaution of choosing the size of the biggest of them as unit of measurement. The employees of the enterprise would be the members of this fuzzy sub-set but in very differing degrees.

Let us get back to the life forms of the Tahitian classification. The characteristic feature of the manumanu as made explicit by the Tahitians : smallness, is a relative notion implying innumerable possible degrees. It may be represented with greater verisimilitude by a characteristic function taking all of the values between 0 and 1, rather than by a function taking only 2 values. The representation of the manumanu by a fuzzy sub-set is therefore preferable to a representation connected with two-valued logic. The "flying" criterion of manu would seem aprioristically to correspond to a proposition to which it is possible to reply by yes or no. In fact, such is not the case. This will be illustrated by the examples that follow.

The characteristic features of the various life forms are not mutually exclusive. It does not always suffice to observe that a generic taxon possesses one of them in order to assign it the name of a life form. As a matter of fact, it may possess characteristic features of several forms. The reactions of the informants show that, in this latter case, after comparison, a single one of these features is retained as the most conspicuous for the generic taxon under consideration. Everything occurs as though the classification, which is in the domain of thought, authorizes fuzziness and overlap, while the nomenclature, which belongs to the domain of communication, would like to avoid them. Thus, flies and mosquitoes are small enough to be manumanu and/or do not fly well enough to be manu. Butterflies fly well enough to be manu and/or are not small enough to be manumanu. The classification of cricket, for instance, is uncertain. The chicken is considered rather as an 'animara as it does not fly very much.

In order to put these notions into practice in view of the description of ethnobiological categories, it is necessary to be able to evaluate the characteristic functions. A model where these characteristic

functions can take all of the values between 0 and 1 requires using elaborate tests.

A three-valued model (0, 1/2, 1) corresponding to a three-valued logic (false, doubtful, true), leads to distinguishing within the classes a marginal zone (1/2) from a central zone (1), table 5.

Within the Tahitian system that has been examined, the boolean logic of scientific taxonomies does not permit explaining in a satisfactory way the relations between generic taxa and biological types. The fuzzy set theory and the more general logic associated with it are better adapted to a description of this level of classification. A clue would seem to indicate that this particularity is not restricted to Tahitian : often enough in the ethnobiological classifications, generic classes are not affiliated with biological forms (Berlin et al., 1973, p. 216, p. 219). As Kaufmann observes "The laws of thought that we can have entered into the cumputer programs are obligatorily formal ; the laws of thought in man-to-man dialogue are fuzzy" (Kaufmann, 1973, p. 191).

Table 5. Distribution of a few generic taxa in keeping with the biological forms as fuzzy sets (4 informants, wherefore a few overlapping)

Generic taxa	Life forms: manumanu (very small animals)								manu (animals that fly (birds, winged insects))								'animare (big animals (domestic and exotic animals))							
vīvī sauterelle	1	0	1/2	0	0	1	1	1/2	0	0	1	1/2	0	1	1/2	0	0	0	1/2	0	0	0	0	1
veri scolopendre																								
vāva phasme																								
'utu pou																								
'urī chien																								
tūtūrahonui araignée grande taille																								
tutu'a puce																								
rō fourmi																								
ra'o mouche																								
pūrehua papillon de nuit																								
pua'a cochon																								
potipoti cancrelat																								
pī'ao libellule																								
perete'i grillon (Grillus oceanicus)																								
pepe papillon de jour																								
naonao moustique																								
mo'o lézard																								
moa poule																								
mīmī chat																								
manu patia guêpe																								
'iore rat																								
'arau'au'a cloporte (esp.ind.)																								

N O T E S

(1) I wish to thank Ralph G. WHITE who translated this paper in English and made useful remarks, and J.C. THIBAULT (EPHE, Paris) who worked out the scientific names of the birds cited.

(2) The standard word is hūmī.

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